Monetary institutions for a finite planet –
Essays toward an ecologically-embedded political economy of money

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June, 2020

A thesis submitted to McGill University in partial fulfillment of the requirements of the degree of Doctor of Philosophy

"Labor is only another name for a human activity which goes with life itself . . . ; land is only another name for nature, which is not produced by man; actual money, finally, is merely a token. . . . The commodity description of labor, land, and money is entirely fictitious".

Karl Polanyi (1944/2001, p.75)

Abstract

This research advances the scholarship on how the monetary and financial system contributes to our ecological crises and is increasingly affected by them; and on the kind of reforms needed to re-embed monetary institutions within our planetary boundaries. The academic community and policymakers are increasingly aware of the vulnerability of the global financial system to the materialization of ecological risks. However, most approaches to the problem are grounded in an apolitical and therefore limited understanding of both ecological issues and of money and finance.

This thesis departs from the neoclassical economics worldview supporting these approaches by building on two largely disconnected streams of research, which have respectively re-politicized: human-nature relationships, notably through ecological economics and the world-ecology perspective; the role of money and finance in capitalist dynamics, notably through post-Keynesian economics and institutional approaches to money. Together, these different perspectives point to the fact that, since the ways in which money is institutionalized result from conflicting views over what should represent value, the need to revisit our dominant value systems in the Anthropocene will require transforming our monetary institutional arrangements.

By merging these ecologically- and monetarily-informed perspectives, this thesis addresses, in the form of essays, the following four critical topics:

(i) The limitations of central banks' theoretical framework to identify and manage ecological risks ("Green Swans"), including those related to climate change. Climate-related risks are not only too complex and nonlinear to be measured with precision, rendering existing financial risk models and climate-economic models largely useless, they are also impossible to hedge as long as system-wide action is not taken. This means that central banks, and with them, our existing monetary institutional arrangements, will unavoidably be dragged into uncharted waters in the age of climate and ecological risks.

(ii) The relative ability of the incipient field of ecological macroeconomics – at the crossroad between post-Keynesian economics and ecological economics – to overcome the limitations of mainstream environmental economics. While the field provides new policy tools that could be used for an ecological transition, it falls short of addressing both the political economy implications of different possible transition paths, and how human-nature relationships need to be revisited for the purpose of a finite planet.

(iii) The need to revisit the so-called "monetary growth imperative" debate through institutionalist approaches to money, which nuance the findings of ecological macroeconomics. Whereas the post-Keynesian endogenous view of money shows that there is no mechanical impossibility to maintaining interest rates in a non-growing economy, its approach remains incomplete insofar as it dismisses the historical reasons that led to the generalization of interest-bearing debt and their connection to the aspiration of endless accumulation, which is incompatible with the physical reality of a finite planet.

(iv) The need for, and obstacles to, a reform of the international monetary system (IMS) through ecologically-informed perspectives. Reforming the IMS will be essential to a global ecological transition but will first require addressing the political ecology of global imbalances. The international currency hierarchy that stands in the way of Peripheral countries' development paths is inextricably related to an ecological hierarchy, which maintains these countries in the role of providers of cheap resources to the Center and recipients of multiple forms of pollution.

These four essays bring complementary insights into the development of an ecologically-embedded political economy of money, one that can provide theoretical foundations to envision monetary institutions for a finite planet.

Résumé

Cette thèse vise à faire progresser l'état des connaissances sur la manière dont le système monétaire et financier contribue aux crises écologiques, comment il est affecté par celles-ci, et quels types de réformes pourraient être nécessaires afin de le ré-encastrer dans nos limites planétaires. Malgré une prise de conscience croissante par la communauté académique et les responsables politiques de la vulnérabilité du système monétaire et financier international aux risques écologiques, leur manière d'aborder le problème reste souvent ancrée dans une vision dépolitisée et donc incomplète des crises écologiques et de la monnaie.

Afin de pallier ces lacunes, cette thèse repose sur deux courants de recherche qui ont re-politisé, d'une part, les relations entre systèmes humains et systèmes naturels, en s'appuyant notamment sur l'économie écologique et l'approche de l'écologie-monde (« world-ecology ») ; et, d'autre part, le rôle joué par la monnaie et la finance dans les dynamiques du capitalisme, en s'appuyant notamment sur l'économie post-keynésienne et les approches institutionnalistes de la monnaie. Ensemble, ces approches indiquent que la transformation des systèmes de valeur dominants qui est nécessaire pour faire face à l'Anthropocène ne pourra se faire sans revisiter nos institutions monétaires, celles-ci étant au cœur même de l'expression de la valeur.

Cette thèse mobilise et croise ces différentes approches afin d'analyser, sous la forme d'essais, quatre sujets identifiés comme essentiels pour penser nos institutions monétaires à l'ère des crises écologiques :

(i) Les limites du cadre théorique utilisé par les banques centrales pour identifier et gérer les risques écologiques extrêmes (« Cygnes Verts ») tels que ceux liés au changement climatique. La complexité et l'incertitude liées aux risques climatiques sont telles qu'elles rendent inopérants les outils traditionnels de gestion du risque et les modèles économie-climat. Les banques centrales sont par conséquent entraînées en terrain inconnu à l'ère du changement climatique et des risques écologiques ;

(ii) La capacité de la macroéconomie écologique, à la croisée de l'économie écologique et de la théorie post-keynésienne, à répondre aux limites du cadre théorique dominant. Cette discipline encore naissante offre une panoplie de mesures pouvant être utilisées dans le cadre d'une transition écologique et ignorées par la théorie néoclassique. Néanmoins, elle ne parvient pas à s'attaquer à la question des relations entre systèmes humains et systèmes naturels, ni à penser l'économie politique des différents chemins de transition possibles ;

(iii) Le besoin de revisiter le débat sur « l'impératif de croissance monétaire » à travers l'institutionnalisme monétaire. L'approche post-keynésienne a démontré qu'il n'y a pas d'impossibilité mécanique à prélever des taux d'intérêt dans une économie sans croissance. Cependant, cette approche ignore les raisons historiques qui ont mené à généraliser la pratique du taux d'intérêt, et leur articulation avec la recherche d'une accumulation infinie qui reste fondamentalement incompatible avec la finitude de notre planète ;

(iv) L'exigence de réformer le système monétaire international (SMI) en vue d'une transition écologique, et les obstacles potentiels auxquels une telle réforme ferait face. Une refonte écologique du SMI ne pourra se faire sans s'attaquer à l'écologie politique des déséquilibres globaux : la hiérarchie entre devises qui empêche aux pays périphériques de développer des politiques économiques autonomes est intrinsèquement liée à une hiérarchie écologique, qui les maintient dans le rôle de fournisseurs de ressources peu chères et de réceptacles de pollutions multiples.

Ces quatre essais apportent des enseignements complémentaires qui contribuent à poser les bases d'une économie politique de la monnaie encastrée écologiquement. Celle-ci s'avérera essentielle pour penser nos institutions monétaires dans une planète finie.

Acknowledgments

I would like to express my sincere thanks and appreciation to:

Dr. Nicolás Kosoy for his invaluable guidance. His expertise and passion have been essential to find my path in the muddy waters of transdisciplinary studies. I am extremely grateful for all the time he dedicated to me, including long conversations that helped me define my research, trust in my ideas and make my thesis a fulfilling adventure.

Dr. Peter G. Brown for believing in me from the very first day and for accepting me into the Economics for the Anthropocene (E4A) research initiative, while giving me the time and intellectual space to explore what I was truly looking for. He contributed to make a dream come true.

Eli for her love and friendship, for the endless support throughout the ups and downs of this thesis, for taking interest in my research and helping me shape my ideas.

My family, and in particular my parents for always being there, my abuela Rosita (RIP), my mamie Colette, my tía Marina, Boris, Luciano, and Rory for her caring presence over my work.

Stefano Menegat and Raphaelle Occhietti for their friendship and their moral support, for endless conversations and for being my family in Montreal.

Dominique Dron and Etienne Espagne for their friendship and for believing in my work as I went through the hardest part of this thesis. Their support has been invaluable.

Jeff Althouse for his friendship and for unforgettable Wittgensteinian conversations.

Joe Ament for his friendship and for all the time spent together talking about money since the very beginning of this thesis. It has also meant the world to me.

David Barmes for his friendship and his outstanding intellectual support throughout these years.

The E4A community and in particular Dina Spigelski for her support at all times, as well as Charles Guay-Boutet, Christopher Orr, Deissy Perilla, Ellie Perkins, Eric Miller, Janica Anderzén, Jen Gobby, Jon Erickson, Joshua Farley, María Juncos Gautier and Peter Victor.

The following persons for inspiring conversations, email exchanges, shared experiences, feedbacks or publications that contributed in many different ways to making this thesis possible: Antoine De Mena, Antoine Monserand, Bruno Théret, Daniel Bastidas, Diana Vela Almeida, Elena Hofferberth, Eric Zencey (RIP), Fadhel Kaboub, Frédéric Samama, Hadrien Lantremange, Iván Weigandi, Joan Martínez-Alier, Luiz Awazu Pereira da Silva, Mabel Thwaites Rey, Michel Aglietta, Morgan Després, Nelo Magalhães, Pablo Maas, Patrick Bolton, Sally Goerner, Simon Dikau, Sofia Valeonti, Vijay Kolinjivadi, William Oman and Wojtek Kalinowski.

Aaron Vansintjan and Nicholas Daly for their outstanding advice in editing parts of this thesis.

Banque de France for providing me with the intellectual space to explore new research avenues in an out-of-equilibrium, complex and uncertain world.

The Social Sciences and Humanities Research Council (SSHRC) of Canada and McGill University for the funding provided, which made this journey possible.

Contributions of Authors

This thesis is composed of: a general introduction that includes the overall research objectives; a literature review; four chapters written in manuscript format according to the guidelines of the Graduate and Postdoctoral Studies Office of McGill University; a general conclusion and contributions to knowledge.

Contributions to original knowledge:

The following aspects of originality – further elaborated in Chapter 8 – characterize novel contributions to knowledge stemming from this body of research:

- The first manuscript of the thesis included herein – chapter 3 – is by: Romain Svartzman, Patrick Bolton, Morgan Després, Luiz Awazu Pereira da Silva and Frédéric Samama. It assesses the limitations of central banks' theoretical framework to face climate change and other ecological crises, and articulates the need for an epistemological rupture with regard to existing risk management practices.
- The second manuscript – chapter 4 – is by: Romain Svartzman, Dominique Dron and Etienne Espagne. It gauges the insights and limitations of the incipient field of ecological macroeconomics, at the crossroad between post-Keynesian economics and ecological economics.
- The third manuscript – chapter 5 – is by: Romain Svartzman, Joseph Ament, David Barmes, Jon Erickson, Joshua Farley, Charles Guay-Boutet and Nicolás Kosoy. It contributes to the debate on whether the very nature of capitalist money is at odds with the finiteness of natural resources and ecosystems' carrying capacity – the *monetary growth imperative debate*.
- The fourth manuscript – chapter 6 – is by: Romain Svartzman and Jeffrey Althouse. It revisits the need for and obstacles to a reform of the international monetary system, by using the different ecologically- and monetarily-informed perspectives explored throughout this thesis.

Contributions of Authors:

The author of this thesis is the first author of the four published or submitted manuscripts included in this thesis. He was responsible for conceptual development, background research, data analysis, and preparation of manuscripts for publication. Patrick Bolton, Morgan Després, Luiz Awazu Pereira da Silva and Frédéric Samama provided critical advice and review to the first manuscript. Dominique Dron and Etienne Espagne provided advice to develop the conceptual framework of the second manuscript, and provided critical advice and review. Jon Erickson, Joshua Farley and Nicolás Kosoy provided review to the third manuscript. Joseph Ament, David Barmes and Charles Guay-Boutet provided critical advice and review to the development of the third manuscript. Jeffrey Althouse helped develop the conceptual framework of the fourth manuscript, and provided critical advice and review. Nicolás Kosoy provided review and feedback to the four manuscripts of the thesis.

Publication of thesis components:

These manuscripts are presented as chapters of the thesis and have been published or submitted for publication. More specifically:

- The first manuscript was submitted to the peer-reviewed journal Climate Policy, submission N° sciencesconf.org:isefi:321124. A longer version of the paper was published as a book (ISBN: 978-92-9259-326-1);
- The second manuscript was published in the peer-reviewed journal Ecological Economics (DOI: 10.1016/j.ecolecon.2019.04.018);
- The third manuscript was accepted for publication as a book chapter in "Sustainable Wellbeing Futures – A Research and Action Agenda for Ecological Economics" (ISBN: 978 1 78990 094 1);
- The fourth manuscript was submitted to the peer-reviewed journal Review of International Political Economy, submission N° RIPE-2020-0098.

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Chapter 1 – Introduction

"Every habitable part of the earth, in our time, has been discovered, surveyed, and divided up among nations. . . . There is no rock that does not bear a flag, there are no more blanks on the map, no region out of the reach of customs officials and the law, no tribe whose affairs do not fill some dossier. . . . *The age of the finite world has begun.* . . . An entirely new, excessive, and immediate interdependence between regions and events is the already perceptible consequence of this great fact".

Paul Valéry (1931/1962, pp.14-15. Emphasis in original)

The current global socio-economic system is destabilizing the Earth's life support systems and increasingly threatening the ability of human and nonhuman life to flourish on Earth (Kosoy et al., 2012). Climate change (IPCC, 2018), biodiversity loss (IPBES, 2019) and land degradation (FAO, 2015; IPCC, 2019) are just a few of the nine "planetary boundaries" (Rockström et al., 2009; Steffen et al., 2015) that have been transgressed as our current system is impinging on "the safe operating space for humanity" (Rockström et al., 2009).

In 1992, over 1,700 scientists worldwide (Union of Concerned Scientists, 1992) signed a "warning to humanity" describing the critical stress imposed by humans on the atmosphere, water resources, oceans, soil, forests and other living species; they further demanded "fundamental changes ... in our stewardship of the Earth and the life on it" and indicated that a few decades remained "before the chance to avert the threats we now confront will be lost". Two and a half decades later, in 2017, more than 15,000 scientists from 184 countries sent a second warning. The alarming trends they had outlined a quarter-century earlier had worsened, and "immediate action as a moral imperative" had become necessary "to prevent widespread misery" (Ripple et al., 2017, p. 1028). Climate change, by far the most discussed ecological crisis although it may only be the "tip of the iceberg" (Steffen et al., 2011, p. 843), may suffice on its own to generate "untold suffering" (Ripple et al., 2020, p. 8).

The impact of human activity on the Earth's systems is such that it may have led to the unfolding of a new geological epoch, the Anthropocene (Crutzen, 2002; Steffen et al., 2011, 2018), literally the *age of humans*. The Anthropocene indicates that humans have become the dominant force shaping the Earth's geology and ecosystems. While scientists are debating around the fingerprints that could officially designate a new geological epoch (Subramanian, 2019) – and besides the fact that the term "Anthropocene" remains problematic for other reasons (e.g. Bonneuil & Fressoz, 2016; Malm & Hornborg, 2014; Moore, 2015) discussed below – it is undisputable that the rates of resource extraction and pollution emissions generated by socio-economic activities are exceeding the rates of resource regeneration and ecosystems' assimilative capacities (Daly & Farley, 2011), leading to multiple and interconnected ecological crises (Lade et al., 2020; Lenton et al., 2019; Steffen et al., 2018).

This suggests that the global socio-economic system is disembedded from its planetary boundaries. The concept of (dis)embeddedness was introduced by Polanyi (1944) who, in *The Great Transformation,* contended that the capitalist market economy thrived by disembedding and isolating the market economy from social relationships and the natural environment on which it actually depends. This process of disembedding allows the economic sphere to "evolve according to its own laws" (Polanyi, 1944/2001, p. 136). The disregard for the socio-ecological environment is made possible by the fictitious commodification of three pillars of life in society: labor, land and money. While these may seem thoroughly integrated into the economic system today, in reality, "labor is only another name for a human activity which goes with life itself ... Land is only another name for nature, which is not produced by man ... Money, finally, is merely a token" (Polanyi, 1944/2001, p. 75), a symbol representing value.

1.1 Problem statement

This thesis focuses on the latter, money. It explores how this "token" or symbol representing value (Aglietta, 2018; Hornborg, 2019; Orléan, 2015) contributes to the disembeddedness of our

global socio-economic system, how the existing monetary order is increasingly threatened by ecological crises, and what kind of reforms may be necessary to re-embed monetary institutions within our planetary boundaries. This thesis therefore aims to revisit our monetary institutional arrangements in light of the finiteness of our planet.

The term "monetary institutional arrangements", which will be further unpacked throughout this research, purposefully refers to a broad range of organizations (e.g. central banks, commercial banks and investment funds), rules (e.g. financial regulation and central banks' mandates), patterns and behaviors (e.g. financial globalization, financialization of non-financial corporations and risk management practices) that make up the monetary and financial system.

Institutions, in turn, are understood as "the conventions, norms and formally sanctioned rules of a society. They provide expectations, stability and meaning essential to human existence and coordination. Institutions regularize life, support values and produce and protect interests" (Vatn, 2005, p. 83). By delineating the "rules of the game", institutions shape the goals and interests of actors within the system (Thelen & Steimo, 1992) and affect their relative power to thrive within the system and/or to change its rules (Hall & Taylor, 1996). Hence, "different institutional designs may generate different incentives affecting the goals, interests and behavior of the actors involved" (Ryan, 2016, p. 250). Within the field of economics, the Institutionalist school (e.g. Commons, 1934; Galbraith, 1958; Veblen, 1899) has emphasized – using Polanyian terminology – "the embeddedness of the economy with respect to the rest of society" (Harvey, 2015, p. 112), and has sought to unveil the values informing evolutionary socio-economic systems.

The notion that existing monetary institutions could both fuel and suffer the consequences of ecological crises is rapidly gaining ground among academics and policy makers. For instance, Article 2.1(c) of the international Paris Agreement (UNFCCC, 2015) on climate change explicitly recognizes the need to make "finance [sic] flows compatible with a pathway toward low greenhouse gas emissions and climate-resilient development". In 2015, the same year the

Agreement was concluded, the former Governor of the Bank of England, Mark Carney, suggested the possibility of a systemic financial crisis caused by climate-related risks, either because of the physical impacts of climate change or because of a rapid and disorderly transition toward a low-carbon economy (Carney, 2015).

The question of the potential impacts of ecological hazards on financial stability and price stability has since triggered significant concern among central bankers (e.g. Carney, 2018; Coeuré, 2018; Lagarde, 2020; Villeroy de Galhau, 2019). This prompted the creation of the Network for Greening the Financial System (NGFS, 2018, 2019), comprised of 59 central banks and financial supervisors[1] willing to manage ecological risks – mostly climate-related ones – and to support the transition to a sustainable economy. Private financial institutions have also expressed concern about potential climate-related financial crises (e.g. TCFD, 2017) and the possibility that preventing them could require a "fundamental reshaping of finance", as the CEO of the world's largest money-management firm put it (Fink, 2020). This fundamental reshaping of finance may include penalizing the short-term orientation of financial markets and promoting long-term incentives in order to handle the "tragedy of the horizon" (Carney, 2015): the fact that the worst impacts of ecological crises such as climate change will fall beyond the time horizons typically considered by financial actors – e.g. from a few seconds to a few years for financial institutions engaged in market and credit activities, and no more than a few years for central banks and supervisors engaged in financial stability monitoring.

Despite this significant progress – inconceivable just a few years ago when I started this thesis – I argue that the financial community's recent acknowledgment of the connections between the monetary and financial system and our ecological crises remains limited and even problematic because of its apolitical and ahistorical approach to both ecological challenges and money. These ecological and monetary blind spots are briefly presented below and developed in further detail in the literature review (Chapter 2) and throughout the thesis.

[1] As of March 7th, 2020. Twelve observers also compose the network, including the Bank for International Settlements (BIS), the International Monetary Fund (IMF) and the World Bank. See www.ngfs.net.

1.2 From environmental externalities to ecologically-embedded ethics, economics and history of capitalism

First, the financial community's understanding of our ecological predicament remains grounded in an ahistorical and apolitical view of ecological damages, informed by neoclassical economics. Ecological problems are seen as negative externalities, i.e. as costs affecting a party that did not take part in a transaction and did not choose to incur such costs. It follows from this market-driven definition that environmental externalities can be fully *internalized* and thus resolved through pricing mechanisms such as carbon taxes. From a financial perspective, the key role of policymakers is to ensure that ecological risks are adequately accounted for by financial players. For instance, Carney (2015) considers that "that which is measured can be managed", meaning that succeeding in measuring the risks posed by climate change would suffice for financial markets to act and solve the problem.

In contrast to these views, a rapidly growing and not yet fully structured body of literature indicates that bringing the economic system back within Earth's planetary boundaries will involve a lot more than marginal changes in the pricing systems and/or transparent information with regard to climate-related financial risks. In fact, the idea that such measures will suffice may belong to a disembedded view of market relations (Dron, 2018), corresponding to a neoliberal view of environmental governance (Christophers, 2017) and a subscription to the Efficient Market Hypothesis (Fama, 1970). The latter postulates that transparent markets in which financial players have access to full information naturally lead to an optimal allocation of credit and capital, and to economic equilibrium.

Instead, facing the Anthropocene with the appropriate analytical tools requires a much deeper dive into the intricate worldviews, institutional arrangements and technological choices (Beddoe et al., 2009) that have led to and shaped the current situation. In particular, it becomes necessary to build ecologically-embedded social sciences, i.e. to overcome the traditional divide that exists

between natural and social sciences (Hornborg, 2006) in order to provide more comprehensive accounts of the interconnections between the Earth system and the global socio-economic system. As our disembedded modes of development are increasingly backfiring through multiple ecological crises (Bonneuil & Fressoz, 2016), and as the future of human and nonhuman life becomes "hyper-besieged" (Valantin, 2017) by ecological breakdown, alternative analytical frameworks become essential.

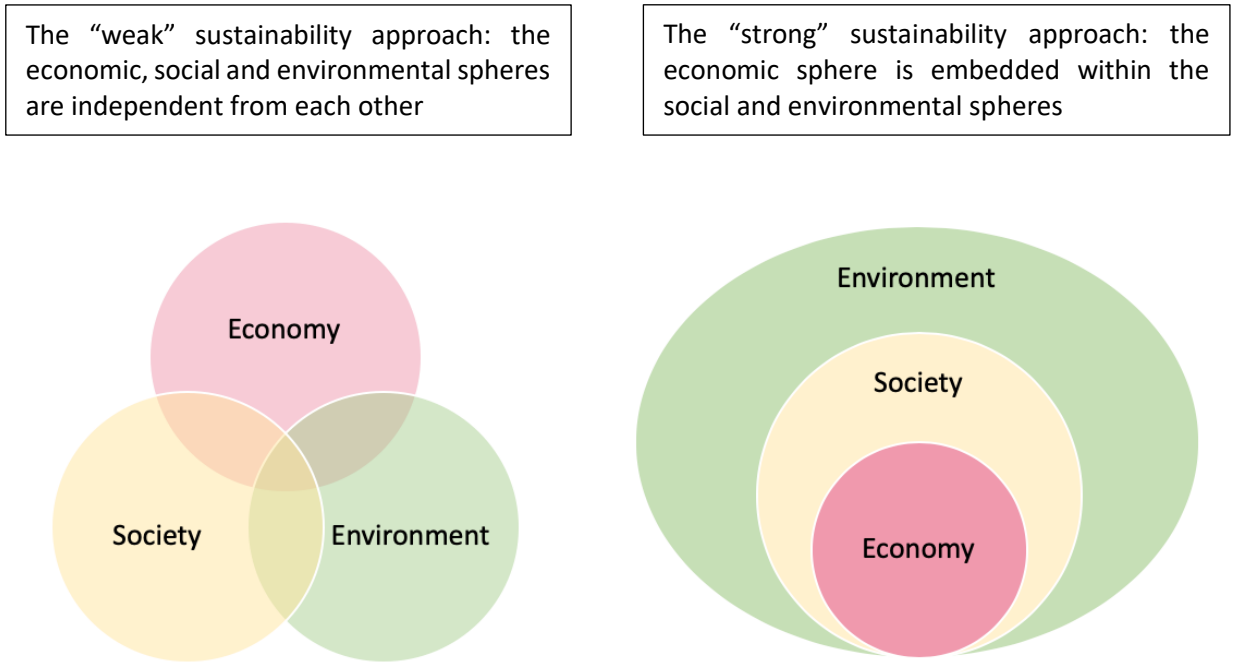
Within this blooming literature at the crossroad between social and natural sciences, three complementary fields of research[2] form the theoretical background to this thesis: they focus on re-embedding our current approaches to ethics – ecological ethics –, economics – ecological economics – and global history of capitalism – world-ecology perspective – in the biophysical milieu that enabled and shaped them, while consciously avoiding ecological determinism (Georgescu-Roegen, 1971; Hornborg, 2013). In other words, they aim at *rematerializing* the ethical, economic and historical accounts that have theoretically supported our existing institutional arrangements, thereby shaping the goals and interests of actors in ways that may need to be revisited in light of the Anthropocene.

Among the points raised in these three fields – and further discussed in the Literature Review – the following ones can be emphasized here. First, scholars in the field of ecological ethics (e.g. Brown, 2012; Charbonnier, 2020; Descola, 2005; Latour, 2004) have focused on the problematic Western – yet largely globalized – dualistic view of nature and society as two separate entities, and the ensuing vision of progress as guided by an infinite expansion of the human sphere upon its natural environment. Second, the field of ecological economics (e.g. Daly & Farley, 2011; Georgescu-Roegen, 1971; Jackson, 2017; Martinez-Alier, 1987; Røpke, 2005; Spash, 2017) has been particularly insightful in overcoming mainstream economics' view of natural, social and economic systems as three independent spheres – the "weak sustainability" approach – through

[2] The scholars cited do not necessarily categorize themselves as belonging strictly to each field, as many overlaps and gray areas exist among the three fields. This categorization is nevertheless used to render explicit the theoretical background of this thesis.

an analysis of the economic sphere as embedded within social and ecological ones – the "strong sustainability" approach (Daly & Farley, 2011) –, as shown in figure 1.1. Ecological economists have criticized the notion of endless economic growth and called for revisiting questions such as inequality in light of finite natural resources and ecosystems' carrying capacity. Third, when it comes to the history of capitalism, the world-ecology perspective (Moore, 2015) enables us to articulate the recent history of the Earth system and its multiple ecological transformations with that of the capitalist world-economy (à la Braudel, 2011) or world-systems (à la Wallerstein, 2011). The world-ecology approach thus seeks to overcome the dualistic view of nature and society not only in theoretical terms but also through the study of capitalism's historical patterns.

Figure 1.1 – The "weak" and "strong" approaches to sustainability



Source: adapted from Daly & Farley (2011)

The main commonality between these different streams of literature is the finding that, as we enter the Anthropocene, it becomes fundamental to revisit our value systems – broadly understood as the set of beliefs and attitudes shared by a group of people – in a way that serves

humans "while respecting and being constrained by the limits of Earth's life support systems and the well-being of other species" (Kosoy et al., 2012, p. 78). The issue of value is not merely debated among social scientists: some of the leading natural scientists who have developed the concept of the Anthropocene argue that, in order to stabilize the Earth system in a habitable interglacial-like state, we will not only need behavioral changes and technological innovations but also "new governance arrangements [and] transformed social values" (Steffen et al., 2018, p. 8252). Yet the prevailing divide between natural and social sciences seems to have prevented them from exploring such questions in satisfactory ways (Bonneuil & Fressoz, 2016).

These complementary insights from ecologically-embedded ethics, ecological economics and environmental history of global capitalism therefore form the first layer of the theoretical framework which grounds this thesis. However, scholars working in the aforementioned fields have barely addressed the question of monetary institutions. This relative disregard for money and finance may be due to the fact that these are considered "specialist topics that are discussed in an impenetrable language" (Røpke, 2017, p. 178), repelling natural scientists and most social scientists. In fact, some ecological economists have worked on the question of money (e.g. Farley et al., 2013) but their approach has not sufficiently questioned the axioms of neoclassical economics, as highlighted by scholars in the nascent field of ecological macroeconomics (e.g. Cahen-Fourot & Lavoie, 2016; Rezai & Stagl, 2016).

1.3 From exogenous to endogenous money – post-Keynesian and institutional monetary approaches

This leads me to the second limitation or blind spot of the financial community's approach: its treatment of money. Grounded in neoclassical economic theory, most of the financial community and economic discipline view money as a convenient commodity that enables humans to exchange while avoiding the inefficiencies of barter (e.g. Samuelson & Nordhaus, 2009). Money is therefore discussed, like ecological issues, from an ahistorical and apolitical perspective. It is seen as an exogenous variable that seemingly came out of nowhere, as if it had been "dropped

from a helicopter, as Friedman once famously said, or like manna from heaven" (Lavoie, 2014, p. 187).

In contrast, several streams of scholarship have emphasized that capitalist dynamics cannot be understood without paying close attention to the evolutionary and political essence of monetary institutions. Two of them form the monetary layer of the theoretical background to this thesis. First, scholars in the field of post-Keynesian economics (e.g. Kaldor, 1970; Lavoie, 2014; Minsky, 1986; Moore, 1988; Wray, 1998) adopt what is called an endogenous approach to money. The starting point of their analysis is the fact – increasingly acknowledged by central banks (e.g. McLeay, Radia & Thomas, 2014) – that "money is mainly created when banks make loans" (Chick & Dow, 2013, p. 152). This has critical implications for the ways we understand fiscal policy, monetary policy and financial regulation, and how these can be mobilized for the purpose of ecological transitions (Svartzman, Dron & Espagne, 2019), thereby overcoming the purely market-based approach of neoclassical economics.

The second monetary stream informing this thesis is that of monetary institutionalism. It is mostly informed by French scholars – such as Aglietta (2018), Orléan (2015) and Théret (2008) – identified as French monetary institutionalists (see Alary et al., 2016), but also by other scholars who do not claim this affiliation although they produce closely-related work (e.g. Amato & Fantacci, 2013; Desan, 2017; Goodhart, 1998; Graeber, 2014; Hornborg, 2019; Ingham, 2004). Largely informed by anthropological and historical studies (e.g. Le Goff, 1956; Mauss, 1925; Simiand, 1934; Simmel, 1907), monetary institutionalism claims that money is a fundamental institution, a "total social fact" (Théret, 2008, p. 834) that encompasses the economic, political and cultural dimensions of life in society. In particular, the ways in which money is institutionalized – including its creation, circulation and destruction – result from political processes composed of conflicting views over what should represent value (Orléan, 2015).

Hence, money is essential not only to understand economics – as emphasized by post-Keynesian scholars – but also and perhaps most importantly to understand our value systems. As defined by Aglietta (2018):

> *Money is a social contract objectivated in a common medium. In the act of payment, the collectivity that uses this medium gives back to each of its members what it judges it has received from that member through her activity. Value is recognised and established by way of the logic of money.* (p. 33)

Together, the post-Keynesian and institutionalist approaches to money form a consistent political economy of money, i.e. an insightful starting point to revisit our value systems and corresponding monetary institutional arrangements on a finite planet. However, and despite their growing concern for ecological questions – especially in the nascent field of ecological macroeconomics (e.g. Rezai & Stagl, 2016) –, most scholars within these fields have not paid much attention to the ethical and historical foundations of our current situation and have largely embraced the neoclassical notion that ecological issues can be resolved *all other things being equal* (Svartzman, Dron & Espagne, 2019). In other words and as further discussed in chapter 4, they have tended to impose their own notion of money to a new type of – ecological – problems, without addressing the ways that these problems should challenge their own analytical framework.

1.4 Methodological and epistemological obstacles

In short, the above indicates that the financial community's approach to solving ecological crises suffers from two blind spots, related to its respective treatment of ecological and monetary issues. Moreover, the scholars who have worked on addressing one blind spot have generally not worked on addressing the other, or have done so to a limited extent. As Hornborg (2013) writes on energy:

> *The ambiguous relation between energy and money continues to elude us to this day. . . . The particular way in which access to energy is significant for the economy seems to escape economics as a discipline and profession. . . . But neither, of course, is there a clear*

understanding of money. . . . Suffice it to say that concepts of energy and money appear to fill similar functions in denoting a vital essence flowing through society. (pp. 43-4)

As a result of this lack of cross-pollination between endogenous approaches to money and ecologically-embedded economic theories, this thesis starts from a relative theoretical void. The starting point of my research is the necessity to build on the insights of both approaches, i.e. on those that crossed the divide between natural and social sciences – such as ecologically-embedded ethics, economics and history of capitalism – and those that have overcome the neoclassical economics' understanding of money and finance – such as post-Keynesian economics and monetary institutionalism. I therefore argue that bridging these two approaches can provide future research with an appropriate analytical framework to confront the Anthropocene.

In fact, in reaction to the quasi-collapse of the financial system in 2007-08 and the concomitant rise of ecological crises, a rapidly growing number of scholars has already started to bridge the gap between these different fields (e.g. Aglietta, 2018; Aglietta & Espagne, 2016; Ament, 2019; Hornborg, 2013, 2019; Farley et al., 2013; Jackson, 2017; Jackson & Victor, 2015; Lietaer et al., 2012; Røpke, 2016, 2017). Whereas this thesis largely builds on their individual insights, these authors do not form a clearly delimited and coherent field. In particular, significant divergences are found among the monetary reforms proposed by these scholars, which focus on issues such as: reforming the international monetary system through ecological considerations (e.g. Aglietta, 2018); issuing ecological local currencies either through central banks (e.g. Hornborg, 2019) or through *ad hoc* decentralized mechanisms possibly inspired by distributed ledger technology (e.g. Lietaer et al., 2012); forbidding banks from issuing money and designing an ecological sovereign institution to do so (e.g. Ament, 2019); building on more traditional policy mixes between fiscal, monetary and prudential measures, while ensuring that they include new ecological considerations (e.g. Jackson, 2017).

In short, these very different policy proposals correspond to diverging views of how value creation and institutional arrangements should be transformed to face the Anthropocene. In other words, there are as many possible monetary orders as visions of what an ecological society should look like.

In this context, it is impossible to start this thesis by focusing on a specific question within a clearly established and recognized academic field. This methodological challenge calls for taking a step back and approaching the question of monetary institutions for a finite planet as an epistemological obstacle (Bachelard, 1938). The latter refers to how scientific methods and intellectual habits that were useful under certain circumstances can become problematic and hamper scientific research under new circumstances – the Anthropocene in this case. In other words, epistemological obstacles require to redefine the problem itself in order to address it.

However, it would also be ill-advised to redefine the whole problem, i.e. to aim at building a *new theory* of money for a finite planet. This would require knowing with certainty and precision how our value systems should be changed, and how monetary institutions should be modified to this end. This is clearly beyond the purpose and capacity of this thesis, which therefore does not aim to *resolve* the question of monetary institutions for a finite planet – as some of the scholars cited above have done[3].

1.5 Research objectives and methodology

Instead, for reasons of feasibility, this thesis mobilizes the ecologically- and monetarily-informed approaches presented above to address four particularly important, specific questions, which have already started being discussed by other authors. These four questions are assessed in

[3] This does not imply disagreement with the possibility or necessity of formulating solutions. As mentioned earlier, the propositions made by several authors are critical to this thesis, but the latter seeks to critically assess them rather than formulating new propositions. This approach is similar to the one taken by Røpke (2016, 2017) when assessing the insights and potential limitations of specific propositions and debates in the field of ecological macroeconomics.

separate essays that can provide complementary entry points into the issue of monetary institutions for a finite planet. Exploring these four questions therefore corresponds to the specific objectives of this thesis.

1.5.1 Specific objectives

1. *Assessing the limitations of central banks' theoretical framework and policy toolbox to face ecological crises, and articulating the ensuing need for an epistemological rupture (Bachelard, 1938).* The first essay builds on the idea introduced above according to which the Anthropocene acts as a boomerang (Bonneuil & Fressoz, 2016) or as a hyper-siege (Valantin, 2017), i.e. as a backfiring phenomenon that our existing analytical frameworks and institutional arrangements are unable to handle. This essay explores how climate change – by far the most discussed ecological crisis we face – increasingly threatens the existing monetary institutional arrangements: the community of central bankers and financial supervisors has realized over the past few years that "climate-related risks are a source of financial risk. It is therefore within the mandates of central banks and supervisors to ensure the financial system is resilient to these risks" (NGFS, 2018, p. 3). However, the uncertainty and complexity related to climate change mean that central banks' traditional approach, which consists in measuring the risks before managing them (Carney, 2015), is no longer applicable: the risks posed by climate change are not only impossible to measure with precision – rendering existing financial risk models and climate-economic models useless –, they are also impossible to hedge as long as system-wide action is not taken. This means that central banks will be led into uncharted waters because of the climate change *boomerang*. In the face of this situation, they will need to put aside or significantly revisit certain concepts such as central bank independence on which they have been relying over the past decades, since climate change will increasingly force them to engage with multiple stakeholders if they are to preserve financial stability in the age of climate-related uncertainty.

2. *Gauging the insights and limitations of the incipient field of ecological macroeconomics, at the crossroad between post-Keynesian economics and ecological economics*. The second essay discusses whether the embryonic field of ecological macroeconomics is a more promising starting point to re-embed monetary institutions within our planetary boundaries. Both schools of thought that have most contributed to ecological macroeconomics embrace fundamental concepts such as radical uncertainty, while complementing each other on other concepts: post-Keynesians have developed an endogenous approach to money that may prove essential to revert the financialization of the global economy and to fund the ecological transition; ecological economists have always considered that the socio-economic system is embedded within the biosphere. While this alliance is a promising one, it is found to paradoxically repeat some of the errors of the mainstream approach: it tends to impose a specific economic view – a post-Keynesian one in this case – to problems that require alternative analytical tools. This is particularly visible through the fact that the only tool envisioned to solve all ecological crises is that of increasing the amount of *green* investments, without paying attention to their socio-technical limitations and to the deeper ethical and historical roots of our ecological crises, as revealed by the world-ecology approach. This essay argues that the monetary institutionalist approach could help overcome some of these limitations by inviting post-Keynesian scholars to explore deeper monetary reforms than the ones they are used to consider.

3. *Contributing to the debate on whether the very nature of capitalist money is at odds with the finiteness of natural resources and ecosystems' carrying capacity*. The third essay furthers the discussion of the merits and limitations of ecological macroeconomics by revisiting the so-called "monetary growth imperative" debate through institutionalist approaches to money. This debate revolves around whether the very nature of modern money, created by banks through interest-bearing debt, forces our socio-economic system to seek perpetual growth. The post-Keynesian endogenous view of money shows that, in contrast to what ecological economists have often claimed, there is no mechanical

impossibility to maintaining interest rates in a non-growing economy. However, the post-Keynesian critique is also incomplete insofar as the conditions under which its findings hold are extremely tenuous and contradict the historical reasons that led to the generalization of interest-bearing debt. In other words, an institutionalist approach to money shows that whereas ecological economists' understanding of money is limited, their willingness to question the role of interest rates remains an essential question for the purpose of an ecological transition.

4. *Revisiting the need for and obstacles to a reform of the international monetary system (IMS) through ecologically-informed perspectives.* The fourth and final essay delves into what the previous three essays identified as a major roadblock: the need to reform the IMS in a way that would jointly address structural imbalances between Core and Peripheral countries and ecological issues such as climate change. By bringing together insights from all the disciplines and fields discussed above into a single analytical framework, this essay finds that these two problems – global imbalances and ecological degradations – are much more entangled than assumed by most of the literature. The international currency hierarchy (Prates, 2017) that impinges on Peripheral countries' development paths is inextricably related to ecologically unequal forms of development (Hornborg, 2014), which maintain Peripheral countries in the role of providers of cheap resources to the Center. This political ecology of global imbalances is particularly visible through the "Chinamerica" (Valantin, 2020) paradigm that explains more than 40% of global CO_2 emissions, although the latter is rapidly evolving toward new forms of Center-Periphery relationships. This essay finds that the quest for a truly balanced and ecological IMS on a finite planet cannot be dissociated from radical socio-economic transformations, including degrowth in the Center and new (post)development imaginaries (e.g. Kothari, Salleh, Escobar, Demaría & Acosta, 2019) for the whole community of human beings inhabiting our finite planet.

1.5.2 General objective

Whereas these four specific and distinct objectives do not seek to *resolve* the vast question of money in the Anthropocene, the essays treating them ambition to bring complementary insights into the general objective of this thesis: to contribute to the development of a political economy of money for a finite planet. The latter is still a nascent field, yet it could prove essential to generating better understandings of how existing monetary institutional arrangements contribute to the disembeddedness of our global socio-economic system from planetary boundaries, and shed light on the types of reforms that might be needed. In this context, the essays composing this thesis can be understood as complementary entry points into the critical exploration of monetary institutions for a finite planet, i.e. toward an ecologically-embedded political economy of money.

Chapter 2 – Literature Review

2.1 Foreword

As discussed in the Introduction, this thesis follows a transdisciplinary approach to explore the interactions between monetary institutions and ecological crises. In order to study monetary institutions, two main approaches are outlined: the post-Keynesian and institutionalist views of money. In order to assess our ecological crises, three complementary approaches are presented: environmental ethics, ecological economics, and global environmental history through the world-ecology perspective. Together, these approaches form the theoretical background to this thesis.

2.2 Endogenous money – The post-Keynesian and institutionalist perspectives

"The love of money as a possession – as distinguished from the love of money as a means to the enjoyments and realities of life – will be recognised for what it is, a somewhat disgusting morbidity, one of those semi-criminal, semi-pathological propensities which one hands over with a shudder to the specialists of mental disease".
Keynes (1930, p. 97)

This thesis argues that it will be unfeasible to re-embed our global socio-economic system within its planetary means without revisiting its monetary institutions. This stems from two main reasons, which are discussed below. First, the study of the economic system itself – let alone its embeddedness within finite planetary boundaries – will be incomplete or flawed if we do not question the understanding of money held by mainstream economics. Money is not merely a neutral tool enabling exchange, as claimed by orthodox economists: it is the very engine of economic activity, as shown by the post-Keynesian school of thought and closely related scholars sharing what is called an endogenous approach to money. The first section below therefore provides an overview of endogenous money and some policy implications.

Second and even more importantly for the purpose of this thesis, money is not just an economic tool, it is a semiotic system (Hornborg, 2016) and even a "total social fact" (Théret, 2008, p. 834) that encompasses the economic, political and cultural dimensions of life in society. As emphasized by the diverse institutionalist approaches to money, largely grounded in historical and anthropological studies, the institution of money is fundamental to both capitalist and non-capitalist systems. A brief overview of the history of money is therefore provided through an institutionalist lens, including a focus on central banks and on the international dimensions of capitalist money.

Together, the post-Keynesian and institutionalist approaches to money form a consistent political economy of money and offer a starting point to explore how monetary institutions can be revisited through an ecological lens.

2.2.1 The post-Keynesian approach – Endogenous money as the engine of capitalism

Aiming to understand the economic system – including its governance for a finite planet – requires questioning the understanding of money held by mainstream economics. The latter argues that because of the inefficiencies of barter, traders needed to identify a convenient commodity to serve as means of exchange (e.g. Samuelson & Nordhaus, 1973). In these accounts, since the market is analytically thought to respond to a natural human "propensity" to barter (Smith, 1776/2010, cited in Graeber, 2014, p. 25), money only plays a lubricating role, i.e. it simply greases the wheels of exchange. As a result, for mainstream economists, money can be "just throw[n...] into their models, as if it were dropped from a helicopter, as Friedman once famously said, or like manna from heaven" (Lavoie, 2014, p. 187). Since money is seen as a neutral veil, the economic discipline therefore focuses on the *real* side of the economy, assuming that money is neutral in the long term (Goodhart, 1998). In fact, most mainstream economists acknowledge the non-neutrality of money in the short-term (e.g. Mankiw, 2009) but only as they aim to make sure that government policies maintain neutrality over the long-term.

In sharp contrast to mainstream economists' views, several streams of heterodox economics have proposed an endogenous approach to money as a key feature of a more comprehensive and realistic starting point to assess the economic system (Kaldor, 1970; Moore, 1988). Post-Keynesian economics and closely-related schools of thought (Lavoie, 2014) such as monetary circuitists (Graziani, 1990; Parguez, 1980) and neochartalists (Wray, 1998) – also known as Modern Monetary Theory (MMT) – are considered to belong to this endogenous money approach, despite disagreements on certain aspects (see Chick and Dow, 2013). According to these scholars, the role of money is so fundamental to understand the dynamics of capitalism that the latter should be defined as a monetary economy of production, meaning that "the purpose of production is to accumulate money – not to barter" (Wray, 2013, pp. 139-40).

2.2.1.a Money as bank-created debt and credit relationships

All the approaches that support the endogenous view of money "share a principle of fundamental importance: money is mainly created when banks make loans" (Chick & Dow, 2013, p. 152). Indeed, when granting a loan, banks increase their assets and liabilities at the same time, and thereby generate new means of payment in the economic system (Lavoie, 2014, p. 188). In other words, and contrary to what is believed by mainstream economists, banks are not mere intermediaries between depositors and creditors: they are creators of credit, and therefore of money. It follows from this that when loans are repaid to the bank, money is destroyed. Since the money supply results from the demand for credit, then prior savings are not necessary to fund new projects, as believed by mainstream economists. The causality is actually reversed: credits – and ensuing investments – create savings (Lavoie, 2014). Money is therefore demand-led, i.e. it is created by banks in response to the demand for credit arising from different agents such as firms, households, governments or financial players.

Since money is created in the form of debt and credit, the structure and dynamics of the monetary system can be formalized through accounting identities. With regard to the dynamics of the system, or its flows, Godley (1997) put forward a fundamental identity: Savings –

Investments = Government expenditures – Tax revenues + Current Account Balance. This means that the private sector's savings minus its investment are equal to the deficit or surplus of the public sector – that is, its expenditures minus its net tax revenues – to which the amount lent to or borrowed from the rest of the world – in the case of an open economy – should be added or deducted. A corollary is that if a country aims for both a government surplus and a current account surplus – as most policymakers would seek – this can only be achieved through private sector deficit. That is, one agent's deficit must be equal to other agents' surpluses. Similarly, with regard to the structure – or the stocks – of the system: one agent's asset is by definition another agent's liability. These identities form the backbone of the stock-flow consistent models that are largely used in post-Keynesian economics (Godley and Lavoie, 2007).

Another important consequence of this approach is that post-Keynesians object to the mainstream assertion that inflation is a monetary phenomenon that would result from an excessive growth of the money supply (Lavoie, 2013). Given that the money supply is a function of the demand for credit, i.e. of the amount of loans made by banks, governments cannot even act on the money supply, no more "than a gardener can control the direction of a hosepipe by grabbing at the water jet" (Godley, 1997, p. 4). Inflationary processes are therefore caused by other factors such as context-specific conflicts over the distribution of value added between labor and capital (Lavoie, 2014).

Although they respond to the demand for credit, banks are not merely passive players in post-Keynesian theory. Quite the contrary, they play a critical role in capitalism as they decide who can access credit – i.e. who is creditworthy – and under which conditions. As such, they can accelerate financial and economic cycles by loosening their rules in periods of euphoria, potentially leading to booms and busts such as the 2007-08 Global Financial Crisis, and by rationing credits when they lack confidence (Lavoie, 2014; Minsky, 1986). According to post-Keynesians, if credit rationing occurs, it is mainly because of a lack of confidence on the part of the banking or financial system, and not so much because of asymmetric information or because

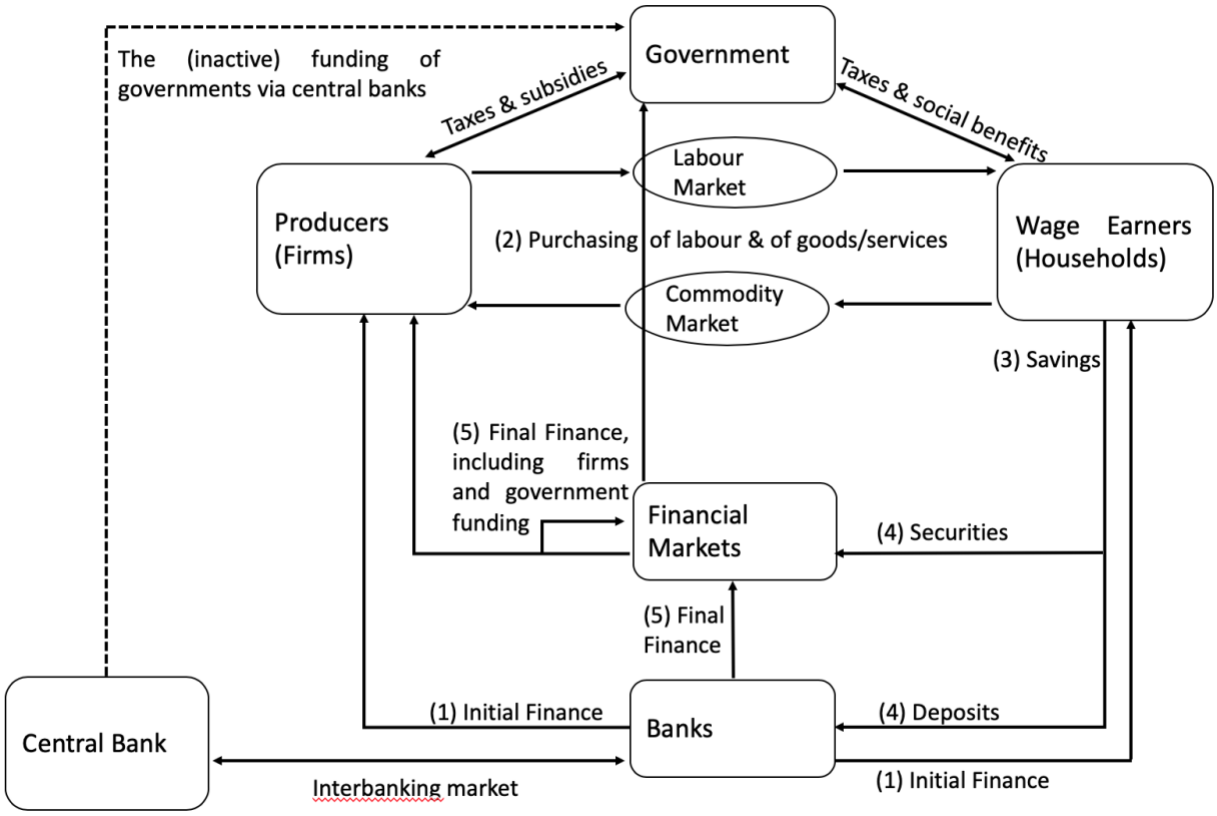
of a lack of financial resources – reserves, own capital, or the like – as orthodox theorists would argue.

The concept of radical uncertainty (Keynes, 1936/2013; Minsky, 1986) is critical to appreciate how banks' willingness to lend can vary throughout time, with critical financial and economic outcomes. It helps understand how banks and other financial players, through their limited or bounded rationality, permanently make bets on who will be able to repay loans in the future, and in the process they end up acting on this very future. Money and finance therefore act as intermediary institutions between present and future economic systems, in a context of radical uncertainty.

In short, the endogenous view of money attributes a critical role to banks and finance: "the banking sector plays a particular role in generating credit money and creating "initial finance" for investment [step 1 in figure 2.1], which then generates income and saving" (Hein, 2015, p. 181) – step 2 in the figure. Following this, "the role of financial markets is then to allocate accumulated savings generated by investment" (ibid) and the importance of the financial system will increase as savings rise – steps 3, 4 and 5. Finally, the whole system is supported by the role of central banks, and notably their ability to provide liquidity the financial system. Along similar lines, Mehrling (2017) argues that the dynamics of capitalism are explained by the interactions between the three critical institutions of money, finance and banking:

> *First,* money*, which plays a central coordinating role as a means of daily settlement of maturing promises to pay. Second,* finance*, which plays a central coordinating role as a means of daily valuation of existing promises stretching out into the future. Third,* banking*, which plays a central coordinating role as a means of daily allocation of credit, which is to say new promises to pay that channel purchasing power in one direction rather than another*. (Mehrling, 2017, pp. 3-4)

Figure 2.1 – An overview of the monetary economy of production



Source: adapted from Fontana & Sawyer (2016)

Note: the figure shows a closed economy. It is assumed for simplicity that that firms' profits go to households.

2.2.1.b Financial instability through an endogenous view of money

Based on the study of the interactions between money, finance and banking discussed above, the post-Keynesian economist Hyman Minsky (1982, 1986) described the tendency of capitalist economies to endogenously engender financial instability. Through his "Financial Instability Hypothesis" (Minsky, 1992), he explained how economic systems have the tendency to progress throughout three main stages. In the first stage, stable economies are characterized by bank's conservative or "hedge" financing: loans are granted only to borrowers who are expected to generate sufficient cash-flows to repay the principal and interests of their debt. When most loans

are repaid and the economy does not face any major crisis, the financial system tends to move toward a riskier second stage of "speculative" finance: lenders no longer require that the repayment of the principal is guaranteed. They count on other mechanisms as means to be reimbursed, such as an increase in the market value of the underlying asset – e.g. the value of a house for a mortgage loan. Third, the financial system reaches a "Ponzi" stage, in which borrowers need to take out new loans in order to repay the interests of the outstanding loans. In this later stage, the realization among asset holders that firms' and households' cash flows are no longer sufficient to repay interests and principal, can lead to massive fire-selling and freezing new loans, thereby triggering a financial crisis and potentially an ensuing debt-deflation process.

Minsky's insights indicate that when left to its own devices, the market does not lead to economic equilibrium – as postulated in mainstream theory (e.g. Fama, 1970) and believed by many policy makers – but instead to financial fragility and economic instability. Using the analytical framework of the Financial Instability Hypothesis, Minsky (1996) rapidly identified that in the 1970s and 1980s, capitalism was moving from a "hedge" position to a riskier stage, which he called "money manager capitalism". The latter referred to the rise of highly leveraged finance, innovative financial instruments "that quickly spread around the world" (Wray, 2009, p. 4) and a systematic underpricing of risks, all enabled by an increasingly negligent regulation of the financial system.

Other authors, notably but not exclusively within the post-Keynesian school of thought, have referred to this trend over the past decades as the financialization of capitalism (e.g. Epstein, 2001; Hein, Dodig & Budyldina, 2016; Lapavitsas 2013). Epstein (2001) defines financialization as "the increasing importance of financial markets, financial motives, financial institutions, and financial elites in the operation of the economy and its governing institutions, both at the national and international level" (Epstein, 2001, p. 1). Lapavitsas (2013) argues that financialization has permeated our economic and social systems in three ways: non-financial firms "have become increasingly involved in financial processes" (ibid, p. 794); financial firms now make most of their profits in trading activities rather than in traditional lending activities to firms and households;

and individuals increasingly rely on the “financial system to facilitate access to vital goods and services, including housing, education, health and transport” (ibid).

Among others, financialization has been characterized by the "increasing volume of financial transactions, relative to ‘real’ transactions" (Stockhammer, 2012, pp. 121-22). For instance, between 1980 and 2007 the ratio of financial assets relative to world GDP rose from 1.2 to 4.4 (Røpke, 2017), while the shadow banking sector[4] grew from $ 27 trillion in trillion in 2002 to $60 trillion in 2007 (Financial Stability Board, 2011, p. 2) and $137 trillion in 2015 (Financial Stability Board, 2015). The increase in liquidity provided by financial markets also tends to inflate the value of financial assets held globally. For instance, total market value of derivatives amounted to $15 trillion in 2016 – about 20% of the world GDP – of which less than 10% is estimated to be related to non-financial firms’ operations (BIS, 2016). However, this increase in financial wealth resulting from financial innovation is unsustainable in the long term, as financial innovation “decreases the volume of liquidity available to redeem the debts incurred” (Nesvetailova, 2007, p. 78), i.e. it simply increases the ratio of debts incurred relative to income-generating physical assets.

Financialization therefore seems to signal a systemic disconnection between financial and economic dynamics. The latter has resulted in a sharp and undeniable increase in financial crises, in both developed and developing economies (Aglietta, 2018). These culminated in the 2007-08 Global Financial Crisis, which threatened the foundations of capitalism. Today, as new risks arise – e.g. with the growth of the shadow banking sector – a much bigger and systemic crisis may be looming on the horizon, as increasingly acknowledged even among non-heterodox economists who held key positions in institutions aimed at guaranteeing financial stability (e.g. Hannoun & Dittus, 2017; Turner, 2015). Moreover, the growing wealth of financiers and rentiers since the 1970s has been accompanied by a decrease in aggregate demand and by a sharp rise in inequality (Bezemer & Hudson, 2016; Lavoie, 2014; Piketty, 2014).

[4] Shadow banks are financial intermediaries that conduct maturity, credit and liquidity transformation without access to central bank liquidity or public sector credit guarantees (Pozsar, Adrian, Ashcraft & Boesky, 2012).

In response, post-Keynesian authors call for a tight and reactive regulation of finance, as well as for an important role for government interventions as a way of stabilizing capitalism's intrinsic instability (e.g. Lavoie, 2014; Minsky, 1986; Wray, 2015). Their propositions are discussed in chapter 4 in the context of an ecological transition.

Whereas the line between post-Keynesians and orthodox economists used to be easy to draw, this is somehow less the case today. Indeed, many "orthodox dissenters" (Lavoie, 2014) and central banks have developed views that are increasingly compatible with the endogenous view of money, in particular in the aftermath of the 2007-08 Global Financial Crisis. For instance, economists from the Bank of England (McLeay, Radia & Thomas, 2014) have acknowledged that the way in which money is described in most textbooks is flawed and that money is indeed created as debt by private banks.

Despite these insights, central banks and recent orthodox developments – e.g. with the development of the New Consensus theory (e.g. Woodford, 2009) – maintain axioms that are largely incompatible with the endogenous view of money. In particular, dynamic stochastic general equilibrium (DGSE) models used by central banks can conceive of financial frictions related to the financial system, but they do not incorporate the idea that banks create money in the first place in a context of radical uncertainty. Similarly, the concept of a natural rate of interest toward which the central bank interest rates should converge is still prevalent in the mainstream economies, and such a position is irreconcilable with the endogenous view of money (Lavoie, 2013). Indeed, post-Keynesians argue that interest rates do not respond to the law of supply and demand for money, as in mainstream economics' IS-LM models where the stock of money is set exogenously. Instead, interest rates are set exogenously by central banks (Lavoie, 2013, 2014).

Building on the monetary insights of post-Keynesian economics and on the field of ecological economics – discussed below – an emerging field of ecological macroeconomics (Holt, Pressman & Spash, 2009; Jackson & Victor, 2015; Rezai & Stagl, 2016) has emerged over the past decade.

It devotes particular attention to how an endogenous approach to money can facilitate the funding of the investments needed for an ecological transition, through a mix of government expenditures, financial regulation and monetary policy. The endogenous view of money also informs several Green New Deal propositions that are increasingly discussed in both the academic and policy circles (e.g. Ekeland & Sæther, 2017; Harris, 2013; Kelton, 2019; Macquarie, 2019; Pettifor, 2019; Stiglitz, 2019; UNCTAD, 2019; Varoufakis and Adler, 2019).

As discussed in chapter 4, although these proposals open new avenues to engage in a socio-ecological transition, they remain grounded in a rather reductionist view of the ecological transition as consisting in simply filling a funding gap, without more deeply questioning our value systems and institutional arrangements (Svartzman et al., 2020). In order to overcome these limitations, it is not only necessary for post-Keynesian theory to delve deeper into the causes of our ecological predicament – as discussed later – but also to better understand money itself, as explored below. Indeed, the institutionalist approach to money (à la Aglietta, 2018) suggests complementary and critical insights to explore the deeper connections between monetary and value systems in the age of ecological crises.

2.2.2 Monetary institutionalism – Money as a social relation

The most fundamental feature emphasized by monetary institutionalists is the intricate relationship between money, value and sovereignty. In this view, money is first and above all a socially-constructed unit of account (Innes, 1913; Simmel, 1907), which is always embedded within a political order guaranteeing its acceptance by a community – be it local, national or global. Below, I start by describing the theoretical framework of money as a socially-constructed unit of account. I follow by outlining some evolutions of money before, toward and within capitalism. I then focus on the international dimension of capitalist money and its relations with uneven development.

2.2.2.a Which and whose unit of account? A theoretical framework

Minsky famously said that "everyone can create money; the problem is to get it accepted" (Minsky, 1986, p. 228). As Keynes (1930) noted in his *Treatise on Money*, money is the unit of account in which debts and general purchasing power are expressed. It is therefore necessary to understand how and why a specific *thing* comes to represent value over some polity. In this regard, neochartalist – or MMT – authors (Tcherneva, 2005; Wray, 2014, 2015) have argued that "taxes drive money" and that "money is a creature of the state" (Tcherneva, 2005, p. 4): the ability to impose a specific unit of account occurs through taxation, as the latter forces agents to get hold of the unit of account in order to meet their fiscal obligations. For instance, during the American Civil War, the Union issued paper money – the Greenbacks – to pay its soldiers, while accepting it in return for the purpose of tax payment. The acceptance of this specific "thing" (Wray, 2014) as means for tax payments would be what transforms it into a transferable unit of account, i.e. into money. Similarly, tally sticks had occasionally served as currency in the Middle Ages. Sticks were split in two and one part was kept by the monarch, whereas the other could be exchanged and therefore circulate as currency. When taxes were due, the tax collector could match the two parts of the stick, thereby discharging the owner of the circulating part of its tax obligations (Wray, 2015).

Whereas governments can magnify their ability to mobilize resources by taxing and spending in a specific unit of account (Desan, 2017), the neochartalist idea that money can be reduced to the ability to impose taxation remains too simplistic to be accepted as such. By treating the government as an exogenous agent that suddenly gives value to money, MMT remains unable to provide a historically-grounded account of money, and post-Keynesian thought in general does not provide clearer responses. As Desan (2017) asks:

> *What is the substantive value captured by a dollar, one that convinces people with different needs and means to understand it as a common measure? And how, if they do, can it be applied to assess goods, labor, and even time? […] How does a measure transfer*

value from hand to hand, delivering it unconditionally between strangers and those who will never meet again? (p. 112)

In the quest for more nuanced responses to such questions, it is essential to dive into the institutionalist approaches to money. This approach does not correspond to a clearly identified discipline but it regroups three main categories of authors: (i) French scholars such as Aglietta (2018), Orléan (2015), Théret (2008)[5] who are the most clearly identified group of scholars working on the topic; (ii) other non-French scholars who do not claim an institutionalist perspective on money although they produce similar work (e.g. Amato & Fantacci, 2013; Desan, 2017; Goodhart, 1998; Graeber, 2014; Hornborg, 2016; Ingham, 2004); and (iii) older contributors, notably in anthropological and historical studies (e.g. Innes, 1913; Le Goff, 1956; Mauss, 1925; Simiand, 1934; Simmel, 1907), who provided critical insights into the two former categories. For the purpose of this thesis, their respective contributions are regrouped under the term of monetary institutionalism.

In the monetary institutionalist view, money is not only an economic tool, it is an evolving semiotic system (Hornborg, 2016) that signals value within a community. That is, money produces a specific language, that of value (Orléan, 2015): it creates an abstract unit according to which the diverse activities that take place within a community can be measured, "a relation of belonging […] that links each member of a social group to the whole" (Aglietta, 2018, p. 31). Moreover, "the unit of account defines itself. Exclusively fiduciary, it is the unit of the issuing institution's liabilities" (Aglietta, 2002, p. 37).

The acceptation of a unit of account would therefore transcend the neochartalist view of monetary imposition through taxation and rather focus on a broader faith in the existence and viability of the community itself (Simiand, 1934). Aglietta (2018) distinguishes three levels of trust that ensure the adoption of money, i.e. of a common unit of account, by a community: (i) methodical – or mimetic – trust, based on the fact that all agents conduct regular transactions

[5] See Alary, Blanc, Desmedt & Théret (2016) for an anthology.

using the same unit of account, i.e. they trust in the existence of the currency by copying other agents' behaviors; (ii) hierarchical trust in the authorities that issue and guarantee the value of money and the system of payments. Central banks, by guaranteeing the functioning of the payment system and by acting as lender of last resort – especially in times of financial crises – are the cornerstone of hierarchical trust; (iii) ethical trust, based on broader philosophical and symbolic values shared within a society, meaning that money is accepted because it is governed in accordance with ethical values founding the community in which it circulates.

Orléan (2015) reminds us that such trust results not only from voluntary participation but also from violence: the way in which money is institutionalized is a result of a political process composed of conflicting views over what will represent value. Hence, whereas monetary instruments "are struck with the insignia of sovereignty" (Goodhart, 1998, p. 408), their imposition has often occurred through violence (Graeber, 2014). For instance, the imposition of a "hut tax" by British colonial authorities in Africa pushed local populations to sell their labor to the colonial power so that they could pay these taxes. Money therefore lies between violence and trust (Aglietta & Orléan, 1982), i.e. "from the very outset, money's ambivalence reflects the ambiguity of its social function: an instrument of cohesion and pacification in the community, it is also at the center of power struggles and a source of violence" (Aglietta, 2002, p. 31).

Whereas value precedes money in the neoclassical utilitarian approach – but also in the Marxian labor-value approach[6] – (Orléan, 2015) and as the links between money and value remain unsatisfactorily unveiled by post-Keynesian theory – the monetary institutionalist approach brings a new point of departure: value emerges precisely through the mediation of money. Following Marcel Mauss (1925/1966), money can be seen as a "total social fact" (Théret, 2008, p. 834) that – just like God, the nation, justice, law or civil ethics (Aglietta, 2018) – encompasses the economic, political, and cultural dimensions of a society all at once. In other words, money is

[6] According to Orléan (2015), neoclassical economics' utility theory of value and Marx's labor theory of value both assume that value can be defined without money, i.e. that money appears later on in the process of valuation. However, he acknowledges that the Marxian approach pays close attention to the circulation of money, which is not the case of neoclassical economics.

a social relation: embedded within societal processes, money is inherently political and can only be apprehended by mobilizing the tools of anthropology and history (Aglietta, 2018; Ingham, 2004).

At this stage, and while acknowledging its complex and evasive nature (Ingham, 2004), an attempt of definition of money can be provided (Aglietta, 2018):

> *Money is a social contract objectivated in a common medium. In the act of payment, the collectivity that uses this medium gives back to each of its members what it judges it has received from that member through her activity. Value is recognised and established by way of the logic of money.* (p. 33)

2.2.2.b Money as evolutionary institution

As a result of this close relationship between money, sovereignty and value, it is not surprising that monetary institutions have always evolved along with the transformations in the principles of sovereignty that drive human societies. Indeed, "societies produce [money] by structuring claims of value in ways that make those claims commensurable, transferable, and available for certain private as well as public uses […] As societies change the way they engineer money, they change its character" (Desan, 2017, p. 111). Money can therefore be understood through coevolutionary dynamics: the monetary order is the result of a social compromise at any point in time, but transformations in the governance of money is also an essential part of broader socio-economic transformations (Ould Ahmed & Ponsot, 2015). In other words, money is both "a force driving economic and social change" (Aglietta, 2002, p. 31) and the result of these changes.

Historically, the appearance of money in Mesopotamia at the end of the Neolithic was the result of complex interactions between the sedentarization of societies and the ensuing division of labor – enabled by a stable climate and the ensuing development of agriculture, among other factors – wars for the appropriation of land and new surpluses, and the creation of states (Aglietta, 2018). The primary purpose of money was to tabulate debts such as rents due to

tenants of temples and rations of barley due to temple workers (Graeber, 2014). It is therefore not surprising that the creation of money is more or less concomitant to the invention of writing and of legal texts: the creation of a common unit of account had become an essential component in a context in which society was becoming more complex, which involved increased division of labor and of social functions (Graeber, 2014). For instance, the code of Hammurabi, one of the oldest code of laws and deciphered writings of significant length in the world – dated to about 1,750 BC –, contains multiple rules related to monetary payments, such as the amount of shekels due to unskilled workers for their labor – a form of minimum wage – and the fines due for different types of illegal acts (Grandpierre, 2010).

Although credits and debts in Mesopotamia were calculated in silver shekels, coins hardly circulated, meaning that money served first as unit of account and not as medium of exchange – in contrast to the myth of barter commonly assumed in mainstream economics. Coinage did not become widespread until several thousand years later, with the invention of minted coins in the Lydian cities of the Aegean in the seventh century BC (Aglietta, 2002, 2018). Graeber (2014) argues that the appearance of coins is closely related to the concomitant rise of religions – from Zoroastrianism and Buddhism to the monotheist religions, between 800 BC and 600 AD – and the invention of professional armies. The close relationship between coinage, religion and armies would be due to the fact that coins were the most convenient form of payment to soldiers, relative to promissory notes or agricultural commodities. In turn, modern religions would have appeared as a reaction to the rise of impersonal markets and wars that developed during this age. Along similar lines, Hudson (2018), relying on the work of Assyriologists and biblical scholars, argues that the main concern of the Bible was precisely to offer protection to debtors in an age of increasing power of creditors over debtors. As such, the rise of religion can be partially understood as an early Polanyian countermovement[7] to the disembeddedness of market relations.

[7] Polanyi (1944) identified a recurrent "double movement" in the history of capitalism: the liberal movement to disembed the economy from its socio-ecological environment and install a "market society" tends to become so extreme that a "countermovement" takes place in society to re-embed the economic sphere through the creation of social – or ecological – protections. As mentioned in the Introduction, the

2.2.2.c The rise of capitalist money

The Middle Ages would have seen a social re-embeddedness of the relationships between creditors and debtors, as economic life became increasingly controlled by religious authorities (Graeber, 2014), but also saw the emergence of a new financial product – the bill of exchange – and a new kind of institution, the bank, which signaled the birth of proto-capitalist practices (Braudel, 1985/2011; Le Goff, 1956, 2010). The bill of exchange was brought into circulation in the 13th century by Italian merchant bankers in trade with Muslim merchants (Aglietta, 2002; Braudel, 1985/2011). It consists in a written document guaranteeing the payment of an amount of money to a named payee at a specific date, usually upon receipt of merchandises by the payer.

Its creation amounted to a monetary revolution: while in previous ages debts involved a personal relationship between two parties – although such debts could be centralized by a central authority such as the Babylonian temple – the bill of exchange brought a new agent into debtor-creditor relationships: the issuer of the bill, i.e. the bank. In other words, the first banks played the role of private bookkeepers of other different agents' debts and credits. Moreover, as bills of exchange started to be accepted by merchants for different payments and exchanged for each other, they progressively became the equivalent of money.

This newly created private monetary dynamic was "a forerunner of bank money which would develop in the 17th century" (Aglietta, 2002, p. 45). Indeed, whereas banks initially worked as bookkeepers of other agents' debts and credit relationships, they eventually realized that they could issue their own liabilities (Graeber, 2014). That is, banks progressively evolved from being bookkeepers to being creators of their own circulating debts, i.e. of currency. This means that the bank no longer needs to find a lender, since it can directly create its own credits whenever it finds a borrower that is deemed to be creditworthy. Whereas this power of creating credit – and

disembedding process takes place through the fictitious commodification of three pillars of life in society: labor, land and money.

therefore money – was initially forbidden by traditional authorities, by the fifteenth century, private units of account were widely used despite royal bans, and "monarchs…had to reckon with the vigor of private finance [as] merchant bankers wrested franchises and organized themselves into merchant cities in Italy, along the Rhine and in the Hanseatic ports" (Aglietta, 2002, p. 40).

The circulation and tradability of bills of exchange generated new risks: if one bank was unable to honor its promises, it could rapidly drag other banks into bankruptcy with them. In response, guilds of merchant bankers invented private units of account to evaluate multiple bills of exchange, and debt clearings were occasionally conducted during the medieval fairs (Braudel, 1985/2011; Le Goff, 1956). Although much of social life still depended on traditional authorities and not on these monetary and financial dynamics (Le Goff, 1956, 2010), these fairs represented the first international money market ever. Later on, more centralized clearinghouses were created to exchange different private debt instruments, thereby serving as bankers' banks. Though different processes from one country to another, these clearinghouses progressively became central banks between the late seventeenth and the early twentieth century.[8] Central banks ultimately provided clearing systems where all debts issued by multiple financial institutions became fungible and commensurable (Aglietta, 2018; Blanc, 2018; Desan, 2017).

It can therefore be argued that with the bill of exchange, one the main dynamics of what would become capitalism was invented (Aglietta, 2002, p. 45): money is created endogenously by banks as a counterpart to private debt; this debt becomes currency by circulating and being accepted as unit of account by other agents; and the whole system of payments relies on the convertibility of different banks' debts into a single unit of account, provided by central banks. In other words, if capitalism is to be defined as a system that seeks to endlessly make money with money (Aglietta, 2018), bankers can be considered as the "capitalist en chef" (Schumpeter, 1934, cited in Festré and Nasica, 2009) and central banks as the cornerstone of the system (Aglietta, 2018).

[8] The Swedish central bank was created in 1668 and the Bank of England in 1694. Although the US Federal Reserve was created much later, in 1913, many clearinghouses had been active in the US in the nineteenth century (Gorton & Mullineaux, 1987).

Indeed, the progressive commodification of money is what gave money its function as a store of value, i.e. it became possible to accumulate it for its own sake and not for the things it offers access to (Amato & Fantacci, 2013). Capitalism may therefore be characterized as the system in which "rather than a sovereign ruler or a legislature, the market and its experts would determine the pace and purpose of money creation" (Desan, 2017, p. 124).

Going further, the myth of money as a neutral veil greasing the wheels of exchange – largely supported by Locke (1689/1977) and Smith (1776/2010) – may have been critical to disembed the economic sphere from its social environment (Graeber, 2014; Servet, 2001) and create a vision of a "market society" (Polanyi, 1944) where "everything can be converted into anything else" (Hornborg, 2019, p. 1). That is, the myth of barter and the ensuing neutrality of money may be an essential component of capitalist societies, a myth helping to reify the structure and dynamics of the system itself. This argument is reinforced by the fact that the debates on the neutrality of money go back to the origins of modern economic thought in the 16th century (Goodhart, 1998).

However, the above does not imply that capitalist money can be considered to be a purely private system: the rise of banks and central banks is inextricably linked to the consolidation of nation-states, the expansion of colonial powers into new territories and the industrialization of agricultural societies (Graeber, 2004). For instance, the first central banks were created by private financiers to help governments fund wars (Vernengo, 2016); and the first stock exchanges created in London – in 1571 – and Amsterdam – in 1602 – mostly traded shares of the military and mercantile companies whose concessions were granted by the state, such as the East and West India Companies (Graeber, 2014). In short, capitalist money is best understood through its public-private dualistic nature: "behind the deceptively generic term of 'national currency' are diverse agents through whom a public good (money) is essentially created and managed by private agents for their own self-interest" (Blanc, 2018, p. 57).

2.2.2.d The transformations of capitalist money

In this context, a hallmark of capitalism is rather the public-private dualistic nature of money: “a public good (money) is essentially created and managed by private agents for their own self-interest” (Blanc, 2018, p. 57). Moreover, it should be acknowledged that monetary institutions, and central banks in particular, have also gone through many changes throughout the history of capitalism. Central banks are "institutions that adapt to the needs of the dominant political coalitions to serve specific accumulation regimes" (Vernengo, 2016, p. 459). According to Vernengo (2016), the history of central banks can be divided into four periods[9], briefly described below.

Direct state financing, be it for war or for development purposes, was common among the first central banks such as the Swedish Riksbank and the Bank of England. For instance, the Bank of England was created precisely to provide loans to the government in exchange for the right to issue banknotes, a position it maintained throughout the eighteenth century (Vernengo, 2016). The latter enabled the government to sharply increase its debt – from close to zero in 1694 to about 250% of GDP in the 1820s –, an essential condition to fund both the Industrial Revolution and the Napoleonic Wars. Indeed, "one crucial innovation was the possibility to borrow almost unlimited amounts of money with very low risk" (Vernengo, 2016, p. 454). The Bank of England therefore became a central piece of the institutional framework that supported the rise of the fiscal-military state and the ensuing dominance of Britain over the world in the nineteenth century.

The second period started in the 1840s, after Britain had reached a situation of global military and manufacturing dominance. Central banks then started to be governed by the Victorian principles of fiscal discipline, and the gold standard was established as the fulcrum of sound economic and financial management in the international arena (Goodhart, 2010). In this context,

[9] In his more famous categorization of central banks, Goodhart (2010) distinguishes three periods, which broadly correspond to Vernengo’s except that he does not take Vernengo’s first age into account.

the idea of financing public debt through monetary policy came to be viewed as inflationary. However, the role of the Bank of England still remained critical in this era, as it promoted the international status of Britain. Indeed, as British private banks were involved in financing projects across the world and as Britain experienced high trade surpluses – supported by its industrial and military powers – the British pound did not face any constraints on its ability to be exchanged for gold. The role of the Bank of England, acting as guarantor of the value of the currency – notably by ensuring its tradability with gold – was therefore a critical component of the British Empire's dominance (Polanyi, 1944, p. 202; Vernengo, 2016).

The Victorian consensus was discredited by the collapse of the gold standard, the progressive loss of hegemony of Britain and ultimately the Great Depression of the 1930s (Goodhart, 2010; Vernengo, 2016). As Keynesian ideas came to prevail along with a Fordist model of mass production and consumption, central banks became mostly subservient to government policies during the third period of central banking, extending from the 1930s to the 1960s. During this Fordist-Keynesian' regime[10], private sector credit expansion and interest rates were largely controlled, central banks were actively engaged in the support of government policies and did not hesitate to implement *ad hoc* mechanisms to ensure that the government and the private

[10] The Fordist-Keynesian regime (Harvey, 1989) refers to a model of capitalist economic development that prevailed in the U.S. and in Europe from the end of World War II – and even from the 1930s in the US – until the late 1960s or early 1970s. It was characterized by the convergence of two patterns forming a regime of capital accumulation capable of reproducing itself during this period. The first was the Fordist technological and organizational features – such as, respectively, the electrification of industrial processes and a Taylorist management of workers in the manufacturing sector – that enabled mass production. The second was the macroeconomic and social institutions largely aligned with Keynes' (1936/2013) *General Theory of Interest, Money and Employment*, in the search for a more inclusive and egalitarian model of economic development. Such institutions offered a new compromise between capital and labor, aimed at guaranteeing that the capitalist system would not recreate the conditions of its own destruction, as had almost happened with the Great recession of 1929 and the ensuing years of instability leading to the war. In particular, the Keynesian agenda consisted in guaranteeing high effective demand through "a centralized and rigid system of redistributing productivity gains, stabilized by a network of collective bargaining, social legislation and the welfare state (the system of social security)" (Lipietz, 2001, p. 18). In addition, Keynesianism was characterized by state intervention in education, scientific research and – in some countries – in segments of the productive system (Duménil & Lévy, 2001; Mazzucato, 2015), as well as a partial Keynesian socialization of investments pushing capitalists to reinvest their past profits in the productive economy rather than in seeking rents.

sector could borrow with low interest rates (Goodhart, 2010). For instance, French banks were discretionarily required to acquire government bonds – in proportion to their deposits (Monnet, 2014) – which were then used for public investments in strategic sectors of the French economy while also guaranteeing the government cheap access to capital. Between 1945 and 1980, real interest rates in developed economies were actually as often positive as negative (Coggan, 2011), suggesting that the power of creditor and rentiers was particularly constrained, notably because of the measures taken by central banks.

The transition in Western countries from the Fordist-Keynesian regimes to financialized ones as of the 1970s also included a significant transformation of central banks (Goodhart, 2010) – a fourth period – which saw a "return to Victorian ideas of central banking, now disguised as modern" (Vernengo, 2016, p. 456). The key moment signaling a shift toward this period took place precisely through central banks, when the US Federal Reserve sharply increased interest rates in 1979, thereby relieving the inflationary processes of the 1970s in a way that exclusively favored the owners of financial capital. This fourth period was also made possible and exported to other countries (Johnson, 2016) through the reliance on the concept of central bank independence. According to Vernengo (2016), this structure in which the "central bank structure was independent from the treasury and uniquely concerned with inflation, should be seen as a very specific historical development associated with the neoliberal project" (p.459).

This period can be characterized as a "privatization of money" (Aglietta, 2018), i.e. an accrued control of monetary issuance and circulation by the owners of finance capital that has accompanied the retreat of the welfare state and the dismantlement of the tight regulation of the financial system that had prevailed during the previous decades. For instance, central banks can no longer buy treasury bonds in the primary market or use other instruments to finance public deficits (Hein et al., 2016). Central bank independence therefore means that treasuries now need to fund their deficits in the marketplace. This in turn reduces the autonomy of most of the system's participants when implementing macroeconomic policy, and forces governments to increasingly comply with market dynamics and expectations.

Following the 2007-08 Global Financial Crisis, central banks were led to act as firemen of the financial system as a whole, with ambivalent effects. On the one hand, the unprecedented level of monetary support provided by central banks prevented a systemic collapse: with trillions of dollars poured into the private banking system and the setting of negative interest rates (Eggertsson, Juelsrud & Wold, 2017), the management of money by central banks has saved the capitalist system from its own demise (Aglietta, 2018). Central banks also acted as *de facto* guarantors of financial stability, and not only to price stability – as had been the case during the previous decades (Goodhart, 2010). On the other hand, such interventions were so massive that central banks now find themselves in unchartered territories: their intervention increased the moral hazard in the financial system and generated further inequality, while leaving them potentially incapable to respond to a new crisis as interest rates have remained near the zero lower bound in many countries (Panzera, 2015). In this sense, "the global financial crisis shattered the conventional wisdom about how financial markets work and how to regulate them" (Mastromatteo & Esposito, 2016, p. 2).

It is therefore no coincidence that the aftermath of the 2007-08 Global Financial Crisis led to many critiques of the concept of central bank independence, and to calls aimed at re-embedding central banks' mandates and policies into specific social and political goals (e.g. Harribey et al., 2018). For instance, central banks are increasingly called to take positions on new questions such as climate change, the impact of unconventional monetary policies on inequality, or the socio-economic consequences of their male-dominated forms of governance (Vallet, 2019). Some central banks such as Russia's and China's have also used their reserves to pursue broader geopolitical agendas such as the weakening of the US dollar in the international arena (Aglietta & Coudert, 2019).

These elements suggest that we are in an interregnum (Goodhart, 2010), possibly leading to a fifth age of central banking, although there is still much uncertainty regarding what central banks should do and which accumulation regime and ideology they should serve. Historically, systemic

crises and transitions from one accumulation regime to another have led to major and unforeseen socio-political changes, including wars (Aglietta, 2018). Today, such threats may be compounded by the fact that ecological crises such as climate change may be creating new systemic risks (Bolton et al., 2020), as discussed in chapter 3.

In this context of disintegration of the present monetary and political order, proposals aiming for a more radical transformation of the monetary order have emerged in the past decade. This includes the development of cryptocurrencies (see Malherbe, Montalban, Bédu & Granier, 2019) and local currencies (e.g. Hornborg, 2016), or calls for a truly international currency (e.g. Aglietta & Espagne, 2018), or even the transition toward a system where banks would no longer be able to create money (Benes & Kumhof, 2012). These proposals reflect different attempts to redefine sovereignty and value as the current order is increasingly contested. However, aiming to assess these "monetary contestations" (Ould Ahmed & Ponsot, 2015) through the institutionalist lens discussed above requires bringing one additional dimension to the debate that is often missing, including in institutionalist approaches to money (Prates, 2017): the international nature of capitalist money.

2.2.2.e Monetary institutionalism in the international arena

Whereas institutional approaches to money have mostly focused on the national scale, their analytical framework can also be used at the international scale: “if money of account derives its existence from the political power that establishes it, the same is the case for the international unit of account” (Fields & Vernengo, 2013, p. 746). That is, in the same way that all citizens are subject to monetary coercion within the boundaries of the nation-state, different nation-states’ agencies are also influenced by their insertion into the international monetary system (IMS).

Two related aspects of the IMS are emphasized by the institutionalist perspective. First, in the absence of an international currency that would replace national currencies and would correspond to a universal form of sovereignty – a post-nation-states’ world – or a system to

automatically regulate the value of each currency – as in Keynes' International Clearing Union – hierarchies exist between nation-states' respective currencies. In the international arena, these levels of trust can be measured through the liquidity of national currencies, which correspond to the willingness of agents in the system to hold them (Prates, 2017).

The key currency today, the US dollar, has the higher degree of liquidity provided by the fact that it is the unit of account that is used in most international trade and demanded as store of value by most agents. For example, the US dollar was involved in 88% of all foreign exchange transactions in 2016 and represented 62% of official foreign exchange reserves in 2018 (Aglietta & Coudert, 2019). By producing the international monetary standard, the US faces no foreign exchange constraints and can enjoy an "exorbitant privilege" (Eichengreen, 2010) in terms of products that can be claimed in exchange for US dollars. Other national or regional currencies such as the Japanese yen, the British pound and the euro benefit from similar features although to a smaller extent than the US dollar. At the bottom of this hierarchy are the currencies issued by most peripheral[11] economies. Since these are non-liquid currencies, investors demand higher returns hold them (Prates, 2017).

Second and as a result, by dominating the debits and credits relations of the world-system, the currency that acts as the international currency – i.e. the most liquid one – has the ability to shape the system, i.e. to coerce other countries to follow its rules (Rochon & Vernengo, 2003). As discussed above, the ability to impose a certain unit of account has deep socio-economic implications within a community, and the same is true at the international scale.

[11] Following World-systems theory (Arrighi, 1994; Wallerstein, 2011) and the Latin American structuralist school of dependency (Prebisch, 1949), the term "periphery" refers to countries that are often called "developing" or "emerging" economies, in contrast to "center" or "core" countries that are more often called "advanced" or "developed" economies. The terminological choice of core/periphery emphasizes the dialectical relationships between nation-states within the global economy rather than a more linear view of development implied by alternative terminologies, in which poorer countries would simply need to catch up with wealthier ones (à la Rostow, 1960).

The four historical cycles of accumulation in capitalist world-systems – the Genoese, Dutch, British and American ones – are marked by financial hegemonic power provided by the ability of convincing, through coercion and consent, others to use the hegemon's currency (Arrighi, 1994). As noted by Fields & Vernengo (2013):

> *during the mercantile phase of capitalism bankers had the power to enforce the repayment of debt in a particular token. For that reason the key reserve currencies were over time associated with the main trading empires and their merchant bankers, i.e., the Venetian ducat, the Dutch guilder and the British pound. The [central or hegemonic] state, dominated by mercantile interests [...] manipulated international money markets, controlling exchange rates or disrupting the functioning of financial markets, to subdue weaker countries in the periphery.* (p. 747)

As a result, the ability of a country in the periphery to achieve a specific goal – e.g. industrial development or sustainable forms of development – is subject to the international monetary system in which it is integrated. For instance, since their independence in the early nineteenth century, Latin American countries had problems to borrow in their own currency (Vernengo, 2006) – the so-called "original sin" (Eichengreen & Hausmann, 1999) – and faced several crises due to sudden capital outflows.

Regarding the role of central banks in these dynamics of unequal development, Vernengo (2016) argues that their actions are complementary to the use of trade and financial policies, by building on Chang's (2002) concept of "kicking away the ladder". The latter indicates that developed countries have used specific policies such as high trade tariffs to become rich before exerting a strong pressure on developing economies so that they do not adopt similar policies, thereby kicking away the ladder they have used to climb to the top. A similar process would apply to central bank: developed economies first proactively used central banking policy in their industrialization process and conquest of new markets, as discussed above, before they started focusing on price and financial stability and exerting pressure on other countries to do the same.

They would have therefore kicked away the ladder by pushing developing economies' central banks to move directly to modern practices.

However, the relationships between core and peripheral currencies have evolved over time, and therefore historically-grounded analyses are required to appreciate the room for maneuvering of peripheral countries (Vernengo, 2006). In this regard, a brief historical assessment since the end of World War II shows two main phases: one with a relatively large room for maneuvering for peripheral countries going from the end of World War II to the early 1970s – during the Bretton Woods system; another one with a reduced margin with strong pressure created by a financially-determined form of unequal exchange – the *post*-Bretton Woods system.

2.2.2.f Monetary hierarchies and uneven development

Following World War II, the Bretton Woods system was broadly characterized by fixed but adjustable exchange rates and low capital mobility (Eichengreen, 2010). This system was aligned with the predominance, in the Western world, of a Fordist-Keynesian internal regime of accumulation[12] and mode of regulation[13] based on the welfare state and the labor-wage nexus. In this context, capital controls at the international level were an essential component to the pursuit of full employment and welfare policies at the national level: as Keynes (1980, p. 276) put it, "we cannot hope to control rates of interest at home if movements of capital moneys out of the country are unrestricted". To put it in the language of the monetary institutionalist analytical framework, this system enabled nation-states to develop institutional arrangements where the ethical confidence in their currency was grounded in the belief of the virtues of the welfare state (Bruno, Halevi & Marques Pereira, 2011); and the latter enabled a hierarchical trust in monetary

[12] Following the approach of the French Regulation school (Aglietta, 1979), a regime of accumulation refers to the way in which production, circulation, consumption, and distribution organize and expand capital in an economy.

[13] In the Regulation School, the mode of regulation refers, broadly, to the institutional framework in which a specific regime of accumulation is embedded. Each mode of regulation is typically composed of five "forms": a money form, a wage form, a state form, a competition form, and an international form.

authorities to support macroeconomic policies with a high degree of autonomy – e.g. through the purchase of treasury securities by central banks in the primary market (Prates, 2017).

The limits of the Bretton Woods system are well-known. As noted by Robert Triffin (1960), the role of the US dollar as key currency in this system was a double-edged sword for the monetary hegemon issuing it. As growth in global trade was dependent on the elastic supply of US dollars, the US was faced with a critical dilemma: either it would supply the necessary US dollars to the world economy by incurring external deficits, and therefore face a potential currency crisis if countries with surpluses decided to exchange their US dollars for the limited gold reserves backing them; or it would decide to tightly control its balance of payments to avoid such a situation, thereby threatening to put the global economy on a deflationary trajectory by not supplying the currency needed to conduct trade. The first scenario came to prevail in the late 1960s as the US borrowed enormous sums to pay for Johnson's Great Society and for the Vietnam War (Coggan, 2011).

The end of the Bretton Woods system in the early 1970s, triggered by the end of the automatic convertibility between US dollars and gold in 1971 and the loosening of capital controls over the following years, could be interpreted at first sight as the beginning of a decline of the monetary hegemon – since it would no longer be able to convert its own debts into gold. It should instead be understood as the most achieved form of monetary sovereignty ever achieved in the history of capitalism (Fields & Vernengo, 2013): as the world economy moved from a fixed dollar standard backed by gold to a flexible dollar standard backed by trust in the currency itself, the US can now incur any desirable level of debt as long as foreign agents see US Treasury bonds as a default-risk-free asset. In other words, "the world passed from a US dollar standard backed by gold to a US dollar standard backed by US dollars" (Naylor, 2004, p. 48), meaning that "America's unique debtor position was to be recognized and institutionalized, not constrained or curtailed" by gold or any other commodity (Hudson, 2003, p. 277).

This situation corresponds to the "exorbitant privilege" of the US dollar, as famously coined in the 1960s by the French minister of finance Valéry Giscard d'Estaing (Eichengreen, 2010). Indeed, "the essential feature of the key currency is that there is no possibility of default in that currency, and that is why in the worst period of [2007-08 global financial crisis...], the dollar actually appreciated, since agents tend to fly to secure assets" (Fields & Vernengo, 2013, p. 751). The post-Bretton Woods system has therefore served to reinforce the power of the monetary hegemon to unprecedented levels, most notably by removing all balance of payments constraints such as those imposed by non-fiat monetary systems.

Building on the institutional approaches to money discussed above, it can be argued that the new institutionalization of money in the post-Bretton Woods system is grounded in a different ethical trust promoted by the hegemon, with an increased reliance on market forces rather than the welfare state. In particular, currencies themselves are subject to these market forces: they can be exchanged on foreign exchange markets where they are treated like any other assets and commodities, and their prices become "function of the degree of confidence they inspire in financial operators" (Théret, 2008, p. 281). The hierarchical trust in the system is granted by the ability of the US Fed to systematically provide the US dollar-denominated assets to the rest of the world, most notably because of the high current account deficits incurred by the US. Finally, this trust in the US dollar is also granted by the inertia of the Bretton Woods system: as all economic agents become used to use one currency, they believe that others will also use it and therefore see no reasons to doubt its stability. This suggests that the US dollar could remain the key currency for a long time (Vernengo, 2006), although other forces, discussed in chapter 6, may challenge the status quo.

However, the "exorbitant privilege" of the US dollar does more than just benefit the US: it also reconfigures monetary and financial flows at the world level, with massive impacts for other countries and especially peripheral ones. The new institutional arrangements under which US dollars are provided to the world economy "set the global social, political and economic conditions, within which the transmission of misery (contagion) between countries, and between

global and national levels, is essentially regulated" (Fields & Vernengo, 2013, p. 753). In other words, the "diplomacy" of the US dollar can be seen as "the real instrument of power, the technology of power so to speak" (Vernengo, 2006, p. 562).

The post-Bretton Woods institutional arrangement has also given room to new forms of financial dependency (Tavares, 1985; Vernengo, 2006): whereas the US and other countries with currencies that are in high demand can incur large deficits, the conditions have become much less favorable for peripheral countries over the past decades. Indeed, the asymmetrical monetary system described above means that the flow of capital toward peripheral countries depends on exogenous factors such as the interest rate set by the Fed or the confidence of investors at any particular point in time. Hence, "whereas the center economies—particularly the larger ones—are 'business-cycle makers,' the developing countries (the 'periphery,' in this framework) are "business cycle takers" (Ocampo, 2003).

The position of "business cycle taker" is particularly problematic as global capital flows can significantly affect peripheral countries' exchange rates and local financial markets. Indeed, the post-Bretton Woods era is characterized by massive transboundary short-term capital flows affecting peripheral countries in particular (Sole & Swarnali, 2017) and putting strong pressure on their nominal exchange rates (Harvey, 2009; Kaltenbrunner & Painceira, 2018; Prates, 2017). As a result, these countries face a bigger dilemma (Rey, 2013) than other countries in the currency hierarchy: they either have to choose free capital mobility and thereby lose any autonomy over their monetary policy, or focus on monetary policy autonomy with strong barriers to capital mobility and therefore potential difficulties to raise capital (Prates, 2017). Moreover, the lower liquidity premium of their currencies "requires them to offer higher interest rates and/or profitable exchange rate movements in order to maintain investor demand" (Kaltenbrunner & Painceira, 2018, p. 294).

Hence, the maintenance of methodic and hierarchical trust in peripheral currencies relies on the capacity of their central banks to find a balance between exchange rate stability, price stability

and financial stability, regardless of the external pressures exerted by other patterns in the system – e.g. short-term capital flows or change in interest rates in the US. In turn, the ethical confidence can come under threat if the central bank's actions do not succeed in preserving a socially-acceptable balance (Prates, 2017). This can trigger a loss of trust in the existing unit of account, which can at best translate into inflationary pressures and at worst lead to periods of political havoc (Aglietta, 2018).

Furthermore, the subordinated position of peripheral countries does not only shape how financialization impacts them, it also has critical impacts on their productive structures. A monetary hierarchy imposes a "survival constraint" on peripheral economies (Angrick, 2018), which are under constant pressure to attract foreign financing to overcome the limits imposed by their balance-of-payments position. In order to relieve these permanent pressures on their balance-of-payments, peripheral countries are generally led to develop export-led strategies for products with low value-added (Vernengo, 2006), such as agricultural commodities, natural resources, and/or low value-added manufactured goods. In contrast, center economies can develop strong deficits – e.g. the US and France – and/or focus on long-term strategies aimed at exporting high-value goods – e.g. Germany.

In this context, peripheral countries also tend to replicate modes of monetary governance found in the center, although these are not necessarily to their advantage. For instance, the neoliberal mode of central bank governance that came to dominate in the West since the 1970s and 1980s, grounded in the theory of independence discussed above, was transposed to and adopted by postcommunist countries with an active participation from organizations such as the Bank for International Settlements and the International Monetary Fund (Johnson, 2016). Similarly, Argentina's central bank imported the neoliberal principles of monetary governance when it changed its organic law in the 1990s with the aim of formalizing the principle of central bank independence, commit to price stability as its only goal, and limit the central bank's ability to finance the treasury (Vernengo, 2016).

In short, the financial globalization or international financialization of the past decades has reinforced the subordinate relationship of peripheral countries to the center, both financially and in terms of their economic production (Bortz & Kaltenbrunner, 2017). Some authors have argued that the patterns of international financialization are so critical that the true advantage of core economies in financialized capitalism is no longer based on technological or institutional dimensions[14], as had been described by earlier scholars (e.g. Prebisch, 1949), but rather on a situation of financially-determined unequal exchange (Tavares, 1985; Vernengo, 2006).

2.3 Ecologically-embedded ethics, economics and history

"Our epistemological and political foundations are changing at a slower pace than the world they contributed to build".
Charbonnier (2020, p. 393)

Despite the insights of the previous section, this thesis argues that revisiting the role of money and finance within a finite planet cannot be done without a clear view of our ecological crises and challenges.

In the following, I argue that successfully retooling monetary institutions for the purpose of a finite planet should be grounded in three approaches that can at least partially compensate for the lack of a theoretical framework discussed in the Introduction: (i) ecologically-embedded ethics, which have challenged the dominant *Western* worldviews according to which humans are disembedded from nature; (ii) the transdisciplinary approach of ecological economics, which

[14] Scholars in schools of thought such as World-Systems theory, Neo-Marxism, the Latin American structuralist school and neostructuralists, argue that center-periphery asymmetrical relations are primarily due to technological dimensions determined by the international division of labor. In particular, according to the so-called *Prebish-Singer* effect, the specialization of peripheral countries in primary commodity production implies underdevelopment because of *Engel's law*: as income rises, expenditures for food products stagnate or grow relatively slower than income. Industrialization is therefore seen as the only solution for peripheral countries to develop an autonomous process of technological innovation and catch up with advanced economies in the center of the world economy (Vernengo, 2006).

provides a critical entry point to re-embed the concept of *finiteness* within the study of economic systems; (iii) the approach of world-ecology, which re-embeds the study of the Earth system within the global dynamics of capitalism, thereby re-historicizing and re-politicizing human-nature relationships.

2.3.1 The Anthropocene as an epistemological and ontological challenge to dominant value systems – Ethics for a finite planet

Acknowledging our entry into the Anthropocene and the potentially existential threats human activities have created (Ripple et al., 2017) calls for considering how the conceptual frameworks we use, implicitly or explicitly, may contribute to this problem: as evidence accumulates to show that as "we are *not* on the 'right track', we need to establish what is the ultimate nature of our problem" (Hornborg, 2019, p. 4). This suggests that addressing our ecological predicament is not just a methodological issue – e.g. finding the optimal price and/or technology to enable sustainable forms of economic growth – but primarily an epistemological one (Bachelard, 1938) requiring revisiting the nature of the problem itself, and perhaps even an ontological one related to the preconception of the nature and structure of reality. In fact, the term "Anthropocene" itself may be part of an epistemological obstacle: it attributes to an unidentified *humanity* the responsibility for the current ecological crises without any concern for the different agents – e.g. nation-states, social classes, companies or financial institutions – and the specific historical patterns that may be responsible for the current situation (Malm, 2018; Mann & Wainwright, 2017; Moore, 2015).

Bonneuil & Fressoz (2016) explore alternative and complementary narratives and terminologies to the Anthropocene that emphasize: the political history of energy uses that permitted the emergence of thermo-industrial societies – the *Thermocene*; the critical role played by wars and the military in ecological degradation – the *Thanatocene*; the social construction of consumption societies – the *Phagocene*; the dismissal of multiple forms of knowledge, alerts and grammars of nature that contradict the idea that we did not know about ecological degradation until very

recently – the *Phronocene*; the intellectual constructions that marginalized the role of nature – the *Agnotocene*; the annihilation of multiple socioenvironmental forms of resistance to the ecological degradations imposed by industrial societies – the *Polemocene;* and the fundamental relation between the global processes of capital accumulation and ecological transformations – the *Capitalocene* – as studied in particular through the perspective of world-ecology (Moore, 2015) discussed below. For lack of an optimal term, I follow Bonneuil & Fressoz (2016) in keeping the concept of the Anthropocene while using it in a reflexive manner, which acknowledges its limitations and the need to understand it through multiple approaches.

All these narratives point to at least one similar issue: as we enter the Anthropocene, we need to develop alternative narratives of *how we got there*. In this context, a promising development has taken place with the rapid development of a literature in humanities and social sciences, which points to the values of Western Modernity as being grounded in a dualistic worldview between humans and nature (Brown, 2012; Descola, 2005; Latour, 2004) that would problematically treat individuals as being disembedded from their biophysical milieu. The definition of Western Modernity generally refers to the entanglement of capitalism, liberal values, European Enlightenment and scientific revolution during the seventeenth and eighteenth centuries. Those would have played a critical role in conceptualizing society and nature as ontologically discrete (Moore, 2015, p. 30), with "*Science*" (Latour, 2004, p. 9. Capital letter and italics in original) playing the role of a new "sacred myth" (Sideris, 2015) through which humans can control and master nature. According to Merchant (1996, p. 136), the "Baconian-Cartesian-Newtonian project is premised on the power of technology to subdue and dominate nature".

In particular, the ideals of liberalism – such as universalism, formal egalitarianism, proceduralism and the ethical of the rational, autonomous individual – and its stories of endless progress "driven by human communities distinct from their nonhuman and inanimate environments" (Mann 2019) may be unfit for the challenges of the Anthropocene (Mann & Wainwright 2017). For instance, the liberal Lockean tryptic of "life, liberty, and property" which implies that freedom

can be acquired through the conquest of nature (Charbonnier, 2020), entails an antagonistic relationship between humans and nonhumans (Locke, 1689/1977):

> *Though the earth, and all inferior creatures, be common to all men, yet every man has a property in his own person ... Whatsoever then he removes out of the state that nature hath provided, and left it in, he hath mixed his labour with, and joined to it something that is his own, and thereby makes it his property*. (p. 289)

According to many scholars, Western Modernity's project to subdue and dominate nature is deeply connected to another project: that of domination by men over women. For instance, Merchant's (2006) analysis of the conquest of North America shows that nature was primarily considered as a female to be conquered through force and violence by male energy. As summarized by Bacon (cited in Merchant, 2006, p. 520. Italics added): "*she* is put in constraint, molded and made as it were new by art and the hand of man ... Nature takes orders from man and works under his authority". The conquests of "women, nature, and colonies" therefore appear as deeply entangled projects (Mies, 1986). Today, the vast majority of unpaid and underpaid work is still accomplished by women (Federici, 2012) and by former colonies of the Western nation-states (Moore, 2015).

Some authors argue that the roots of our ecological predicament go even further back in time. Latour (2004) argues that "Greek politics" share the blame with French Cartesianism for our current ecological predicament. For instance, Plato's allegory of the Cave would have created an artificial division between two worlds, one of external realities and one of a social world, thereby generating a rupture between the "irrefutable objective law and the human—all too human—logorrhea of the prisoners shackled in the shadows, who never know how to bring their interminable disputes to an end" (Latour, 2004, p. 11). Brown (2012, p.7) argues that "the now globally dominant Western culture" has deep roots in both the Greek and Biblical traditions, which would have contributed to develop a view of the world as "something to be owned and used, not loved and respected". Christianity, with its doctrine that man has dominion over nature, is seen by some as "the most anthropocentric religion the world has ever seen" (White,

1967). However, different Christian figures such as Saint Francis of Assisi (White, 1967) and Christian narratives of liberation (Boff & Boff, 1987) can also serve as inspirations to ecologically-grounded narratives, and the recent encyclical “Laudato si’” (Pope Francis, 2015, p. 162) argues that Christian spirituality "implies avoiding the dynamic of dominion" of humans over nature.

The literature above is not presented to take position on where precisely the roots of our ecological predicament may lie, as to provide evidence of the following: building new relationships toward an Earth citizenship that serves humans – including future generations – without impinging on the capabilities of nonhumans will require nothing less than challenging our worldviews, institutions and technologies (Beddoe et al., 2009) altogether. It goes without a doubt that such a task will not be easy. For instance, Charbonnier (2020) argues that the tensions between the liberal and classical worldviews and the related Polanyian double movements of the past centuries will be of limited help, since these were grounded in a destructive relation to nature. As such, discomforting compromises are needed. For example, as Giorgos Kallis (in Kallis, Mastini & Jackson, 2018) puts it, it is necessary to retain the Enlightenment’s “quest for autonomy, our right to question our institutions and a refusal to accept truths as handed down from tradition or the gods”, while fighting its deeply associated quest for conquering nature. In this quest for new ontologies, finding synergies between non-Western worldviews and modern science may also be needed: as many indigenous cultures have long emphasized (Rose & Robin, 2004) and in contrast to the Baconian-Cartesian-Newtonian mechanistic and atomistic view of the world as made out of independent parts, contemporary science shows that the material world is a network of inseparable patterns of relationships (Capra & Luisi, 2014).

The journey to more harmonious and re-embedded human-Earth relationships therefore depends on an exploration of alternative ways of inhabiting the Earth that have been barred by the Western worldview. Toward this end, ethnology and history provide us with multiple examples throughout time and space of collectives where the status of humans is intrinsically related to their nonhuman environment. In such systems, humans do not own nature but are owned by nature (Descola, 2005), although humans can retain peculiar functions as mandatory

of the rights and capabilities of nonhumans (ibid) or as "custodians of Earth's household" (Brown, 2012, p. 2). Other ontologies such as animism – which sees a continuation between human and nonhuman life – involve the belief that nature does not exist as something external to humans (Descola, 2005), and many societies are even unacquainted with the very concept of nature since humans and nonhumans are simply seen as agents within the same web of life (Galeano, 1982/2015; Latour, 2004; Rose & Robin, 2004).

One of the main epistemological obstacles to be overcome by the Western worldview is the acknowledgment of the concept of finiteness, at the core of this thesis. Finiteness here is not understood in the sense of Malthusian scarcity but rather as the realization that as human activity is already impinging on the Earth's life support systems, concepts such as abundance and freedom need to be revisited without relying on the promises of infinite expansion generated by liberal and industrial capitalism (Charbonnier, 2020; Kallis, 2019). The question of finiteness therefore invites us to revisit the concept of value under a new light, which involves asking what we really need and want.

The above suggests that in an ecological society sobriety would be an essential value (Kallis, 2019), one that would enable us to live fulfilling lives not at the expense of other forms of life. But even if such sobriety can be "liberating" and "a way of living life to the full" (Pope Francis, 2015, p. 162), and even if "sober simplicity may resonate with dormant common senses about the good life' present in many cultures, East and West" (Kallis, 2018, p. 32), its implementation remains an open question. Whereas it may be relatively easy to agree – at least theoretically – that all individuals should access primary needs such as food, shelter or health, the boundaries between *essential, acceptable* and *unacceptable* needs on a finite planet will not be easy to draw (Keucheyan, 2017). Who is to decide on such things? Traveling, for instance, enables individuals to open up to alterity and can be considered as necessary as education, yet the democratization and massification of tourism over the past decades also contributed to a sharp rise in CO_2 emissions and to the destruction of local ecosystems (ibid). A purely technical view on such

questions – e.g. a universal price on carbon – would hardly have anything to say on how ecological limits can be reconciled with liberty and individual agency (Gorz, 2008).

Such questions are far from being merely theoretical. For instance, the French association Negawatts (2015) shows that energy sobriety will be fundamental if France is to function with 100% of renewable energy in the future – excluding nuclear in their scenario. In order to implement energy sobriety, difficult choices must be made. Negawatts distinguishes different categories of energy use, going from "vital" and "essential" ones to "unacceptable" and "selfish" ones. That is, decarbonizing our economic system requires questioning the way we live and the social value of our needs and wants. However, establishing what is acceptable or not for a finite planet without impinging on individual freedom is far from evident and would require continuous collective deliberation (Kallis, 2019; Keucheyan, 2017).

A promising development toward the practical implementation of alternative worldviews that can account for finiteness may be taking place with the resurgence of the commons. The commons are broadly understood here as the multiple nonhuman agents (Latour, 2004) such as the forests, rivers, and meadowlands with which – or whom – human societies have developed diverse types of relationships and associated systems of governance, often based on regulated rights of access and use rather than on property rights (Dron, Espagne & Svartzman, 2020). An important literature has assessed how governing the commons may require significant transformations in property regimes. In particular, Ostrom (1990, 2010) and others (e.g. Bromley, 2007; Cash et al., 2006; Muradian & Rival, 2012; Paavola, 2007; Vatn, 2010), based on multiple case studies across the globe, have found that the effectiveness in governing the commons does not depend so much on the property regime itself – public or private – as on the formal and informal rules governing them and the worldviews supporting them. For instance, strong levels of cooperation and flexible arrangements among the users of an ecosystem are often more important to their governance that property rights or pricing mechanisms.

In contrast with these approaches, capitalism seems to have been enabled by a form of sacralization of private property, which started precisely with the enclosure of the commons in England and the ensuing commodification of the natural environment, including meadowland, forests, water sources, underground resources or genetic resources, to name just a few (Descola, 2015). The French revolution made of private property a fundamental human right (Capra & Mattei, 2015), thereby accelerating the erosion of the commons. For instance, a decree of September 4, 1791, enacted that the access to wood was no longer regulated by forest agents and became the sole property of its owner (Ost, 1995). The young Marx would observe a similar phenomenon in his *Debates on the Law on Theft of Wood* in 1842 (in Marx & Engels, 1975), where he criticized the state for favoring private property rights to detriment of the former customary rights of the poor to withdraw wood for their primary needs (Dron et al., 2020). Placing the commons in the agenda would therefore amount to reconsider them not as resources to be exploited, but as a shared milieu of whom everyone is accountable. The governance of the commons is made even more difficult because many commons today are global, such as the climate or biodiversity (Descola, 2015).

Shifting toward a worldview that better acknowledges the nature of the commons could therefore imply systemic changes to our institutional arrangements. Indeed, governing the commons requires thinking both beyond the horizon of nation-states—e.g. to handle global problems such as climate change—and beneath it, accounting for the fact that each ecosystem requires a different governance scheme. For instance, the public sector should no longer be viewed as a monocentric hierarchy imposed by state power, but rather as a polycentric system "where many elements are capable of making mutual adjustments for ordering their relationships with one another within a general system of rules where each element acts with independence of other elements" (Ostrom, 2009, p. 33). The concept of the commons has now gone beyond the governance of natural resources and is increasingly mobilized by citizens engaged in a large range of commercial and non-commercial activities (e.g. Coriat, 2015). The commons could also act as a catalyzer to envision broader systemic changes, including post-capitalist systems (Dardot & Laval, 2014; Gibson-Graham, 2008).

Whereas the commons have provided critical insights into the governance of local ecosystems, the question of how to manage global commons such as climate change remains largely unanswered (Dietz, Ostrom & Stern, 2003). The field of ecological economics and the world-ecology approach, respectively discussed below, can provide critical insights to this end.

2.3.2 Re-embedding the economic sphere within a finite biosphere – The approach of ecological economics

The dominant approach so far to addressing ecological crises in the international and national arenas has revolved around the concept of sustainable development, defined as a development that "meets the needs of the present without compromising the ability of future generations to meet their own needs" (World Commission on Environment and Development, 1987, p. 15). This approach is informed by the view, largely supported by international organizations, that humanity will find its way to *green* and *inclusive* forms of economic growth (e.g. OECD, World Bank & United Nations, 2012; World Bank, 2012) thanks to sound economic policies that would not require revisiting deeper worldviews and institutional arrangements at the global, national and local scales.

In particular, mainstream economists working on sustainable development maintain that ecological crises such as climate change are *market failures* stemming from negative externalities, i.e. from costs affecting a third party that did not take part in a transaction and did not choose to incur that cost. It follows from this market-centered definition of the problem that externalities can be reinternalized through economic incentives and market mechanisms such as cap-and-trade systems[15] and/or pricing mechanisms such as carbon taxes[16]. For instance, from a

[15] See for instance the European Union Emissions Trading System (EU ETS): https://ec.europa.eu/clima/policies/ets_en

[16] See for instance the Carbon Pricing Leadership Coalition: https://www.carbonpricingleadership.org/what

mainstream economist's perspective, a carbon tax that reflects the social cost of carbon – which adds up in monetary terms all the costs and benefits of adding one additional ton of CO2 – would make explicit the shadow cost of carbon emissions, and the latter would be sufficient to induce economic actors to reduce emissions. Some mainstream economists and policymakers acknowledge that it will also be necessary to consider the historical responsibility of wealthier nations in contributing to the current situation, as reflected by the principle of "common but differentiated responsibilities" (UNFCCC, 2015) enshrined in climate negotiations. For instance, the Copenhagen Accord established during the 2009 United Nations Climate Change Conference (UNFCCC, 2009) provided the foundations to the creation of the Green Climate Fund, to be financed by wealthy nations in order to promote climate change mitigation and adaption policies in developing countries. But here, too, no systemic changes are put forward as part of a low-carbon transition.

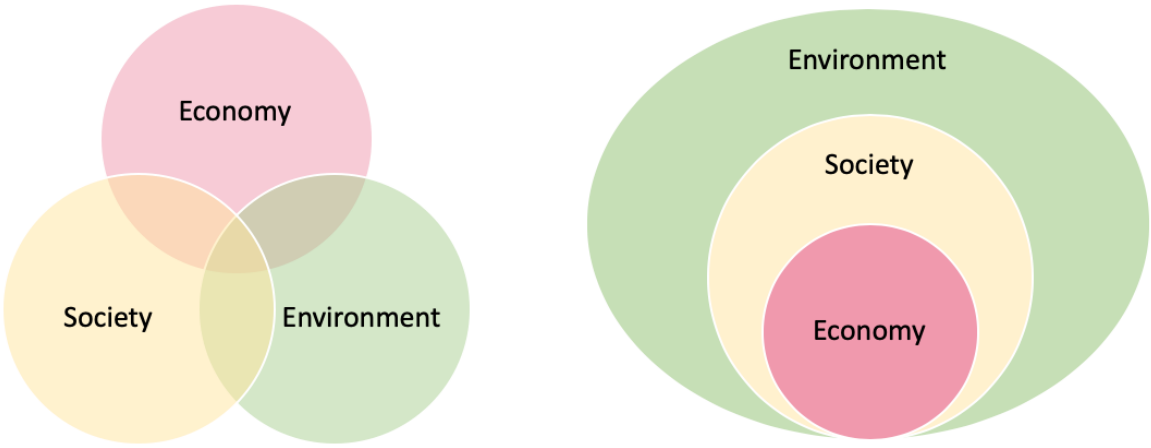
This paradigm of sustainable development and its associated views of greener and more inclusive forms of economic growth have faced increasing criticism for failing to address the nature of the interactions between the economic, social and biophysical spheres. From an empirical perspective, the goal of decoupling perpetual economic growth from environmental damages does not seem to have much evidence supporting it and rather seems to be an act of faith in the Promethean role of technology (e.g. Hickel & Kallis, 2019; Jackson, 2017; Macquarie, 2019; Parrique et al., 2019). From international political economy and political ecology perspectives, some have argued that implementing a fair and global ecological transition cannot take place through patchy solutions such as a Green Climate Fund and should instead involve questioning the very imbalances at the heart of the world-system through an ecological perspective (e.g. Althouse, Guarini & Porcile, 2020; Hornborg, 1998; Martínez-Alier, 2002).

The transdisciplinary field of ecological economics, developed in the 1980s and inspired by earlier contributions – such as those of chemist F. Soddy (1926), institutional economist W. Kapp (1950), economist K. Boulding (1966), ecologist H.T. Odum (1971) and mathematician and economist N. Georgescu-Roegen (1971) – has been at the forefront of this critique. The fundamental insight of

ecological economics – as developed by some of its main contemporary scholars such as Martínez-Alier (1987), Daly & Farley (2011), Jackson (2017) and Spash (2017) – is to insist that the human socio-economic system is embedded within and dependent upon the Earth's biophysical systems (see figure 2.2). Economic activity functions by transforming flows of nutrients, energy and materials into economic surpluses, while generating waste and transforming the natural environment in which human and nonhuman societies live, evolve and reproduce themselves. Ecological economics is effectively "the only heterodox school of economics focusing on the human economy both as a social system and as one embedded in the biophysical universe" (Gowdy & Erickson, 2005, p. 207).

Figure 2.2 – The "weak" and "strong" approaches to sustainability

The "weak" sustainability approach: the economic, social and environmental spheres are independent from each other	The "strong" sustainability approach: the economic sphere is embedded within the social and environmental spheres



Source: adapted from Daly & Farley (2011)

Ecological economists have therefore argued that the worldview supported by the concept of sustainable development corresponds to a "weak sustainability" approach (Daly & Farley, 2011),

which considers that different forms of capital are substitutable with each other. For instance, as believed by many mainstream environmental and resource economists, the impacts of climate change or the exhaustion of resources do not matter as long as their monetary costs are compensated by an increase in capital (Hartwick, 1977; Nordhaus, 2018). In contrast, the "strong sustainability" approach supported by ecological economists posits that the loss of resources or ecosystems' regenerative capacities can only be partially substituted by increases in physical or financial capital.

From this perspective, it quickly appears that the scale of the current global economy can become too large and prevent natural cycles from providing resources in sufficient quantities and from absorbing or assimilating different forms of waste such as carbon dioxide emissions (Daly & Farley, 2011). A sustainable economic system is therefore one that (Daly & Farley, 2011): (i) uses renewable resources at a rate that does not exceed their ability to regenerate; (ii) uses non-renewable resources at a rate that does not exceed the rate at which sustainable renewable substitutes are developed; (iii) generates pollution emissions that do not exceed the assimilative capacity of the natural environment.

The concept of "social metabolism" (Martínez-Alier, Kallis, Veuthey, Walter & Temper, 2010) lies at the intersection between the social and biophysical considerations of ecological economics: it acknowledges that much like biological systems, socio-economic systems depend on a continuous throughput of energy and material to maintain their internal structure (Fischer-Kowalski & Haberl, 2007). This social metabolism can be quantified through different approaches such as the ecological footprint (Wackernagel & Rees, 1996), the human appropriation of net primary production (Haberl et al., 2009) or material flow analysis (MFA. Krausmann et al., 2009). The latter is based on the aggregation of the material throughput of national economies, expressed in flows of tonnes supporting different societies' metabolism. Over the past decades, MFA have been conducted at multiple scales, from the global (Haberl et al., 2009) to national scales (e.g. Magalhães et al., 2019). MFA studies show, among others, that the twentieth century has been characterized by a massive extraction of primary materials (Krausmann et al., 2017),

and that a significant part of these materials went from poorer countries to wealthier ones (Schaffartzik et al., 2014).

This finding strengthens the theory of "ecologically-unequal exchange" supported by some ecological economists (Bunker & Ciccantell, 2005; Hornborg, 2014; Jorgenson, 2016): capital has historically tended to accumulate in the core of the world-system while causing multiple forms of environmental degradation — including overexploitation of resources but also multiple forms of pollutions — in its peripheries. MFAs therefore provide us with a "rematerialized" (Magalhães et al., 2019) understanding of the economic system, which is particularly insightful when combined with historical perspectives (Giampietro, 2008) such as the world-ecology framework (Moore, 2015), discussed later on.

In short, ecological economics considers the economy as being embedded in nature (Røpke, 2005) and subject to – yet not determined by[17] – its laws, including "the laws of physics and ecology" (Farley et al. 2013, p. 2804). Regarding the laws of physics, the law of entropy – or second law of thermodynamics – was emphasized by Georgescu-Roegen (1971), one of earliest contributors to the field. It tells us that the entropy – i.e. a system's thermal energy per unit temperature that is unavailable for doing useful work (Drake, 2018) – of an isolated system strictly increases in irreversible transformations. Applied to an economic system, it means that as industrial economies use an existing stock of fossil fuels, its heat content gets dissipated and the stock cannot be reused (Smil, 2010). That is, industrial production inexorably increases entropy. Whereas the Earth system is open to energy from the sun – i.e. it is a closed system, not an isolated one – current stocks of fossil fuel stocks are depleted much faster than they are replenished – through photosynthesis over hundreds of millions of years – and than renewable sources of energy are being deployed. The law of entropy ultimately tells us that the exponential

[17] Indeed, whereas ecological economics invites us to revisit socio-economic dynamics in a new ecological light, this does not suggest by any means that we should "transfer our understanding of the network's material structures from the biological to the social domain" (Capra & Luisi, 2014), as the latter is composed of specific patterns related to behaviors, values, intentions or power relations.

growth of a finite system is impossible, although there is no agreement on whether the physical limits to growth are around the corner or a distant reality.

The "laws of ecology impose even tighter constraints on economic activity" (Farley et al., 2013, p. 2806). These laws tell us that the economy does not only use low entropy energy and matter from its surrounding natural environment to produce consumption goods, it also discards high entropy wastes and dissipated heat back into the environment, such as carbon dioxide. When ecosystems cannot adapt to the modifications imposed by economic activities, their functions are affected. Indeed, particular configurations of ecosystems create ecosystem funds that generate flows of services essential to sustaining life. Hence, as we keep crossing several of our nine planetary boundaries[18] (Rockström, 2009; Steffen et al., 2015), we put increasing pressure on Earth's life support systems. Moreover, ecosystems are highly complex and subject to non-linearities, feedback loops and emergent behavior. They are also highly connected among themselves, meaning for instance that "impacts related to one of the planetary boundaries affect the status of other planetary boundaries" (Lade, 2019), potentially leading to cascades of ecological catastrophes (Steffen et al., 2018).

Once we recognize that resources and waste absorption capacity are finite, the goal of the economic system becomes different. With the entry into the Anthropocene, there is no longer doubt that we now live in a "full world" (Daly, 2005), i.e. that the global economy is largely operating outside its "safe operating space" (Rockström, 2009). In this context, bringing the economic system back within planetary boundaries entails re-evaluating the notion of endless economic growth itself, and designing a new socio-economic system that can provide development opportunities within our finite biosphere. As a result, ecological economics has often been described as focusing simultaneously on the issues of scale, distribution and efficiency (Daly & Farley, 2011): scale refers to how the economic system should not surpass the limits

[18] These are nine critical systems that regulate the state of the planet: climate change, biogeochemical flows, land-system change, freshwater use, aerosol loading, ozone depletion, ocean acidification, loss of biosphere integrity including biodiversity, and introductions of novel entities such as toxic chemicals and plastics.

enabled by biogeochemical processes; distribution then recognizes that fairness and equity cannot simply be the result of an increase in economic output, they need to revisited within the finiteness of planetary systems; and efficiency in allocation is often kept as a traditional economic goal although its definition varies (e.g. Brown, 2012).

The analogy of the transition developed by a critical contributor to the field of ecological economics, Kenneth Boulding (1966), is that of moving from the current "cowboy economy" characterized by the belief in "illimitable plains and also associated with reckless, exploitative, romantic, and violent behavior: to a "'spaceman' economy, in which the earth has become a single spaceship, without unlimited reservoirs of anything, either for extraction or for pollution, and in which, therefore, man must find his place in a cyclical ecological system" (ibid, p. 281). The latter has radical implications for the ways in which we value things (Boulding, 1966):

> *In the cowboy economy, consumption is regarded as a good thing and production likewise ... By contrast, in the spaceman economy, throughput is by no means a desideratum, and is indeed to be regarded as something to be minimized rather than maximized ... In the spaceman economy, what we are primarily concerned with is stock maintenance, and any technological change which results in the maintenance of a given total stock with a lessened throughput (that is, less production and consumption) is clearly a gain.* (p. 282)

In order to account for the finiteness and complexity of planetary ecosystems and for the need to promote new value systems, many ecological economists – especially in the sub-discipline of social ecological economics (Spash, 2013) – embrace the pluralism of values and their incommensurability, i.e. the absence of a relevant common unit of measurement across them. Indeed, the natural environment "is a site of conflict between competing values and interests and different groups and communities that represent them" (Martínez-Alier, Munda & O'Neill, 1998, p. 277). Whereas the utilitarianism at the heart of neoclassical economics aims to resolve such conflicts through individual utility expressed through market mechanisms, a cornerstone of social ecological economics is that the sum of individual preferences does not necessarily provide for the common good (Spash, 2013). In this context, aiming to resolve all ecological issues

through market mechanisms may amount to a modern form of commodity fetishism (Kosoy & Corbera, 2010) and lead to inefficient and/or unequal outcomes. For instance, individual utility usually fails to account for the welfare of the poor who often directly depend on the maintenance of certain ecosystems to sustain themselves, yet are unable to place a high monetary value on them given their limited purchasing power (Martínez-Alier, 2002).

As a consequence, alternative mechanisms such as participative deliberative processes seem to be a more promising avenue to unveil the preferences of different social groups and individuals: "the validity of a given approach depends on the inclusion of the several legitimate perspectives as well as the non-omission of the reflexive properties of the system, even though these are not easy to deal with" (Martínez-Alier et al., 1998, p. 282). Moreover, the values attributed through market mechanisms can even be resisted through ecological distribution conflicts (Martínez-Alier et al. 2010), which correspond to different forms of Polanyian countermovement aimed at protecting the intrinsic rights of nature and humans inhabiting it. The protagonists of countermovement are often marginalized populations such as indigenous groups, peasant groups and women activists who also "deploy their own values against the logic of the market" (Kosoy et al., 2012). In this sense, resistance and socioenvironmental conflicts are an active force of transformation (Scheidel, Temper, Demaría & Martínez-Alier, 2018). More broadly, these perspectives are a reminder that the interactions between humans and nature are mediated by evolving social structures and institutions (Kallis & Norgaard, 2010; Norgaard, 2010; Vatn, 2010), and that ecological economics should concern itself with revisiting "environmental values and human relationships with Nature" (Spash, 2013, p. 352).

In summary, the basic perspective of ecological economics is "the embeddedness of the economy in nature, the importance of considering nature as a life-support system, and the need for understanding ecological and economic systems and their interactions in terms of flows of energy and matter" (Røpke, 2005, p. 267). In addition, a number of core beliefs characterize the field, including): the view that the economy has already exceeded the maximum sustainable scale; the importance of embracing transdisciplinary work, pluralism of values, systems thinking and deep

uncertainty with regard to our understanding of nature; and the need to revisit issues of equity and distribution in the context of ecological boundaries (Ibid.).

2.3.3 Integrating human-nature relationships within the study of capitalism's dynamics – The world-ecology approach

Whereas the ecologically-embedded views of ethics and economic systems discussed above are critical to understand the disembeddedness of the global socio-economic system from its biophysical milieu, they hardly touch upon the main system under which the vast majority of ecological degradation has taken place, that of capitalism. The world-ecology perspective – or approach – which has emerged over the past few years, seeks to fill this gap by articulating the recent history of the Earth system and its multiple ecological transformations alongside that of the capitalist world-economy (à la Braudel, 1985/2011) or world-systems (à la Wallerstein, 2011). That is, the world-ecology approach seeks to overcome the dualistic view of nature and society through the study of capitalism's historical patterns. As Chakrabaty (2017, p. 41) puts it: "we have to think the history of capital (spanning a few hundred years) and much longer histories (of the earth system and life on it) at the same time".

The premise of the world-ecology perspective is that "capitalism works through nature, rather than upon nature" (Moore, 2015), i.e. "capitalism is not just part of an ecology but is an ecology — a set of relationships integrating power, capital and nature" (Moore & Patel, 2017, p. 38). Put differently, the accumulation of capital and the production of nature form a "dialectical unity" (Moore, 2015, p. 14). This suggests that the capture and control of natural resources are not merely consequences of capitalism but are "internal" to the forces of capital (Huber, 2013): the biophysical milieu enables, transforms and constrains – yet never determines – different regimes of capital accumulation at the global scale.

Following this, several authors have argued that instead of the decontextualized concept of the Anthropocene, we should refer to the Capitalocene (Malm, 2016; Moore, 2015) to emphasize the intrinsic relationship between ecological crises – including climate change – and the dominant socio-economic system of capitalism. Indeed, ecological patterns such as climate change or biodiversity extinction cannot be attributed to humanity as a whole. For example, whereas indigenous peoples in the Amazon or Aboriginal Australians have constantly transformed their environment, their traditional lifestyles cannot explain why CO_2 atmospheric concentration has increased from the range of 270-280 parts per million (ppm) that had prevailed for the past twelve millennia – guaranteeing stable climate conditions in which human societies were able to develop agriculture (Feynman & Ruzmaikin, 2007) and become more complex (Chaisson, 2014) – to 415 ppm[19] in a just a few centuries. There is no doubt that the beginning of the sharp increase in CO2 emissions takes place with the start of capitalism's Industrial Revolution (Descola, 2015), even though the premises of capitalism are older, as dicussed above.

To be clear, this does not suggest that capitalism alone is to be blamed for all ecological degradations. As discussed previously, the roots of current human-nature relations seem to go further back in time than the history of capitalism and to be entangled with it. One can also think of the ecological degradations caused by communism: Audier (2019) argues that right after the Russian Revolution, a temporary compromise was found between Russian environmentalists and the Bolshevik regime – e.g. with the creation of national parks policy – but the latter rapidly gave way to the productivist imperative fueled by the desire to compete with the American military power and way of life. Hence, state communism did not question the two main features of the capitalist relation to nature (Descola, 2015): the values that are essential to life can be captured, whether it is by the private or the public sector; and the multiple values attached to nature are first and foremost understood as resources, i.e. through their ability to be used in industrial production, thereby barring the way to alternative relations with nature. According to Moore

[19] In May 2019, based on the daily record of global atmospheric carbon dioxide concentration measured at Mauna Loa Observatory in Hawaii, and reported by the Scripps Institution of Oceanography at UC San Diego. See https://scripps.ucsd.edu/programs/keelingcurve/.

(2015), the communist regimes of the twentieth century were established in opposition and therefore in close interaction with capitalism, not as an ontologically separate project.

Instead, the world-ecology approach suggests that a rematerialized analytical framework is needed to better understand the functioning of capitalism itself. It shows that the four historical cycles of accumulation in capitalist world-systems – that of the Genoese, Dutch, British and American – discussed above through the lens of financial hegemony, also relied on different forms of ecological hegemony. For instance, the rise of the first capitalist hegemon – according to world-systems analysis – the Dutch Republic[20], would not have been possible without the grain from Poland, the energy delivered by peatlands or the timber from the Baltic. At a much more massive scale, British industrialization relied on the appropriation of "an ecological footprint several times the size of its entire national territory, and ... the toil of a workforce several times larger than its national population" (Hornborg, 2013, p. 46), most notably by colonizing territories that were fundamental to its material development (Pomeranz, 2000). The accounts of the creation of the first stock exchanges in London and Amsterdam, discussed in the literature review on money, therefore seem to remain incomplete without mentioning the ecological revolutions on which they were based.

Similarly, the Fordist-Keynesian regime did not only rely on the elements identified in the literature review on money – i.e. the mass production systems of the second Industrial Revolution and the capital-labor accord that prevailed during this time – but also on very material processes. In fact, the triumph of the Fordist-Keynesian regime of accumulation following World War II corresponds to the "Great Acceleration" (Steffen et al., 2015) of the Anthropocene

[20] Interestingly, Moore (2015) notices that the Cartesian mechanistic and dualistic views between humans and nature, touched upon above, becomes particularly instructive when analyzing the context in which it came about: Descartes wrote most of his major works during the first half of the seventeenth century while living in the Dutch Republic, precisely when the country rose as the first capitalist hegemon ever, becoming the epicenter of "a revolution that stretched from South East Asia to the north Atlantic" (Moore, 2015, p. 29). Viewed in this light, Descartes' concern for the rationalizing the universe "can be viewed as both symptomatic of, and contributing to, the seventeenth century's massive reorganization of power, capital, and nature" (ibid, p. 30).

observed by scientists, i.e. to the beginning of the most profound transformations of the natural world caused by human activity. As Moore (2015) puts it:

> *The assembly line of classic Fordism, for instance, was unthinkable without Cheap steel, rubber, and oil. It is impossible to overstate the irreducibly socio-ecological character of this surplus … The origins of the long twentieth century were found not only in the mass production systems of the "second industrial revolution," but also in multiple appropriations of human and extra-human natures: of the soil and water resources of the American Midwest; of Eastern European and South Asian peasantries; of the forests, fields, and resource veins of the colonial and semi-colonial worlds.* (p. 107)

The considerations above suggest that the technologies and institutional arrangements, through which resources are exploited can have major impact on socio-economic dynamics and on capitalism's modes of regulation. For example, Malm (2012) shows that the transition from biomass and hydropower to coal in Great Britain during the Industrial Revolution cannot be explained simply by the higher profits provided by coal – hydraulic power was actually cheaper than coal according to him – but rather by the social project of further advancing the commodification of labor: coal-fired production demanded that workers concentrate in cities and larger factories and therefore provide the owners of capital with the ability to use and dispose of labor in a more flexible manner. Notwithstanding, Mitchell (2011) argues that coal extraction also enabled miners to join forces to block economic activity at its source, thereby providing these new armies of workers with a critical bargaining power. As such, the captains of industry strongly supported the emergence of an oil-based economy in the twentieth century, as they foresaw how its reliance on more technical and managerial work would be an opportunity to break down workers' rights.

According to Mitchell (2011), the success of the postwar Golden Age can be partially explained by a peculiar alliance: the windfalls provided by the oil economy – e.g. through the multiple uses of oil in industry – enabled mass production, whereas the institutional setup still dominated by the structures of the coal age – including strong labor unions – ensured mass consumption. But

the role of oil was also fundamental to support nexus of mass production and mass consumption during the Fordist-Keynesian regime. In particular, the suburbanization of industrial and residential development and the development of massive national highway systems produced a more spatially extensive mode of development in which individual house and individual car ownership became fundamental (Huber, 2013). Hence, the two commodities that structured the Fordist wage relation and its associated social norm of mass consumption, home and automobile (Aglietta, 1979), were highly dependent upon a very specific institutionalization of oil supply. As outlined in chapter 4, this institutionalization of oil fell apart in the early 1970s at the same time as the Bretton Woods regime and the Fordist-Keynesian also came to an end (Huber, 2013; Mitchell, 2011; Sager, 2016; Smith-Nonini, 2016), suggesting that a regime of accumulation cannot survive without its biophysical foundations.

The transition from the Fordist-Keynesian regime to the financialized one since the 1970s also shows deep transformations in the relationship to nature, and to energy in particular. For instance, Cahen-Fourot & Durand (2016) find in five countries – France, Germany, Japan, U.K. and U.S. – that, while Fordist-Keynesianism is characterized by "an extensive energy use and an intensive labor use [with] high labor productivity gains ... from 1970 onwards, a decrease in the growth of energy quantity goes together with a decrease in labor productivity growth and contributes to the erosion of the fordist social compromise". In other words, the Fordist-Keynesian regime can be casted as an era enabled by the extensive use of natural resources, with an important increase – compared with the regime prior to World War II – in the quantity of exergy[21]. In comparison, the financialized regime sees a quasi-stagnation in the quantity of exergy but a strong increase in quantities of exergy in developing countries, related to outsourcing and offshoring of production (Malm, 2012; Moore, 2015).

However, interpreting this transition through a world-ecology perspective is still a pending task (Bonneuil & Fressoz, 2016, p. 279). For instance, Cahen-Fourot & Durand's (2016) analysis could

[21] Exergy is known as known as "availability" or "work potential". It corresponds to the maximum amount of energy that can be converted into any other form of energy, under given thermodynamic conditions.

easily be interpreted through one-sided causal arguments, meaning either that financialization has led to a shift in energy uses or, reversely, that energy realities have led to a shift in financial-economic dynamics. More recently, it is the economic rise of China that is vastly transforming the social metabolism of the global economy. For instance, China has become the largest importer of oil worldwide (Potter et al., 2017, p. 278) and its quest for resources has deeply transformed socio-ecological systems in distant regions such as Latin America (Brand et al., 2016). Adding to the complexity of the situation, the ecological pressures created by China's industrialization along with those traditionally created by wealthier countries' lifestyles, could trigger systemic biophysical crises as we enter the Anthropocene (Bolton et al., 2020). Chapter 6 turns to these questions by revisiting the financial globalization of capitalism, the economic rise of China and the build-up of ecological risks as three interconnected elements of a new global regime of accumulation.

Connecting Text

The Introduction and the Literature Review introduced the idea that the Anthropocene acts as a boomerang (Bonneuil & Fressoz, 2016) or as a hyper-siege (Valantin, 2017), i.e. as a backfiring phenomenon that our ecologically-disembedded analytical frameworks (Charbonnier, 2020) are largely unable to appreciate and handle.

The following chapter tests this idea in the realm of money and finance, by exploring how climate change increasingly threatens existing monetary institutional arrangements: it generates new financial risks that are widely disregarded by finance practitioners. In fact, central bankers and financial supervisors have recently realized that climate-related risks are a source of financial risk, meaning that it is within their mandates "to ensure the financial system is resilient to these risks" (NGFS, 2018, p. 3). However, the uncertainty and complexity related to climate change mean that central banks' traditional approaches to financial risks are unable to capture the nature of climate-related risks.

This chapter therefore explores the limitations of central banks' analytical frameworks to handle climate-related risks and suggests alternative approaches, borrowing notably from ecological economics and from non-equilibrium approaches to economics, such as post-Keynesian economics.

This chapter was submitted to the peer-reviewed journal Climate Policy, submission N° sciencesconf.org:isefi:321124.
A longer version of the chapter was published as a book: Bolton, P., Després, M., Pereira da Silva, L. A., Samama, F., & Svartzman, R. (2020). *The green swan: Central banking and financial stability in the age of climate change.* Bank for International Settlements. ISBN: 978-92-9259-326-1.

Chapter 3 – The Green Swan: Central banking, financial stability and policy coordination in the age of climate uncertainty

3.1 Abstract

This paper explores how climate change and the transition to a low-carbon economy pose new financial risks, and the role of central banks in addressing them within their financial stability mandate. By merging insights from climate science and the socio-technical transition approach, we find that both climate-economy and risk assessment models are unable to capture the radical uncertainty associated with climate-related physical and transition risks. These can lead to potentially extremely disruptive "green swan" events, which could be behind a systemic crisis. Whereas alternative approaches such as non-equilibrium models and scenario-based analysis can help address some of these challenges, climate-related risks will remain largely unhedgeable as long as system-wide action is not undertaken. Preserving financial stability in the age of climate change will mostly occur through an unprecedented level of cooperation between central banks and the private sector, public sector, civil society and international community. Embracing climate-related uncertainty, therefore, requires central banks to recognize the limits of their existing models and policy toolbox and to play an additional role by helping coordinate the measures to fight climate change, although many of them extend far beyond their reach. An analytical framework and specific policy propositions are presented toward this end.

Key policy insights

- Central banks' analytical tools do not enable them to manage potentially systemic climate-related risks.
- Whereas new modeling approaches and a new epistemology of risk management will be fundamental to appreciate the nature of climate-related risks, they will not be sufficient.

- In order to overcome this deadlock and continue fulfilling their mandate of financial stability over longer time horizons than those traditionally considered, central banks must also contribute to policy coordination to mitigate climate change.
- Strategies toward this end include: exploring new policy mixes (fiscal-monetary-prudential) that can better address the climate imperatives ahead; considering climate stability as a global public good to be supported through reforms of the international monetary and financial system; and systematizing the integration of sustainability criteria in the financial sector.

3.2 Introduction

It is increasingly acknowledged that climate change poses significant threats to financial stability (Carney, 2015; NGFS, 2018, 2019a). The increase in the frequency and intensity of extreme weather events could trigger non-linear and irreversible financial losses, so-called physical risks. In turn, the immediate and system-wide transition required to fight climate change could have far-reaching effects potentially affecting every single agent in the economy and every single asset price, so-called transition risks. As these events could threaten central banks' mandate of financial stability, it falls under their remit to "ensure the financial system is resilient to these risks" (NGFS, 2018, p 3).

However, climate-related risks present specific features that current climate-economic models and risk-assessment models do not fully account for. Climate-related risks are tied to complex layers of interactions between the macroeconomic, financial and climate systems (NGFS, 2019a, 2019b) and subject to nonlinear impacts. That is, climate-related risks could lead to "green swan" events (Bolton et al., 2020), unexpected events with potentially catastrophic consequences. In this context, traditional backward-looking risk assessment models that merely extrapolate historical trends prevent full appreciation of the future systemic risk posed by climate change.
As a response, an "epistemological break" (Bachelard, 1938) is beginning to take place in the financial community: to promote the integration of climate-related risks into prudential

regulation and financial stability monitoring, central banks have already stared to look into new approaches, grounded in scenario-based analysis, which can better account for the uncertainty and complexity at stake.

While these developments are critical and should be pursued, this paper presents two additional messages. First, scenario-based analysis is only a partial solution to apprehend the risks posed by climate change for financial stability. Both physical and transition risks are subject to deep or radical uncertainty related to the structural transformation of our global socioeconomic system. In this context, no single model or scenario can provide a full picture of the potential macroeconomic, sectoral and firm-level impacts caused by climate change. Even more fundamentally, climate-related risks will remain largely unhedgeable as long as system-wide action is not undertaken. It follows from these limitations that central banks may inevitably be led into uncharted waters in the age of climate change. On the one hand, if they sit still and wait for other government agencies to jump into action, they could be exposed to the real risk of not being able to deliver on their mandate of financial stability. On the other hand, central banks cannot simply replace governments and private actors to make up for their insufficient action, despite growing social pressures to do so.

Second, this paper argues that another epistemological break is needed: central banks must also be more proactive in calling for broader and coordinated change, to continue fulfilling their mandate of financial stability over longer time horizons than those traditionally considered. This includes: exploring new policy mixes (fiscal-monetary-prudential) that can better address the climate imperatives ahead; considering climate stability as a global public good to be supported through measures and reforms of the international monetary and financial system; and systematizing the integration of sustainability criteria in the financial sector.

This paper is structured as follows. Section 2 reviews how climate-related physical and transition risks can threaten financial stability, and the peculiar forward-looking nature of such risks. Section 3 critically assesses the insights and limitations of scenario-based analysis as a tool to

manage climate-related risks. Section 4 explores how these limitations could be partially overcome through new forms of cooperation between central banks and other players. Section 5 concludes by extending the concept of climate-related risks to other ecological risks.

3.3 Climate change as a source of "green swan" events threatening financial stability

3.3.1 Climate change and financial stability – An overview

The community of central bankers, financial regulators and supervisors, increasingly acknowledges that climate change poses potentially systemic threats to financial stability (Bolton et al., 2020; Carney 2015; NGFS, 2018, 2019a, 2019b). Two main types of risks are identified: physical and transition risks.

Physical risks include the economic costs and financial losses due to increasing frequency and severity of climate-related weather events (e.g., storms, floods or heat waves) and the effects of long-term changes in climate patterns (e.g., ocean acidification, rising sea levels or changes in precipitation). For instance, as natural catastrophes increase worldwide, non-insured losses (which represent 70% of weather-related losses (IAIS, 2018) can threaten the solvency of households, businesses and governments, and therefore financial institutions. Insured losses, on their end, may place insurers and reinsurers in a situation of fragility as claims for damages keep increasing (Finansinspektionen, 2016). This could place financial institutions in situations in which they might not have sufficient capital to absorb climate-related losses.

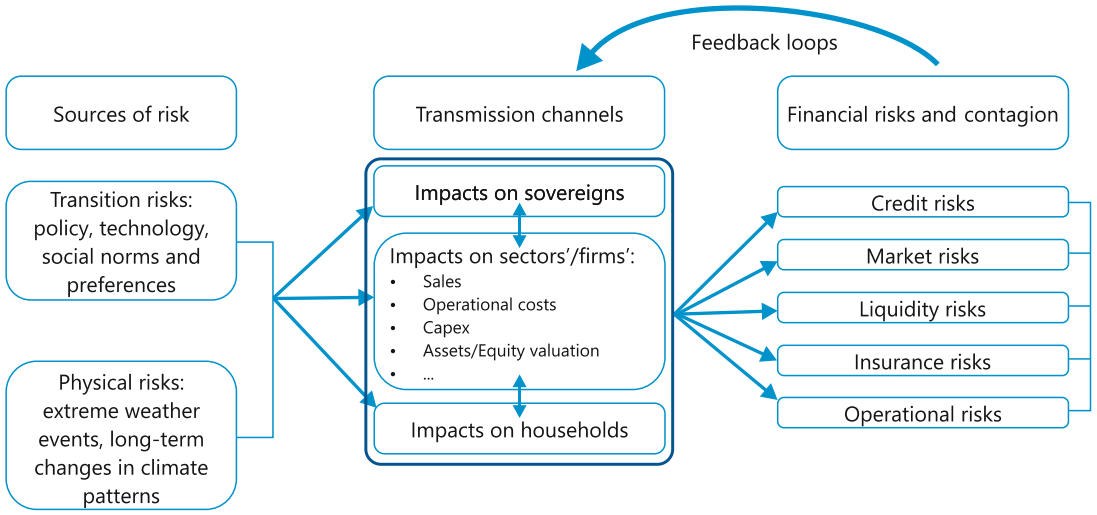
A rapid shift to a low-carbon economy could avoid most of these physical risks but would not be exempt from the second type of risks: transition risks. These are associated with the uncertain financial impacts that could result from a rapid low-carbon transition, including policy changes, reputational impacts, technological breakthroughs or limitations, and shifts in market preferences and social norms. In particular, the structural economic transformation required to lower emissions pathways means that a large fraction of proven reserves of fossil fuel cannot be

extracted, becoming “stranded assets” (Johnsson et al., 2019; Matikainen, 2018; McGlade & Elkins, 2015). This could lead to major and sudden reassessments of the prospects of such assets, triggering an archetypal fire sale potentially leading to a “climate Minsky moment” (Carney, 2016) i.e. a systemic financial crisis (Pereira da Silva, 2019) caused by the materialization of transition risks.

Physical and transition risks can materialize in terms of financial risk in five main ways, with many second-round effects and spillover effects among them (Graph 1):

- ***Credit risk**:* climate-related risks can induce, through direct or indirect exposure, a deterioration in borrowers’ ability to repay their debts;
- ***Market risk**:* financial assets could be subject to a change in investors’ perception of profitability, and therefore suddenly lose value;
- ***Liquidity risk**:* banks whose balance sheet would be hit by credit and market risks could be unable to refinance themselves in the short term, potentially leading to tensions on the interbank lending market;
- ***Operational risk**:* financial institutions can also be affected through their direct exposure to climate-related risks (e.g. through data centers impacted by physical risks);
- ***Insurance risk**:* higher than expected insurance claim payouts could result from physical risks and potential underpricing of new insurance products covering green technologies could result from transition risks (Cleary et al., 2019).

Channels and spillovers for materialization of physical and transition risks Graph 1



Source: Bolton et al. (2020).

Altogether, these patterns indicate that climate change could trigger "green swan" events. The "green swan" concept finds its inspiration in the now-famous concept of the "black swan" developed by Nassim Nicholas Taleb (2007). Black swan events have three characteristics: (i) they are unexpected and rare, thereby lying outside the realm of regular expectations; (ii) their impacts are wide-ranging or extreme; (iii) they can only be explained after the fact, i.e. with analytical tools developed to explain the shock *ex-post* rather than preventing it *ex-ante*. Climate-related risks typically fit fat-tailed distributions: both physical and transition risks are characterized by deep uncertainty and nonlinearity, their chances of occurrence are not reflected in past data, and the possibility of extreme values cannot be ruled out (Weitzman, 2009, 2011).

These potentially systemic risks posed by climate change explain why it is in the interest of central banks, regulators and financial supervisors to ensure that climate-related risks are appropriately understood by all players (NGFS, 2019a). The first recommendation made by the NGFS, an international network of central bankers involved in the management of climate-related risks,

calls precisely for "integrating climate-related risks into financial stability monitoring and micro-supervision" (NGFS, 2019a, p. 4).

3.3.2 The forward-looking nature of climate-related risks – Towards a new epistemology of risk

Nevertheless, integrating climate-related risks into financial stability monitoring and prudential supervision presents a significant challenge: traditional approaches to risk management are based on historical data and assumptions that shocks are normally distributed (Dépoues, Bouchet, Cardona & Nicol, 2019). For instance, the concept of value-at-risk (VaR) captures losses that can be expected with a 95–99% level of confidence and over a relatively short-term horizon, whereas climate-related risks typically fit fat-tailed distributions and concentrate precisely in the 1% to 5% not considered by VaR. Capital requirements are also calculated (through estimated probabilities of default (PD), exposure at default (EAD) and estimated loss-given-defaults (LGD) on a one-year horizon and based on credit ratings that largely rely on historical track records of counterparties. As a result, the standard risk-management approach consisting in extrapolating historical values (e.g. PD, market prices) is no longer valid in a world that is fundamentally reshaped by climate change (Kunreuther et al., 2013; Weitzman, 2011).

The current situation can be characterised as an "epistemological obstacle" (Bachelard, 1938). The term refers to how scientific methods that were useful under certain circumstances, can progressively become problematic and hamper scientific research. In fact, precisely such an epistemological break may be taking place in the financial sector: a consensus is emerging among central banks, supervisors and practitioners involved in climate-related risks about the need to use forward-looking, scenario-based methodologies (Batten et al., 2016; NGFS, 2019a; Regelink et al., 2017; TCFD, 2017). Unlike probabilistic approaches to financial risk management, they seek to set up plausible hypotheses for the future without relying on the probability of occurrence of each scenario.

According to the NGFS (2019a), central banks and supervisors should push for climate-related scenario-based analysis to be integrated into both financial stability monitoring and micro-supervision. The first task, assessing the size of climate-related risks in the financial system, requires developing new analytical tools, for example by integrating climate scenarios into regular stress tests. In the same way that stress tests are conducted by regulatory authorities to assess the resilience of banking institutions in an adverse macro-financial scenario (Borio et al., 2014), proposals have been made over the past years to develop "climate stress-tests" (e.g. Battiston, 2019; Battiston et al., 2017; ESRB, 2016; Regelink et al., 2017; UNEP-FI, 2019). Some central banks, regulators and supervisors have already started to consider or develop climate risk scenario analyses for stress tests (Allen et al., 2020; EBA, 2019; EIOPA, 2019; PRA, 2019; Vermeulen et al., 2018, 2019).

The second task for central banks and supervisors consists of ensuring that climate-related risks are well incorporated into individual financial institutions' strategies and risk management procedures. Financial institutions should better understand the forward-looking nature of climate-related risks and consider them in their risk management procedures and investment decisions, as well as in their longer-term strategies (NGFS, 2019a). Managing climate-related risks through a forward-looking approach can lead financial institutions to test the resilience of corporations in their portfolios to potential materializations of physical and transition risks (TCFD, 2017). As a result, discussions have emerged about how the three pillars of the Basel international regulatory framework could integrate climate-related risks. For instance, concerning the Pillar 1 on minimum capital requirements: if being exposed to climate-related risks is seen as part of financial risks, then it might be appropriate to consider capital requirements to reflect such risks. Some developing and emerging economies have already started developing climate-related regulations (see D'Orazio & Popoyan, 2019; Dikau & Ryan-Collins, 2017; Dikau & Volz, 2019), although no measures on capital requirements have yet been implemented.

As the materialization of climate-related risks will increasingly affect central banks' financial stability mandate, it becomes critical for them to assess the extent to which these forward-looking, scenario-based methodologies can ensure that the financial system is resilient to climate-related risks and "green swan" events, as discussed next.

3.4 From climate-related risks to fundamental uncertainty – a first epistemological break

This section reviews some of the methodological challenges that financial institutions and supervisors face when conducting forward-looking, scenario-based analyses aimed at identifying and managing climate-related risks. The goal is not to conduct an exhaustive review of these methodologies but rather to assess what central banks can draw from them. Our key conclusion is that, despite their promising potential, forward-looking analyses cannot fully overcome the limitations of the probabilistic approaches discussed in the previous chapter and provide sufficient hedging against "green swan" events.

Since most methodologies rely on climate-economy models such as Integrated Assessment Models (IAMs), we mostly focus on these models' ability to capture climate-related risks. IAMs cover a great range of methodological approaches and sectoral and regional disaggregation, but at their core they generally combine a climate science module linking greenhouse gas (GHG) emissions to temperature increases, and an economic module linking increases in temperatures to economic and policy outcomes. Some key variables serve to link the climate and economic modules, such as the accumulation of GHGs in the atmosphere, the evolution of mean temperatures, a measure of well-being (GDP), a damage function linking increases in global temperatures to losses in GDP, and a cost function generated by the policies aimed at reducing GHG emissions (e.g., a carbon tax).

However, IAMs are largely unable to satisfactorily address many sources of uncertainty related to physical and transition risks (discussed below). Whereas the use of alternative modeling approaches can help overcome some of these limitations (discussed subsequently), the radical

uncertainty tied to climate change demands alternative approaches (explored in the following section).

3.4.1 Uncertainty related to the physical impacts of climate change

Regarding physical risks, the main methodological limitation of existing models relates to the fact that deep uncertainty exists concerning the biogeochemical processes potentially triggered by climate change. Climate and Earth scientists have shown not only that tipping points remain difficult to estimate with precision (IPCC, 2018; Lenton et al., 2019), but also that they can generate tipping cascades on other biogeochemical processes (Steffen et al., 2018). Moreover, the impacts of such biogeochemical processes on socioeconomic systems can be highly nonlinear, meaning that small changes in one part of the system can lead to large changes elsewhere in the system (Chandra, McNamara & Dargusch, 2018; Smith, 2014) and to chaotic dynamics that become impossible to model with high levels of confidence (Allen et al., 2009; Barnett, Brock & Hansen, 2019). Indeed, "the most striking feature of the economics of climate change is that its extreme downside is non-negligible. Deep structural uncertainty about the unknown unknowns of what might go very wrong is coupled with essentially unlimited downside liability on possible planetary damages" (Weitzman, 2011, p. 275). For instance, it seems that climate change will mostly impact developing economies (although developed economies will also be significantly impacted; see Dantec & Roux, 2019), which could increase global inequality (Diffenbaugh & Burke, 2019; Human Rights Council, 2019) and generate mass migrations and conflicts (Abel et al., 2019; Bamber et al., 2019; Kelley et al., 2015; McNamara et al., 2018).

In the light of these considerations, it has been argued that the damage functions (impacts of climate change on the economy) used by IAMs are unable to account for the tail risks related to climate change (Calel, Stainforth & Dietz, 2015), and in some cases lead studies to suggest "optimal" warming scenarios that would correspond to catastrophic conditions for the future of human and non-human life on Earth (Dietz et al., 2020; Keen, 2019). Similarly, the social cost of carbon (which adds up in monetary terms all the costs and benefits of adding one additional

tonne of CO2), and the choice of a rate of discount of future damages can provide "almost any result one desires" (Pindyck, 2013, p. 5) and lead to outcomes and policy recommendations that are "grossly misleading" (Stern, 2016).

Whereas climate modelers typically embrace uncertainty by showing the great range of outcomes that can result from a specific event or pattern (e.g., a specific CO2 atmospheric concentration can translate into different increases in global temperature and different sea level rises, with respective confidence intervals), this dimension tends to be lost in climate-economy models based on benefit-cost analysis (Giampietro, Mayumi & Sorman, 2013; Martin & Pindyck, 2015).

3.4.2 Uncertainty related to the transition to a low-carbon economy – the socio-technical approach

The textbook solution to mitigating climate change is a globally coordinated Pigovian carbon tax that reflects the shadow social cost of carbon emissions. However, the prospects for an adequate carbon price as an effective, immediate policy intervention to combat climate change look dim, for at least three reasons.

First, it is far-fetched to assume that a significant global carbon tax will be implemented in the current political and economic environment, which is sufficient reason in itself to look for other interventions. Second, given the importance of the climate externality, "the greatest market failure ever seen" according to Stern (2006), estimating the adequate level of a carbon tax and its potential impacts (e.g., its ability to elicit the desired behaviors and technological breakthroughs without unintended consequences) is a delicate exercise. Third, the decarbonization paths we need to take may involve such a dramatic shift in the productive structures of the global economic system that climate change may be best understood as more than an externality. Indeed, it is increasingly understood that mitigating climate change in order to avoid its worst physical impacts amounts to nothing less than an unprecedented

socioeconomic challenge (NGFS, 2019), requiring the replacement of existing technologies, infrastructure and life habits over a very short time frame. The scale and timing of this required transition has even led some to analyze it in terms of a war mobilization or rapid urbanization (Stiglitz, 2019). In this context, the use of a global, economy-wide carbon price as a proxy for climate policy in IAMs (Carbon Brief, 2018) tends to "not structurally represent many social and political forces that can influence the way the world evolves" (IPCC, 2014, p. 422).

In the quest for more comprehensive accounts of how transitions may come about and which corresponding policy tools should be deployed, transdisciplinary approaches such as the study of socio-technical systems and transitions (Geels, Elzen & Green, 2004, 2017) seem more appropriate to embrace the multiple dimensions involved in any climate change mitigation transition than methodologies focusing solely on pricing mechanisms. The socio-technical transition approach is concerned with "understanding the mechanisms through which socioeconomic, biological and technological systems adapt to changes in their internal or external environments" (Lawhon & Murphy, 2011, pp. 356–7). In particular, socio-technical transition scholars provide a framework for more sophisticated qualitative and quantitative approaches, grounded in three layers or parameters that are essential to a low-carbon transition: technological niches, socio-technical regime, and socio-technical landscape. Each of these three layers is discussed below, with examples of potential barriers that will be critical to address yet which are insufficiently captured by existing models.

The first layer of socio-technical transitions corresponds to niche-innovations, i.e. innovations that "differ radically from the prevailing socio-technical system and regime, but are able to gain a foothold in particular applications, geographical areas, or markets" (Geels et al. 2017, p. 465). In this respect, the path of development of low-carbon technologies is unsurprisingly a key parameter for the transition. Yet it is also a significant source of uncertainty, with both potential barriers and breakthroughs to a rapid and smooth transition. The rapidly declining levelized costs of many renewable energy technologies (UNEP, 2019) is an example of unpredictable technological development. Moreover, technologies that are still unknown today may emerge

and develop much more quickly than usually assumed in IAMs (Curran, Robins & Stern, 2019). However, renewable energy is still subject to potential barriers to its development, such as intermittent and unpredictable power output (Moriarty & Honnery, 2016), which requires major improvements in current energy storage technologies. Additionally, some climate-economy models rely so much on negative emissions technologies and on carbon capture and storage (CCS) to meet the 1.5°C or 2°C targets (e.g., leading to an increase in the remaining carbon budget to reach a 2°C world of up to 290% (Carbon Brief, 2018) that they pose question of their technical feasibility, let alone their potentially devastating impacts on other ecosystems (e.g. IPCC, 2019; Pitron, 2018).

The second layer of socio-technical transitions is that of socio-technical regimes, which are "constituted by the conventions, rules, and norms that guide the uses of particular technologies and the everyday practices of the producers, workers, consumers, state agencies, scientists, societal groups, and business people who participate in the regime" (Lawhon & Murphy, 2011, p. 357). For instance, regardless of the price imposed on CO_2 emissions, reducing the number of individual cars (which may be an important part of the solution along with developing cleaner fuels) is much more difficult once cities and suburbs have been planned around individual vehicle ownership. Indeed, once car-based transportation systems are institutionalized, they become self-sustaining "by formal and informal institutions, such as the preferences and habits of car drivers […] and the technical capabilities of car manufacturers, suppliers, and repair shops" (Geels et al., 2017, p. 465).

An additional element of the socio-technical regime has to do with the social acceptability of carbon taxes, which is closely tied to its perceived fairness, and more generally to the fairness of the current wealth distribution. Indeed, the enormous challenges described above mean that the policies to combat climate change are likely to have significant distributional effects (e.g., Dennig et al., 2015; Hallegatte & Rozenberg, 2017; Michaelowa, Allen & Sha, 2018; Rao et al., 2017). Whereas most of the literature in this field has focused on ensuring that carbon taxes are revenue neutral, others have taken a different approach and argued that reducing economic inequalities

may be a pre-condition for an effective carbon tax, as it may be easier for a group to collectively reach a consensus on difficult topics (such as burden-sharing efforts for climate mitigation) when inequalities are considered to be within acceptable boundaries in the first place (Chancel, 2017). Alternatively, carbon mitigation efforts may need to focus first on the lifestyles of the wealthiest individuals, since they are the biggest emitters by far (Otto et al., 2019). In this context, modeling a realistic transition may require better accounting for many dimensions of the current socio-technical regime and the institutional inertia it generates.

The third layer of socio-technical transitions refers to the socio-technical landscape, which considers "the broader contextual developments that influence the socio-technical regime and over which regime actors have little or no influence. Landscape developments comprise both slow-changing trends (e.g., demographics, ideology, spatial structures, geopolitics) and exogenous shocks (e.g., wars, economic crises, major accidents, political upheavals)" (Geels et al., 2017, p. 465). In particular, the geopolitical dimensions of the low-carbon transition are critical yet particularly difficult to grasp through climate-economy models. If no "common but differentiated responsibilities" (UNFCCC, 2015) or burden-sharing principles prevail on climate negotiations, ambitious climate action from one country could lead to free-riding behaviors from others and/or to outsourcing production to less stringent jurisdictions, potentially offsetting the gains in one country with an increase in GHG emissions elsewhere. Moreover, a transition away from fossil fuels can affect the balance of power between states, reconfigure trade flows and transform the nature of conflicts, e.g., with fewer oil-related conflicts but possibly more conflicts related to access to minerals (IRENA, 2019).

Going further into the assessment of the socio-technical landscape in which the low-carbon transition should take place, the major transformations of capitalism of the past decades may also be worth considering when addressing the question of which strategy is realistically the most adequate to tackle climate change. For instance, the shift since the 1970s in the objectives of corporates with a narrow focus on shareholder value maximization, the still-prevailing dominance of the efficient market hypothesis (Mazzucato, 2015) and the "continued erosion of

workers' bargaining power" (BIS, 2019, p. 9) may lead to a situation where corporates are structurally unable to fully embrace the old and new responsibilities associated with their growing power.

Climate-economy models are inherently incapable of representing many of the interactions outlined above. Therefore, they overlook many social and political forces that will strongly influence the way the world evolves (Espagne, 2017; IPCC, 2007). In this context, scenario-based risk analyses should be assessed cautiously, as they rely on strong yet (often) implicit assumptions regarding the three layers discussed above. It is therefore not surprising, for instance, that the financial valuations of stranded assets largely diverge (e.g., between $1 trillion and $4 trillion according to Mercure et al. (2018); around $1.6 trillion as estimated by Carbon Tracker (2018); and up to $18 trillion according to IRENA (2017)) as those rely on largely diverging assumptions and methodological choices.

3.4.3 Cascade effects, non-equilibrium models and radical uncertainty

While the above has mostly focused on the general inability of climate-economy models to capture different sources of uncertainty, the task of identifying climate-related risks is made even more difficult by at least three factors.

First, stranding an asset in one specific sector can trigger a "cascade of stranded assets" affecting many other sectors of the economy (Johnsson et al., 2019). Cahen-Fourot et al. (2019) show that the reduction in production in one sector can cascade to physical stocks supporting the rest of the economic activity through chains of intermediate exchange. For instance, the mining and quarrying sector (including the extraction of fossil fuels), although it accounts for a relatively low share of value added, tends to provide crucial inputs for many other downstream economic activities such as construction, electricity and gas. In turn, these sectors are critical for the correct functioning of public administration, machinery and equipment and real estate activities, and so on.

Second, although physical and transition risks are usually treated separately, these are likely to interact with each other in practice. These interactions can generate new, complex cascade effects that cannot be captured by physical or transition risks separately. In short, the physical and transition risks of climate change are subject to multiple forces (natural, technological, societal, regulatory and cultural, among others) that interact with each other and are subject to uncertainty, irreversibility, nonlinearity and fat-tailed distributions.

Third, and even more fundamentally, climate-related risks will remain largely uninsurable or unhedgeable as long as system-wide action is not taken. In contrast to specific areas where scenario analysis can help financial institutions avoid undesirable outcomes (e.g., avoiding a dam collapse for a hydropower project), climate-related scenario analysis cannot by itself enable a financial institution or the financial system as a whole to avoid and withstand "green swan" events.

To better account for the specific features of climate-related risks discussed above, some alternative modeling approaches seem particularly promising. In particular, Mercure et al. (2019) find that "equilibrium" and "non-equilibrium" models tend to yield opposite conclusions regarding the economic impacts of climate policies. Equilibrium models, such as dynamic stochastic general equilibrium (DSGE), remain the most widely used for climate policy, yet their central assumption that prices coordinate the actions of all agents (under constrained optimization) to equilibrate markets for production factors fails to represent transition patterns (including some discussed above) in a consistent manner. In this context, non-equilibrium models may be better positioned to address three critical features of the transition:

(i) Path dependency: in non-equilibrium models, the state of the economy depends on its state in previous time steps. This approach seems particularly aligned with the purpose of scenario analysis, consisting as it does in describing the economy under different possible and diverging circumstances that are dependent on past and present decisions. For instance, it is easier to represent how socio-technical inertia shapes current behaviors, beyond and despite pricing mechanisms;

(ii) Role of money and finance: the need to better account for the dynamics of the financial sector has been widely discussed after the 2007–08 Great Financial Crisis, yet the discussion has only slightly permeated the field of climate economics so far (Espagne, 2018; Mercure et al., 2019). A more central role is often attributed to finance in non-equilibrium models, particularly in the post-Keynesian school of thought through stock-flow consistent models: money is created by banks in response to demand for loans, and therefore investments are not constrained by existing savings (Lavoie, 2014). This may better represent the behavioral dynamics of financial institutions than DSGE (Dafermos et al., 2017), especially when merged with agent-based models (Monasterolo et al., 2019);

(iii) Role of energy: standard economic theory, based on the cost share of energy in GDP, implies that a decrease in energy use reduces GDP but only to a limited extent. For instance, as energy costs typically represent less than 10% of GDP, a 10% reduction in energy use would lead to a loss in GDP of less than 1% (Batten, 2018, p. 28). However, a growing literature suggests that the role of energy in production should not be treated as a third input independently from labor and capital (as in three-factor Cobb-Douglas production functions) but through a different "epistemological perspective" (Keen, Ayres & Standish, 2019): energy is an input to labor and capital, without which production becomes impossible (Ayres, 2016). In this view, an improvement in energy efficiency may paradoxically lead (all other things being equal) to a sharp decrease in GDP. Given the critical role of energy for the transition, non-equilibrium models which can account for the peculiar role of energy in economics (Ayres, 2016; Keen et al., 2019; The Shift Project & IFPEN, 2019) may be critical for future scenario-based analysis.

Whereas such alternative models can provide many insights, their descriptive and normative power remains limited by the sources of deep and radical uncertainty related to climate change discussed above. That is, the catalytic power of scenario-based analysis, even when grounded in approaches such as non-equilibrium models, will not be sufficient to translate climate-related

uncertainty into measurable and manageable risks. 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, 1921/2009; Keynes, 1936), such as "green swan" events. The question of decision-making under deep or radical uncertainty is making a comeback following the 2007–08 Great Financial Crisis (Webb, Baumslag & Read, 2017). According to former governor of the Bank of England Mervyn King, embracing radical uncertainty requires people to overcome the belief that "uncertainty can be confined to the mathematical manipulation of known probabilities" (King, 2017, p. 87) with alternative and often qualitative strategies aimed at strengthening the resilience and robustness of the system (see also Kay & King, 2020).

As a result of this, more holistic approaches that can better embrace the deep or radical uncertainty related to climate change, as well as the need for system-wide action (Aglietta & Espagne, 2016; Campiglio et al., 2018; Chenet, Ryan-Collins & van Lerven, 2019; Ryan-Collins, 2019; Svartzman, Dron & Espagne, 2019) will also be needed, as discussed next.

3.5 Embracing fundamental uncertainty and systems resilience – a second epistemological break

Because of the limitations discussed above, climate change could drag central banks into uncharted waters. On the one hand, they cannot simply sit still and wait for other government agencies to jump into action: this could expose central banks to the real risk that they will not be able to deliver on their mandate of financial stability. On the other hand, central banks cannot succumb to the growing social demand which argues that, given the severity of climate-related risks and the role played by central banks following the 2007–08 Great Financial Crisis, central banks could now substitute for many (if not all) government interventions. For instance, pressures have grown to have central banks engage in different versions of "green quantitative easing" to "solve" the complex socioeconomic problems related to a low-carbon transition. Without denying the reality of evolutionary perspectives on central banking (e.g., Aglietta, 2018; Goodhart, 2010; Johnson, 2016; Monnet, 2014) and the fact that climate change could perhaps

be a catalyst of new evolutions, the focus on central banks as the main agents of the transition is risky: central bankers are not elected officials and they should not replace or bypass the necessary debates in civil society (Volz, 2017). From a much more pragmatic perspective, mitigating climate change requires a combination of fiscal, industrial and land planning policies (to name just a few) on which central banks have no experience.

In this context, a second "epistemological break" is needed to approach the role of central banks, regulators and supervisors in the face of deep or radical uncertainty. This demands a move from an epistemological position of risk management to one that seeks to build the resilience of complex adaptive systems, which will be impacted in one way or another by climate change (Fath, Dean & Katzmair et al., 2015; Schoon & van der Leeuw, 2015). This system resilience view is grounded in three main tenets: (i) new analytical frameworks are needed to represent the interactions between humans and their natural environment; (ii) these interactions need transdisciplinary approaches (rather than multidisciplinary ones where each discipline continues to adhere to its existing views when approaching another discipline requires a different paradigm); and (iii) open systems are generally not in equilibrium, i.e. their behavior is adaptive and dependent upon multiple evolving interactions.

What are the policy implications of this approach for central banks, regulators and supervisors? In what follows, we argue that the current efforts aimed at measuring, managing and supervising climate-related risks will only make sense if they take place within an institutional environment involving coordination with monetary and fiscal authorities, as well as broader societal changes. In other words, if central banks are to preserve their financial stability mandate over longer-term horizons than those traditionally envisioned, they will need to coordinate their actions with a broad set of measures to be implemented by other players (i.e. governments, the private sector, civil society and the international community).

Towards this end, we suggest and critically discuss three non-exhaustive propositions that could contribute to guaranteeing system resilience and therefore financial stability in the face of

climate uncertainty: (i) better coordination of fiscal, monetary and prudential and carbon regulations is essential to successfully support an environmental transition, especially at the zero lower bound; (ii) increased international cooperation on environmental issues among monetary and financial authorities will be essential; (iii) more systematic integration of climate and sustainability dimensions within financial practices can also help private and public players manage environmental risks. Potential interactions between these developments and central banks' actions are discussed below and outlined in table 3.1.

We do not discuss carbon pricing not because we think it is not important. On the contrary, higher and more extensive carbon pricing is an essential part of the policy mix going forward, and that it will become both more politically accepted and more economically efficient if the other measures outlined here are implemented.

Table 3.1: Central banks' actions and contributions to coordination to combat climate change: the risk, time horizon and system resilience approaches

Responsibilities / Paradigmatic approach to climate change	Measures to be considered by central banks, regulators and supervisors	Measures to be implemented by other players[1] (government, private sector, civil society)
Identification and management of climate-related risks **>> Focus on risks**	Integration of climate-related risks (given the availability of adequate forward-looking methodologies) into: – Prudential regulation – Financial stability monitoring	- Voluntary disclosure of climate-related risks by the private sector - Mandatory disclosure of climate-related risks
Limitations: – Epistemological and methodological obstacles to the development of consistent scenarios at the macroeconomic, sectoral and infra-sectoral levels – Climate-related risks will remain unhedgeable if system-wide transformation is not undertaken		
Internalization of externalities **>> Focus on time horizon**	Promotion of long-termism as a tool to break the tragedy of the horizon, including by integrating environmental, social and governance (ESG) considerations into own portfolios	– Carbon pricing – Systematization of ESG practices in the private sector
Limitations: – Central banks' isolated actions would be insufficient to reallocate capital at the speed and scale required, and could have unintended consequences – Limits of carbon pricing and of internalization of externalities in general: insufficient to reverse existing inertia/generate the necessary structural transformation of the global socioeconomic system		
Structural transformation towards an inclusive and low-carbon global economic system **>> Focus on resilience of complex adaptive systems in the face of uncertainty**	Acknowledgment of radical uncertainty and need for structural change to preserve long-term climate and financial stability. Exploring: – Green monetary-fiscal-prudential coordination – The role of non-equilibrium models and qualitative approaches – Potential reforms of the international monetary and financial system, grounded in the concept of climate and financial stability as public goods	– Green fiscal policy (enabled or facilitated by low interest rates) – Societal debates on the potential need to revisit policy mixes (fiscal-monetary-prudential) given the climate and broader ecological imperatives ahead – Integration of climate stability as a public good to be supported by the international monetary and financial system

[1] Measures which are deemed essential to achieve climate and financial stability, yet which lie beyond the scope of what central banks, regulators and supervisors can do.

Source: adapted from Bolton et al. (2020).

3.5.1 Coordinating prudential regulation and monetary policy with fiscal policy

In order to mitigate climate-related risks, direct government expenditures will be essential to overcome what the former governor of the Bank of England, Mark Carney, called the "tragedy of the horizon"(Carney, 2015): while the physical impacts of climate change will be mostly felt over a long-term horizon, with massive costs and possible civilizational impacts on future generations, the time horizon in which financial and economic players typically plan and act is much shorter. Indeed, the public sector is usually in a better position to fund investments in R&D for early-stage technologies with uncertain and long-term returns. For instance, in a series of case studies across different sectors (e.g., nanotech and biotech), Mazzucato (2015) has shown how government investment in high-risk projects has proved essential to create the conditions for private investments to follow. Sustainable public infrastructure investments are also fundamental as they lock in carbon emissions for a long time (Arezki et al., 2016; Krogstrup & Oman, 2019). They can provide alternative means of production and consumption, which would then enable economic agents to change their behaviour more effectively in response to a carbon price (Fay et al., 2015; Krogstrup & Oman, 2019). The ability of governments to implement measures that account for the welfare of future generations is therefore essential (Michaelowa, Allen & Sha, 2018), while prudential and monetary tools can only complement these policies (Krogstrup & Oman, 2019).

It is noteworthy that, under this approach, government action would not seek to manage climate-related risks optimally but rather to steer markets "in broadly the right direction" (Ryan-Collins, 2019). In turn, such a proactive shift in policymaking could lead market players to reassess the risks related to climate change.

The key question that has arisen regarding fiscal policy is that of how governments could fund such investments, and what kind of policy mix this could entail. In this respect, several economists have recently argued that financing the low-carbon transition with public debt is both politically

more feasible than through carbon taxation and economically more sustainable in the current low interest rate environment, which provides several countries with a larger than previously anticipated fiscal room for maneuver (Bernanke, 2017; Blanchard, 2019; Borio & Song Shin, 2019; DeLong & Summers, 2012; Kelton, 2019; Summers, 2019).

In this context, the fact that central banks in advanced economies are globally setting interest rates near or even below zero at a time where massive and long-term investments are needed is probably their greatest contribution to governments' ability to play their role in combating climate change. Indeed, low interest rates can facilitate the access of governments to long-term and cheap funding. McCulley and Pozsar (2013) suggest that what matters in times of crisis is not monetary stimulus per se but whether monetary policy helps the fiscal authority maintain stimulus. As zero or negative interest rates may remain in place for a long period (Turner, 2019), financing the transition to a low-carbon economy via government debt presents fewer risks and would not threaten the mandate of central banks, as long as private and public debt growth continues to be closely monitored and regulated (Adrian & Natalucci, 2019).

3.5.2 Calling for international monetary and financial cooperation

Climate stability is a global public good, which raises difficult questions regarding international policy coordination and burden-sharing between countries at different stages of economic development, as discussed in the previous section. Unfair or poorly coordinated international action may simply incentivize some countries to free-ride (Krogstrup & Obstfeld, 2018). Thus, climate change mitigation actions need to be built on international cooperation between advanced and developing countries (Villeroy de Galhau, 2019) and the recognition of the need for technology transfers and increases in official development assistance to developing countries.

In this context, several proposals have focused on embedding climate concerns within existing international institutions such as the International Monetary Fund (IMF) (Aglietta & Espagne, 2018), as part of their responsibilities to manage the international monetary and financial system.

In particular, proposals have been made to issue "green" Special Drawing Rights (SDRs) (Aglietta & Coudert, 2019; Bredenkamp & Pattillo, 2010; Ferron & Morel, 2014; Ocampo, 2019), the IMF-managed international reserve asset based on a basket of currencies. For instance, Aglietta and Coudert (2019, p. 9) suggest creating trust funds in which countries' unused foreign exchanges could be converted into SDRs and invested to finance the guaranteed low-carbon investment program. Moreover, SDR loans to developing countries could be pledged to their national intentions of carbon emission reductions, meaning that countries with more ambitious climate policies would more easily access global liquidity.

Scaling up these mechanisms may require a major overhaul of the global governance system and could have major consequences for central banks, notably on their management of foreign exchange reserves; yet they could become essential to build a "green" and multilateral financial system capable of channeling savings from all parts of the world to finance the low-carbon transition (Aglietta & Coudert, 2019; Aglietta & Espagne, 2018).

3.5.3 Promoting sustainability as a tool to break the tragedy of the horizon – The role of values

In addition to these public and international dimensions of climate change, the more systematic integration of sustainability criteria by the financial sector can also play a role. This includes fostering the integration of environmental, social and governance (ESG) standards into financial practices. The definition of ESG criteria and their integration into investment decisions can vary greatly from one institution to another. However, generally it involves structuring a portfolio (of loans, bonds, equities, etc) in a way that aims to deliver a blend of financial, social and environmental benefits (Emerson & Freundlich, 2012). The main benefit of promoting a sustainable finance approach, including through ESG, actually, may not lie in the greater impetus for asset managers to reduce their exposure to climate-related risks, but rather, in broadening the set of values driving the financial sector. By accepting potentially lower financial returns in the short run to ameliorate longer-term social and environmental results, time can be valued in a manner that better corresponds to environmental systems' "own patterns of time sequences

for interactions among parts, abilities to absorb inputs, or produce more resources" (Fullwiler, 2015, p. 14).

In this way, the promotion of sustainable finance practices could incentivize long-termism in the financial sector and thereby contribute to overcoming the "tragedy of the horizon" (therefore indirectly reducing climate-related risks). As such, the recent rise in the sustainable finance movement may offer "an opportunity to build a more general theory of finance" (Fullwiler, 2015) that would seek to balance risk-return considerations with longer-term social and environmental outcomes.

Here too, central banks can contribute to the effort by applying ESG criteria to their own portfolios (NGFS, 2019a). For instance, Sweden's central bank recently applied sustainability criteria to its foreign exchange reserves by selling off bonds emitted by subnational Australian and Canadian authorities highly exposed to carbon-intensive activities (Flodén, 2019). Proposals have been made also to apply sustainable considerations to central banks' collateral framework. These are grounded in the view that the current implementation of market neutrality leads to implicit bias in favor of carbon-intensive industries (Matikainen, Campiglio & Zenghelis, 2017; Jourdan & Kalinowski, 2019) that could end up affecting central banks' very own mandates in the medium to long term. Thus, and subject to safeguarding the ability to implement monetary policy, a sustainable tilt in the collateral framework could contribute to reducing financial risk. That is, it would favor market neutrality over longer time horizons than those traditionally considered in the conduct of monetary policy (van Lerven & Ryan-Collins, 2017).

3.6 Conclusion

Central banks are increasingly aware of the physical and transition risks posed by climate change, and of the peculiar nature of climate-related risks. In this context, a first epistemological break has started to take place within the central banking and financial community with the development of forward-looking risk assessments and incipient climate-related regulations. These assessments and regulations will be essential but not sufficient to ensure that the financial

system remains resilient to climate-related risks: the deep or radical uncertainty involved and the need for a structural transformation of the global socioeconomic system mean that no single model or scenario can provide sufficient information to hedge individual agents from climate change.

Given this situation, central banks can neither sit still (and wait for climate-related risks to materialize) nor substitute for government interventions, given that a system-wide transition is required. In this context, a second epistemological is needed: if central banks are to preserve their financial stability mandate in the age of climate change, they will need to coordinate their actions with a broad set of measures to be implemented by other players (i.e. governments, the private sector, civil society and the international community). Toward this end, this paper explored three non-exhaustive propositions (beyond carbon pricing) related to: the potential interactions between central banks and fiscal policy, the need for international monetary and financial reforms, and the integration of sustainability criteria into the financial system.

Finally, one should keep in mind that climate change is only the "tip of the iceberg" (Steffen et al., 2011): long-term sustainability extends to other human-caused environmental degradations such as biodiversity loss, which could pose new types of financial risks (Schellekens & van Toor, 2019). The potential ramifications of these environmental risks for financial stability are far beyond the scope of this paper. Yet, addressing them will also become critical for central banks, regulators and supervisors insofar as the stability of the Earth system is a prerequisite for financial stability. Rethinking macroeconomic and financial systems in the light of these considerations is still an underdeveloped area of research in most of the economic discipline, although great progress has been achieved in recent times towards bringing this question to the mainstream (e.g. OECD, 2019a, 2019b), including in the field of ecological economics (Georgescu-Roegen, 1971; Martinez-Alier, 1987; Daly & Farley, 2011; Jackson, 2017; Spash, 2017). Future research should draw from their insights if we are to address financial stability and resilience in the age of ecological systemic risks.

3.7 Acknowledgments

The authors acknowledge all the suggestions, comments and contributions made to the book "The green swan: central banking and financial stability in the age of climate change", which has informed this article.

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Connecting Text

The previous chapter identified the limitations of the mainstream approach to ecological risks and suggested alternative approaches. In particular, it highlighted the ability of ecological economics to view the economic system as being embedded in social and biophysical systems, and the ability of post-Keynesian economics to appreciate the importance of money and finance in capitalist dynamics. Several scholars have identified the need to merge the insights from these two disciplines, and gave birth to a still incipient field of ecological macroeconomics.

The following chapter discusses whether this field of ecological macroeconomics is a more appropriate starting point to re-embed monetary institutions within our planetary boundaries. It explores why this field provides both more realistic theoretical foundations to approach the monetary and financial system in the age of ecological crises, and a more promising policy toolbox to trigger an ambitious ecological transition. It also highlights the shortcomings of the field, and in particular its tendency to dismiss the deeper ethical and historical roots of our ecological crises, as revealed by the world-ecology approach.

This chapter was published in the peer-reviewed journal Ecological Economics: Svartzman, R., Dron, D, & Espagne, E. (2019). From ecological macroeconomics to a theory of endogenous money for a finite planet. *Ecological Economics, 162(C),* 108-120. DOI: 10.1016/j.ecolecon.2019.04.018.

Chapter 4 – From ecological macroeconomics to a theory of endogenous money for a finite planet

4.1 Abstract

This paper takes stock of the achievements and gaps of the emerging field of ecological macroeconomics, which has brought insights from specific schools of macroeconomics—most notably post-Keynesian—to ecological economics, with a strong emphasis on the endogeneity of money. Ecological macroeconomics has proposed fiscal, monetary and prudential reforms to boost 'green' investments, and developed new modeling frameworks to explore the interactions between the financial, macroeconomic and biophysical spheres. While these proposals open a broader range of possibilities to engage in a socio-ecological transition than those offered by the current paradigm of a financialized global economy, they paradoxically suffer from similar limitations. By placing much faith in 'green' investments, they impose a vision of the transition that presents strong technical and institutional limitations. The field also fails to revisit its own understanding of macroeconomics and of specific phenomena—e.g. financial instability—through a biophysical lens, in spite of increasing transdisciplinary evidence supporting this approach. We suggest overcoming these limitations through institutionalist perspectives that understand money as a language through which value is created and legitimized. Those perspectives seem essential to re-embed the governance of money within a worldview that acknowledges the finiteness and incommensurable values of Earth's life support systems.

4.2 Introduction

The conjunction of the growing awareness of the human-caused degradation of Earth's life support systems (e.g. Crutzen, 2002; Ripple et al., 2017; Rockström et al., 2015; Steffen et al., 2015) and the economic instability of financialized capitalism evidenced by the 2007-08 global financial crisis (e.g. Keen, 2017; Lavoie, 2014; Turner, 2015) has led to the development of a field of 'ecological macroeconomics'. Over the past decade, this field has strived to integrate insights from ecological economics with those of different macroeconomics streams—mostly post-

Keynesian but also neochartalism (or MMT, Modern Monetary Theory) and Regulation school—that have long worked on the critical role played by money and finance in the functioning of capitalist economies. The dedication of a full section to ecological macroeconomics in this journal (Rezai and Stagl, 2016) and a book published on "Post Keynesian and Ecological Economics" (Holt, Pressman and Spash, 2009) are symptomatic of the growing interest in this field.

The scholars in this emerging field, despite diverging views on various issues—see, for instance, Lavoie (2013), Rochon and Vernengo (2003) and Tymoigne and Wray (2015) for debates between post-Keynesian and MMT perspectives—concur on the view that money is endogenous and demand-led, by opposition to the neoclassical notion that money is merely a veil on the exchange of goods and services between atomistic economic agents. With regard to ecological economics, they have all paid particular attention to how an endogenous approach to money offers new ways of accelerating and increasing the amount of 'green' investments needed for the transition, through a mix of government expenditures, financial regulation and monetary policy. Therefore, for the purpose of this paper, they will be indistinctly referred to as 'endogenous monetary theorists' or 'ecological macroeconomists'.

This article takes stock of the achievements and gaps in ecological macroeconomics some ten years after the field's emergence. Whereas prior assessments have been carried out with regard to the major themes (Rezai and Stagl, 2016), models (Hardt and O'Neill, 2017) and—relative lack of—systems thinking (Røpke, 2016) found in ecological macroeconomics, this paper assesses whether the field provides a relevant epistemological position and methodological toolbox to overcome the limitations of mainstream environmental macroeconomics and engage in an ambitious socio-ecological transition.

We find that ecological macroeconomics has achieved considerable progress in two ways: first, by initiating the process of integrating ecological concerns within streams of macroeconomics—post-Keynesian, MMT and Regulationist—that had historically overlooked such concerns (Lavoie,

2014: 578-581); second, by enabling ecological economists to better understand money and finance, historically a weakness in the field (Fontana and Sawyer, 2016a).

However, we also find that ecological macroeconomics has largely consisted in applying and at times imposing—albeit probably unconsciously—a certain vision largely influenced by post-Keynesian theory, to address ecological issues that require alternative ontological and epistemological approaches. In particular, the field's methodological toolbox remains largely embedded in a conceptual framework that keeps approaching nature first and foremost as a type of 'capital' (e.g. Fontana and Sawyer, 2016a; Jackson and Molho, 2018), the depreciation of which could be avoided with so called 'green' investments[22]. We contend that this view fails to discuss critical technical (e.g. Smil, 2010; 2017), institutional (e.g. Paavola, 2007; Ostrom, 2009; Vatn, 2010) and ethical (e.g. Brown, 2012; Descola, 2005; Latour, 2004) dimensions of a socio-ecological transition.

Moreover, despite growing evidence that human-nature relationships are internal to the process of capital accumulation (Huber, 2013a) and may feed comprehensive assessments of topics like financial instability (Moore, 2015), ecological macroeconomists have failed to revisit their own approach to macroeconomics by integrating notions emerging from ecological economics and related fields such as political ecology, environmental history and "world-ecology" approaches (Moore, 2015). The persistent consideration of ecological issues as an *ad hoc* topic of enquiry has prevented endogenous monetary theorists from questioning their pre-analytical views of a "world of abundance" (Lavoie, 2014: 22).

For these reasons, we find that their proposals fit within a "shallow" approach to ecological economics (Spash, 2013), in the sense that they fail to address concerns "about environmental

[22] This does not suggest that the concept of 'natural capital'—which has been the subject of an ongoing debate in ecological economics since Costanza et al. (1997)—should be entirely dismissed. Rather, we purport that treating nature merely as capital feeds the misconception that investing in 'it' is sufficient to impede its depreciation. This approach is all the more surprising that post-Keynesian authors are aware of the limitations of the concept of capital itself, as reflected by the Cambridge capital controversy (Mearman, 2009).

values and human relationships with Nature" and discuss the political and economic implications of different possible transition paths (ibid: 352). In doing so, it remains unclear whether the methodological toolbox used by ecological macroeconomics represents: i) a realistic and ambitious avenue of reform within the existing institutional framework; ii) a form of 'second best' option given the difficulty of challenging the deep roots of our ecological predicaments; or iii) a missed opportunity to develop a much-needed "third position as regards the discursive battle between austerity policies and Keynesian approaches; a position that can combine social, environmental and distributional concerns" (Røpke, 2016: 238).

Given this article's emphasis on endogenous money theory, we focus on how incorporating institutionalist approaches that understand money as a language through which value is created and legitimized—drawing notably on Aglietta et al. (2016)—may provide a promising entry point for overcoming the current limitations of the field and develop this so-called 'third position'. In particular, it could open research avenues aimed at developing a new monetary order embedded in a worldview that acknowledges the finiteness and incommensurable values of Earth's life support systems.

The article is structured as follows: Section 2 reviews the theoretical foundations and proposals of the emerging field of ecological macroeconomics. The rest of the article presents three critical limitations of the current state of the field: section 3 shows how the concept of 'green' investments—presented as the main tool to tackle ecological issues—imposes a biased view of the transition and is potentially undermined by biophysical and institutional factors ignored by most ecological macroeconomists; section 4 argues that rather than only applying their methodological tools to assess and address ecological concerns, endogenous monetary theorists could also further develop their own understanding of capital accumulation and financial crises by adopting a biophysical lens; section 5 suggests that drawing on institutionalist approaches to money could bridge a critical gap between ecological economics and these macroeconomics schools of thought.

4.3 Foundations and proposals of the incipient field of ecological macroeconomics

4.3.1 Beyond mainstream environmental macroeconomics

The dominant framework for assessing environmental issues at the macroeconomic scale remains grounded in neoclassical economics (e.g. Nordhaus, 2018). The inclusion of 'natural capital' as a third factor of production in addition to capital and labor (Hartwick, 1977; Solow, 1974; Stiglitz, 1974), where each factor's productive power is proportionate to its cost-share in total income, has resulted in the consideration of natural resources as a marginal input to production (Ayres et al., 2013) and the loss in 'natural capital' as being substitutable with human-made capital in most functional forms chosen for the production function. Environmental concerns related to the waste and ecological damages generated by economic activity, such as CO2 atmospheric and oceanic concentration, have been treated as instances "of market failure involving externalities and public goods" (Stern et al., 2006: 25). Given this approach to the problem, the seemingly logical response has been to advocate for the allocation of property rights and pricing mechanisms as the solution to any problem (Gowdy and Erickson, 2005: 209), from global warming and chemical pollution to biodiversity loss.

This neoclassical macroeconomic approach to ecological issues has received two broad categories of critiques. First, the assumption that promoting pricing or market-based instruments will suffice to solve all problems runs into strong limitations, including the following: i) it reduces ecosystems' intrinsic complexity (see Fath et al., 2007; Goerner et al., 2009) and leads to trade-offs between interdependent ecosystem services (Muradian and Rival, 2012); ii) the protection of natural resources and ecosystem services requires flexible institutional arrangements that address specific societal dynamics—including power asymmetries—while promoting cooperation and trust among stakeholders, in a far more complex manner than neoclassical pricing mechanisms suggest (Dron, 2018; Kolinjivadi et al., 2017; Ostrom, 2010; Vaissière and Levrel, 2015; Vatn, 2010); and iii) whereas prices and market mechanisms can work at the local scale, it is structurally impossible to apply their logic to address systemic problems such as climate

change since "the current planetary economic system is viable only because of the huge “free-of-charge” benefits humans derive from natural ecosystems" (Muradian and Rival, 2012: 96).

Second, the analytical frameworks that have been used to deal with ecological issues, such as the Integrated Assessment Modeling (IAM) for climate change, suffer from many flaws related to the axioms of neoclassical economics (Pottier, 2016). Of particular relevance for this paper, 'economic-climate' models fail to account for the critical role played by uncertainty in economic decisions. Uncertainty about the future is the key driver of the decision-making process of economic agents (Keynes, 2013 [1936]). Even in a—very theoretical—free market economy, the coordination of agents around a specific price would take place through individual behaviors that are themselves influenced by institutions, i.e. by a constantly evolving social environment (Aglietta and Espagne, 2016: 5; Orléan, 2015). Pricing mechanisms therefore reflect the agents' beliefs at a particular point in time and in a context of radical uncertainty. The 2007-08 global financial crisis was a sharp reminder of the changing nature of these beliefs with regard to financial assets, and of the structural incapacity of unregulated financial markets to stabilize their own expectations about the future (Minsky, 1986). With regard to the natural environment, understanding price theory as resulting from social interactions implies, among other things, that financial markets do not have the inherent capacity to reflect the actual scarcity of a finite natural resource (Bouleau, 2018) or to anticipate the costs of a damaged ecosystem.

Moreover, climate change is a specific factor of uncertainty in itself for both scientists and policy makers (Otto et al., 2015). In this context, markets are unable to gauge how to avoid or react to the possibility of systemic and irreversible ecological damages or 'fat tails', as posited by Weitzman's "dismal theorem" (2009). Indeed, if the worst impacts of climate change were to materialize, then the idea of using pricing mechanisms to handle them would become irrelevant, as the very instrument that measures prices—money—would itself be affected. For example, investing in safe and liquid assets such as US Treasury bonds could not protect an investor from rising temperatures, i.e. it would not hedge against the risk of climate damages and therefore would no longer be *safe*. Therefore, our collective decision to do our best to avoid these damages

cannot be based on an 'incalculable probability' and on risk management mechanisms, but should rather be dictated by other imperatives such as a precautionary principle. In other words, the fundamental uncertainty related to addressing climate change can only be mitigated by the common agreement around the design and use of specific institutional arrangements (Aglietta and Espagne, 2016), in an effort that goes well beyond measuring risk and pricing damages.

4.3.2 Endogenous money as a necessary starting point - An overview of ecological macroeconomics' modeling frameworks and policy proposals

This state of play started evolving after the 2007-08 global financial crisis, as evidenced by numerous publications assessing the potential alliance between ecological economics and alternative approaches to macroeconomics such as post-Keynesianism (e.g. Holt, Pressman and Spash, 2009), Regulation school (e.g. Aglietta et al., 2016; Chester and Paton, 2013) and Modern Monetary Theory (MMT) (e.g. Hail, 2018; Lawn, 2010). Particular emphasis was placed on merging post-Keynesian and ecological economics, with several articles (e.g. Fontana and Sawyer, 2016a; Kronenberg, 2010), book chapters (e.g. Jackson and Victor, 2015a) and even an entire book (Holt, Pressman and Spash, 2009) dedicated to this question.

The proposals of these respective schools of thought with regard to an ecological transition share enough similarities to be grouped under one category for the purpose of this paper, hereafter the 'endogenous money' approaches. Indeed, they have emphasized that a more accurate understanding of money and finance than the one taken for granted in neoclassical economics is a critical element for developing a field of ecological macroeconomics[23]. The dynamics of capitalism take place within what Keynes referred to as a "monetary economy of production" (Ponsot, 2017: 118). Unlike the neoclassical economics' framework, in which money is seen as a

[23] Sharing an endogenous approach to money is not the only distinguishing feature of ecological macroeconomics. For example, Rezai et al. (2013) argue that by not relying on the assumption that economic agents maximize their utility, post-Keynesian economics is compatible with the pluralism of values advocated by ecological economists. The role of uncertainty is also emphasized in both strands of literature (Fontana and Sawyer, 2016a: 187).

simple lubricant of exchanges, economic production in the 'real world' requires the existence of three institutions forming an integrated system: money, finance and banking (Mehrling, 2017)[24]. More specifically, money is endogenous and mainly demand-led: it is created by banks, in the form of interest-bearing debt, in anticipation of the creation of economic value by an agent demanding it (Fontana and Sawyer, 2016a; Rochon and Rossi, 2013). Money is therefore also an accounting convention: it is created through loans, increasing both the assets and liabilities of the issuing bank, and it is destroyed through the repayments of these loans (Campiglio, 2016; McLeay et al., 2014). Hence, it is critical to explicitly represent monetary and financial dynamics in climate-economy models, thereby adding new factors of uncertainty in the agents' decision-making process. However, their absence in such models has remained largely unnoticed until recently (Espagne, 2018).

In practice, the work conducted by ecological macroeconomists has consisted of a mix of developing new modeling frameworks and formulating "qualitative" (Røpke, 2016: 238) proposals. With regard to modeling—for a thorough overview, see Hardt and O'Neill (2017)—a clear focus on post-Keynesian's stock-flow consistent (SFC) models can be identified (e.g. Campiglio et al., 2017; Dafermos et al., 2017; Jackson and Victor, 2015a). As explained by Jackson (2017: 179), "the overall rationale of the SFC approach is to account consistently for all monetary flows between agents and sectors across the economy", where one agent's expenditures correspond to another agent's income and all financial assets in one sector correspond to financial liabilities in another sector. The endogenous approach to money is therefore at the very core of these models.

In the ecological SFC models developed to date, the financial sector is seen as interacting with macroeconomics as in standard post-Keynesian theory, but the macroeconomy can now be affected by resource scarcity and/or damaged ecosystems services—including through input-

[24] As discussed in sections 4 and 5, understanding capitalism as a monetary economy of production is critical but incomplete, as it leaves aside many non-monetized dimensions that support economic production and capital accumulation. These include the reproductive and domestic duties accomplished mostly by women and the unpaid 'work' of nature (Moore, 2015).

output models (see Hardt and O'Neill, 2017). In this view, ecosystems are thus indirectly connected to finance, via the common forum of the macroeconomy, and feedback channels can take place (e.g. Dafermos et al., 2017). As a recent example of the application of ecological SFC models, Dafermos et al. (2018) aimed to analyze the potential effects of climate change on financial stability. The authors seek to "portray explicitly the balance sheets and the financial flows in the financial sector" (Dafermos et al., 2018: 220) and how, when impacted by climate change, they can in turn affect macroeconomic variables and generate financial instability. They also explore how 'green' monetary policy—further discussed below—can reduce financial instability while mitigating global warming.

When it comes to policy proposals, three main avenues of reform have been proposed in the field of ecological macroeconomics. First, the case has often been made that a stronger regulation of the financial sector could—in addition to bringing systemic stability—decrease investors' current expectations of returns in the 'financial' sphere and therefore facilitate long-term investments towards a low-carbon economy (Grandjean and Martini 2016: 135; Jackson, 2017; Plihon and Rigot, 2018; Røpke, 2016: 242). Indeed, endogenous monetary theorists understand the 2007-08 global financial crisis as part of a long-standing trend that started building up in the 1970s with the financialization of the global economic system[25] (Aglietta et al., 2016; Lavoie, 2014; Wray, 2016), which contributed to the generation of systemic financial risk while allowing financial institutions to expect high and rapid returns through speculative activities and rent extraction (Hudson and Bezemer, 2012). Hence, as discussed in Røpke (2017) stronger financial regulations are often seen as a pre-requisite for a socio-ecological transition. These proposed regulations include strengthening the Basel regulatory mechanisms—e.g. by significantly increasing banks' capital adequacy ratio (Turner, 2015)—and regulating the shadow banking sector, which has kept growing since the crisis afar from any regulatory framework (FSB, 2018).

[25] While debates on financialization have generated an extensive literature that cannot be explored in depth here, financialization is often characterized as "the increasing importance of financial markets, financial motives, financial institutions, and financial elites in the operation of the economy and its governing institutions, both at the national and international level" (Epstein 2001: 1).

Second, it is argued that public investments are needed to overcome the inability of the private sector alone to fund the low-carbon transition, due to the fundamental uncertainty related to it (Fontana and Sawyer, 2016a) and the type of funding needed—e.g. important upfront costs in the case of renewable energy. National and multilateral development banks can play a role in delivering funds towards the low-carbon transition (Aglietta and Espagne, 2016), although their range of action tends to be limited by the fact that their mandate usually prevents them from creating money like commercial banks (Campiglio, 2016). In this context, government expenditure financed through debt and/or taxes could make available the amount of funding needed. For example, a "Green New Deal", advocated by several Keynesian economists (Ekeland and Sæther, 2017: 422) and increasingly discussed in the media and policy arena (e.g. Carlock and Mangan, 2018; Pettifor, 2019), could put public sector spending at the service of climate change mitigation.

Going further, MMT scholars (e.g. Forstater, 2003; Lawn, 2010) have made proposals towards sustainable full-employment policies. By relying on the principle of functional finance as developed by Abba Lerner in the 1940s and 1950s (see Forstater, 1999), these scholars see the government—provided that it issues its own currency—as benefitting from "a bottomless pit of money that endows it with unlimited, internal spending power" (Lawn, 2010: 932). As such, it could use its spending and taxation powers to finance 'green' full employment mechanisms "including monitoring, clean up, recycling, education, and more" (Forstater, 2003: 21) to anyone that is ready and willing to work.

Third, several 'green' monetary policies and 'green' prudential regulations could be used to accelerate investments in the transition (Campiglio et al., 2018). Establishing differential reserve ratio requirements and/or capital requirements could reward banks that hold a higher proportion of 'green' assets (Rozenberg et al., 2013; Campiglio, 2016). Central banks could also implement 'forward guidance' policies through which they would influence market expectations towards 'green' investments (Campiglio, 2016: 227), or offer favorable refinancing conditions to

commercial banks that have invested in low-carbon projects (Aglietta et al., 2015). Going further, reviving older regulatory mechanisms could easily provide additional funds for the transition (Harribey et al., 2018). For example, during the post-war 'Golden Age', French banks were required to acquire government bonds in proportion to their deposits (Monnet, 2014: 142), which were then used for public investments in strategic sectors of the French economy. Such institutional mechanisms could be used today to ensure that private banks subscribe to sovereign 'green' bonds while lowering the cost of credit. Others argue that the unprecedented amount of liquidity created by central banks over the past years, the vast majority of which remained in the realm of financial markets, could have been put to much better use by acquiring sovereign bonds—in the primary or secondary market, depending on the proposals—through a "green Quantitative Easing" (e.g. Giraud, 2014; van Lerven and Ryan-Collins, 2017; Macquarie, 2018).

In short, regulating finance and designing new fiscal and monetary policies while putting these tools to the service of an ecological transition seems to offer practical avenues of reform capable of accelerating the speed at which we tackle ecological crises such as climate change. While the Keynesian toolbox mobilized for this purpose seems better suited than the neoclassical one that justifies austerity measures (Røpke, 2016: 244), it is unclear whether it will prove sufficient to re-embed the economic sub-system within the Earth's biophysical systems, one of the core concerns of ecological economics (Daly and Farley, 2011). In particular, we argue that the field of ecological macroeconomics suffers from three major flaws, as detailed in the next sections: (i) a generalized oversight of the technical and institutional limitations of what 'green' investments can really achieve for an ecological transition (section 3); (ii) the inability to revisit capitalism's regimes of accumulation and macroeconomic phenomena such as financial instability through the incorporation of biophysical dimensions (section 4); and (iii) the lack of inclusion of existing institutional approaches to money, although those seem essential to broaden the scope of policy responses for the purpose of a socio-ecological transition (section 5).

4.4 'Green' investments for the transition: limitations and recontextualization

4.4.1 Technical and institutional limitations to 'green' investments

The amount and timeframe of the funding needed to limit the increase in global temperatures to 2 degrees Celsius varies from one report to another. For example, the annual investment gap between the estimated 'business-as-usual' and 'low-carbon' scenarios was estimated at: $900 billion by the International Energy Agency (IEA, 2012) for the 2010-2020 period; between $1 trillion and $2.6 trillion[26] for the same period by UNEP (2011); $270 billion by the New Climate Economy (NCE, 2014) for the 2015-2030 period; and $200 billion between 2016 and 2040 by Bloomberg New Energy Finance (BNEF, 2016).

The proponents of endogenous money have often used these data without questioning their underlying assumptions or the political choices they entail. For example, Campiglio (2016) uses the idea of an 'investment gap' before he identifies three key sectors where investments are needed to move to a low-carbon economy: production of renewable energy, improvement of energy efficiency, and "conservation and smart use of natural capital" (ibid: 221)[27]. Others call more broadly for "investments for sustainable development" (Holt, 2016: 371) or "investing in natural capital [to] help improve the resilience, health and productivity of national economies" (Jackson and Molho, 2018: 69). In all these cases, it seems that an ecological transition can be achieved through a specific flow of investments shifting from 'brown' to 'green' assets, and the main challenges would consist in *finding* the money.

Should one curtail ecological challenges to climate change and the energy transition without regard for other planetary boundaries (Rockström et al., 2009), as this is typically done in current debates, this way of presenting the challenges ahead is problematic. Overall, the very possibility of transitioning to an energy system entirely based on renewable sources without major socio-economic transformations is subject to extremely diverging opinions among experts who see it

[26] The amounts estimated by UNEP correspond to the transition to a "green economy" (UNEP, 2011), which entails more than the 2 degrees Celsius objective.
[27] Unlike other authors, Campiglio (2016: 222) acknowledges that the size of the investment gap is subject to uncertainty and should therefore be taken cautiously. However, he does not question the very concept of investment gap.

as either doable (e.g. Jacobson and Delucchi, 2011), difficult or even strongly compromised (e.g. Bihouix, 2015; Smil, 2010; 2017).

Among the reasons for concern are the fact that the history of energy has only consisted in *adding* new sources of energy to the existing ones and not in *transitioning* from one source to another (Fressoz and Bonneuil, 2016; Smil, 2010). Also, alternative sources of energy may not compensate for fossil fuels because of their limited ratio of energy returned on energy invested (EROEI) (e.g. Bonaiuti, 2017; Fizaine and Court, 2016; Hall et al., 2014; Murphy and Hall, 2010; Servigne and Stevens, 2015: 51-63) and/or because of the hardly substitutable uses of oil in sectors such as agriculture, construction, industry, transport and warfare (Auzanneau, 2016; IEA, 2017; Huber, 2013a; Hornborg, 2013). For example, the International Energy Agency's forecasted reduction in oil demand due to investments in electric vehicles, renewable energy and energy efficiency is largely offset by the forecasted increase in demand for petrochemicals, aviation and road freight. This leads the agency to declare that we are "not yet ready to say goodbye to the era of oil" (IEA, 2017: 4). Such potential biophysical limitations are rarely discussed in the field of ecological macroeconomics, although some authors in the field coming from ecological economics have clearly acknowledged some of these issues (e.g. Jackson, 2017).

In general, it is believed that the Schumpeterian process of 'creative destruction' can become environmentally-friendly and act as the main agent of change towards an ecological socio-economic system, as explicitly claimed by Campiglio et al. (2018: 462). This theory of change leads to cast doubt on both the feasibility and desirability of the transition paths implicitly supported by most ecological macroeconomists. For instance, the use of data from the New Climate Economy (NCE, 2014) to promote 'green' investments—as in Grandjean and Martini (2016)—entails support for carbon capture and storage (CCS) and other controversial sectors listed as 'green'. Yet, strong technological and political concerns exist around the use of this technology (Krüger, 2017; European Court of Auditors, 2018). Such investments, regardless of their potential chances of success, bear strong socio-technical implications that call for political debate but have been shaded by the concept of 'green' investment.

The approach consisting in viewing the transition from the standpoint of investments also fails to discuss the decline of resources that are critical in today's economy—such as water, land, cement, phosphate, metals or rare earths—and may not be available in sufficient quantities to support an energy transition (Brown et al., 2014). For example, the areas needed to produce renewable energy are considerably larger than those required for concentrated sources of fossil fuels (Pitron, 2018); this could potentially lead to an increase in land grabs, local socio-environmental conflicts, broader geopolitical concerns around energy and food security and biodiversity loss (Muradian et al., 2012; Scheidel and Sorman, 2012; Scheidel et al., 2018). In fact, 'green' investments in the extraction of rare-earth metals, at the heart of the renewable energy, electric mobility and information and communication technology (ICT) transitions, have already caused massive and irreversible ecological damages in several producing countries, mostly China (Pitron, 2018).

4.4.2 A necessary reconceptualization of investments for ecological macroeconomics?

More fundamentally, each transition scenario involves different societal paths and political choices that remain undiscussed due to the predominant idea that an absolute amount of so-called 'green' investments will support the shift from a carbon-intensive to a decarbonized economic system. In fact, the composition of additional funding needed for each sector varies from one 'official' report to another, e.g. with a stronger emphasis on the transportation sector according to the International Energy Agency (IEA, 2012), on energy efficiency in buildings according to the World Economic Forum (WEF, 2013) and on 'low-carbon technologies'—including CCS and nuclear—according to the New Climate Economy (NCE, 2014). These clearly show that beyond uncertain technological bets on the future, diverging social alternatives have also been envisioned to reach that future, either consciously or not.

In this dynamic, assessing the question of an ecological transition strictly from an investment lens imposes specific financial logics on the patterns of the biophysical sphere, in a way similar to the

neoclassical focus on price and market mechanisms. In other words, it leads to the treatment of the biophysical sphere as if its processes could function at the same pace, substitutability, and flexibility as financial processes (Dron, 2015). It is true that regulating finance and promoting long-term investments—as well as developing ESG (environmental, social and governance) investment-screening criteria (Fullwiler, 2016)—can attenuate the grip of financial processes on ecosystems, by promoting lower and more patient expectations of financial return; but the assumption that the sustainable governance of nature should be expected to provide a 'decent' return is not fundamentally questioned. For instance, Grandjean and Martini (2016: 135) argue that financial regulation is needed to decrease equity investors' current requirements for high internal rates of returns (IRR) of 15%, when investments in infrastructure historically provide returns closer to 2% or 3%. In fact, it is hard to see why such a 'green' portfolio of investments *should* deliver any acceptable return—e.g. 2% to 3%—within a timeframe that is deemed acceptable to an institutional investor, while benefitting future generations and other forms of life.

Jackson (2017: 166) achieves a critical step for overcoming this limitation, by acknowledging that the "portfolio of investment" of an ecological macroeconomic system would largely consist in building and maintaining assets from which economic services flow, such as nutrition, health, education, or ecological resilience. As such, "the traditional function of investment, framed around increasing labour productivity, is likely to diminish in importance" (ibid: 166); many 'green' investments could even "'soak up' income without increasing economic output" (ibid: 169) and "slow economic growth down" (ibid: 170). That is, the traditional relationship between increased investments and growing output would be lost. Therefore, the very purpose of investing would have to change in such a socio-economic system: it could hardly be justified by the expectation of private financial return, but the public sector could also have a hard time justifying its expenditures if those do not boost economic growth through a Keynesian fiscal multiplier. Hence, the idea that public 'green' investments will naturally 'crowd in' private ones (e.g. Mazzucato, 2011; 2015) should be questioned.

Going further, a major problem with thinking about a transition through the lens of investments and the returns they provide is that it may miss alternative approaches to an ecological transition that would entail a decrease in aggregate investments compared to business-as-usual scenarios. For instance, calling for investments in the "smart use of natural capital" to promote sustainable agriculture (Campiglio, 2016: 221) leads to an implicit dismissal of other approaches that transcend the "episteme of capital accumulation and advocate agricultural reorganisation according to socially and ecologically sustainable practices" (McMichael, 2009: 164). The emergence of such agricultural practices may require getting rid of the imperative of capital accumulation as a primary goal for the agricultural sector (Lanata, 2013) and addressing some underlying issues that prevent them from blossoming, such as the intertwining dimensions of land and food politics (Borras et al., 2011).

In this respect, Bihouix (2015) argues that an ecological program of full-employment would not so much consist in investing in new infrastructure—or in providing additional 'green' jobs as in the MMT version presented above—as it would in slowing down productivity and economic output through more labor-intensive activities. For example, in the agricultural sector, jobs could be created by massively developing organic farming and short food circuits to the detriment of more capital-intensive petrochemicals and food processing jobs. Similarly, many investments needed such as insulating buildings or restoring ecosystems tend to be labor-intensive and will likely offer very little increases in productivity. Moreover, many of the investments needed should ideally come along with divestments elsewhere. For example, better insulating buildings would fully make sense only if other measures such as reducing investments in non-essential new constructions are also implemented, in order to prevent more energy consumption in the aggregate but also other problems such as land artificialization (Béchet et al., 2017: 8). In this sense, taxing vacant houses to promote a higher rate of occupation may be much 'greener' than investing in new housing with solar panels. Overall, the sharp increase in labor-intensive sectors and the exclusion of certain categories of investments may entail a decrease in aggregate investments and fewer opportunities for financial return.

In short, focusing too much on the concept of 'green' investments may provide biased tools for envisioning an ecological transition, possibly leading to investor-oriented approaches that are not optimal from a socio-ecological perspective. To be sure, any transition path will require major investments, but these can be understood as the result of potentially conflicting political views regarding what a sustainable socio-economic system should entail, rather than some sort of autonomous force capable of taking us from a 'brown' economy to a 'green' economy. In this spirit, The Shift Project (2019) suggests a mix of "technical and organizational solutions" for decarbonizing the European economy, with nine sectorial priorities. For each sector, the potential gains and losses of different stakeholders and the measures needed are assessed comprehensively, well beyond the question of investments. For instance, it is argued that improving energy efficiency in buildings would require a broad range of measures such as stricter building regulations and programs to raise awareness and train the public, not just investments in the sector. It is only after clarifying these assumptions that the authors propose an estimate of the costs and potential investments and divestments needed. And even then, most of the investments needed may consist in reallocating household consumption expenditure to comply with new regulations, without requiring investments from public or private financial institutions.

Following this line of thought, revisiting the very concept of investment, which stands at the core of macroeconomic theory, appears essential. Georgescu-Roegen argued that the goal of economics should be to minimize the flows and stocks of the economic system while aiming to maximize "as large an amount of life as possible" (Georgescu-Roegen, 1975: 368). In this regard, the very concept of 'investments' can be understood as a human claim on the appropriation of the biosphere: the more is invested, the more material and energy tends to be extracted and the more waste tends to be generated. For example, high levels of investments in renewable energy do not merely equate the amount of solar, wind or water flows being 'captured'; they represent the amount of material and energy needed to install and maintain new capacity—excluding labor costs and firms' mark-ups. Hence, the decrease in global investments in "low-carbon and climate-resilient actions" between 2015 and 2016—from $437 billion to $383 billion—seems less

damning when we consider that it partially corresponded to falling renewable energy technology costs (Buchner et al., 2017: 1).

Therefore, it seems essential to revisit the concept of investment for the purpose of a socio-ecological transition. Rather than seeing investments as an instrument aimed at providing internal rates of return or fostering growth in a more or less environment-friendly manner, this requires exploring how specific investments could contribute to transforming our social relation to the environment. This would mean deliberating on how well-targeted investments would enable the emergence of alternative societal patterns while causing a massive reduction in investments elsewhere—e.g. how investing in public transportation could reduce current investments in the production of personal vehicles. So far, proponents of endogenous money have not engaged in such deliberations: by focusing on broad concepts such as a 'Green New Deal', they have not questioned the assumption that 'green' investments will be the main—if not only—agent of change toward a new socio-economic system. It follows that overcoming these limitations and revisiting the role of the financial system for a finite planet demands exploring the deeper relationships between monetary systems and the natural environment, as discussed in the next two sections.

4.5 Revisiting macroeconomics through its biophysical foundations

4.5.1 Capital accumulation as a socio-ecological process

By focusing on how to increase 'green' investments, most of the work in ecological macroeconomics to date has aimed to assess how an endogenous approach to money can help address ecological concerns while disregarding the reverse intellectual path, which would consist in exploring how ecological economics and related fields—such as political ecology and environmental history—could offer new perspectives on the field of macroeconomics itself. In other words, ecological macroeconomics has aimed to improve ecological economics' understanding of the macroeconomy, without considering revisiting the foundations of macroeconomics through ecological economics.

In doing so, the field as it currently exists ignores a growing transdisciplinary literature hinting towards a more intricate relationship between capitalism's regimes of accumulation and socio-ecological transformations than the one implied in ecological macroeconomics' models and proposals. In particular, stemming from Braudel's (2011 [1985]) analysis of capitalism as a financial and global project of endless expansion from its inception and from the closely related world-systems theory (Arrighi, 2009; Wallerstein, 2011), Moore (2015) shows that both the *global* and *financial* dimensions of capitalist expansion have always relied upon the exploitation of "Cheap Natures", i.e. on the boundless commodification of natural resources yielding "extraordinary physical surpluses that could be transformed into capital" (Moore, 2018: 249).

This suggests that capitalism's successive modes of regulation[28] correspond to specific "world-ecologies" (Moore, 2015), i.e. that each phase of capitalism is grounded in and enabled by a specific Earth-system regime (Fressoz and Bonneuil, 2016). From slavery and colonial expansion supporting the movement of eco-hectares of land to Europe (Hornborg, 2010) to today's burning of fossil fuels (Malm, 2016) and land degradation for the extraction of rare metals (Pitron, 2018), the pursuit of capital accumulation has been rooted in successive, evolving ways of controlling and transforming metabolic flows of energy and materials.

As a general framework, a world-ecology approach suggests that through various forms of "ecologically-unequal exchange" (Hornborg, 2014), capital has tended to accumulate in the core of the world-system while causing multiple forms of environmental degradation—including overexploitations of resources, local pollution, and global pollution such as climate change—in its peripheries (Hornborg, 2010). For example, Magalhães et al. (2019) have conducted the first long-term study of material flows of the French economy—from 1830 to 2015—and found that

[28] According to the French Régulation theory, a mode of regulation refers to "the set of procedures and individual and collective behaviours that serve to: 1 Reproduce fundamental social relations through the mode of production in combination with historically determined institutional forms. 2 Support and 'steer' the prevailing regime of accumulation. 3 Ensure the compatibility over time of a set of decentralised decisions, without the economic actors themselves having to internalise the adjustment principles governing the overall system" (Boyer and Saillard, 2002: 341).

France has always relied on massive material imports, thus acting as a "parasite" (ibid) to the countries it traded with. This kind of study allows us to "rematerialize" (ibid) the assessment of industrialized economies and show how they often benefit from a profitable integration into the world-system and its related world-ecologies, allowing them to massively extract free or underpaid resources abroad without which their economic growth would have been impossible.

With the aim of historicizing the relation between capitalism's modes of regulation and the reliance on fossil fuels, Malm (2016) proposes a "fossil capital hypothesis", according to which globally mobile capital naturally tends to relocate production to places that offer the largest sources of fossil energy. For example, since the early 2000s, the expansion of capital towards new frontiers of commodification was enabled by China's vast coal reserves, the deregulation of which may have been a key element to attract foreign direct investments and drive China's industrialization (Malm, 2012). Hence, the fact that coal has been the source of energy with the highest absolute growth over the past decades (Smil, 2017) seems not to be an externality of modern industrialization or the result of failed international climate negotiations, but one of the very engines of Chinese and global economic growth during that period. In other words, Chinese coal-based growth would be a key factor explaining the transformations of globalized capitalism in the early twenty-first century (Malm, 2012; Sager, 2016).

In short, whereas capital accumulation cannot be understood through biophysical dimensions only, it is also impossible to fully apprehend it without considering the role played by human-nature relationships throughout time (Hornborg, 2010). These relationships are "constitutive of and internal to the productive forces and social relations of capital" (Huber, 2013b: 18), rather than apolitical production inputs and outputs. Revisiting the process of capital accumulation through its biophysical foundations could be particularly important for future research in macroeconomics. In particular, the understanding of financial stability, a core topic of inquiry for many proponents of endogenous money, may remain incomplete insofar as it fails to factor in the biophysical world on which financial activity ultimately depends, as explored below.

4.5.2 Revisiting financialized capitalism through its biophysical foundations

The very structure and functions of the financial system have in fact been deeply influenced by biophysical dimensions, and research shows a possible co-evolutionary pattern between energetic and financial concentration: "just as fossil fuels made it possible for manufacturers to de-link energy use from specific, context-bound energy sources—for example, rural rivers and streams—and extract greater surplus ... so the expansion of finance ... always required the extrication of capital from the constraints of locally-specific webs of capital mobilization" (Lohmann and Hildyard, 2014: 71). For instance, the development of the oil industry in the United States required financial innovations such as project finance in the 1930s (Lohmann and Hidlyard, 2014: 70). Reversely, the profits made in the nascent oil industry enabled the emergence and development of large financial institutions in order to manage and multiply the profits generated by fossil fuels extraction (Auzanneau, 2016: 112-113).

Closer to our times, empirical observations show that the two main regimes of capital accumulation since the end of World War II—i.e. the 'Fordist-Keynesian' regime until the early 1970s and the 'financialized' one since then—present a radically different relationship to nature, and to energy in particular. Cahen-Fourot and Durand (2016) find that in five countries—France, Germany, Japan, United Kingdom and United States—while 'Fordism-Keynesianism' was characterized by an extensive energy use and an intensive labour use along with high labour productivity gains, the financialized regime from the 1970s onwards is characterized by a decrease in the growth of energy along with a decrease in labour productivity growth, which contributed to the erosion of the 'Fordist-Keynesian' social compromise.

This concomitant transformation of the social relation to energy and to finance after the 1970s remains unexplored by endogenous monetary theorists, although several recent and transdisciplinary works enable us to suggest some possible interpretations. According to Huber (2013a; 2013b), the role of oil was essential to both the rise and erosion of the 'capital-labor' accord and economic stability that prevailed during the 'Fordist-Keynesian' post-war regime. The

abundance of oil reserves in the United States in the 1930s enabled the country to organize an 'interstate cartel'—following years of price volatility that threatened the oil industry's business model—to ensure that oil prices would remain 'high enough' for the oil industry to generate profits, and 'low enough' to provide cheap consumption goods that were essential to the Fordist regime of mass consumption. At the same time, the control of foreign oil resources also seems to have been a key aspect of the US global monetary and economic hegemony in the post-war period (Auzanneau, 2016; Mitchell, 2011; Yergin, 1991).

In practice, oil appears to have played two critical roles. First, it was used to produce a multitude of products "that literally saturated everyday practices—from plastics to petrochemical pesticides and fertilizers" (Huber, 2013a: 180) and enabled Fordist mass consumption. Second, oil became central in shaping a specific geography of social reproduction that consisted in "the suburbanization of industrial and residential development alongside the development of massive national highway systems" (ibid: 179). At the very heart of this fossil-fueled model of development were two basic carbon-intensive goods, the demand of which supported the entire regime of accumulation of this post-war period: home and automobile ownership (Aglietta, 1979. In Huber, 2013a: 179).

However, this geological and institutional edge started to erode in the 1960s. Domestically, oil consumption rose much faster than new discoveries, and the country reached its peak crude oil production in 1970 (Huber, 2013a)—barring the current surge of shale oil. Overseas, the United States lost access to Middle Eastern oil resources—which had been of critical importance to Europe's post-war economic recovery supported by the United States—due to nationalizations and other geopolitical factors (Mitchell, 2011: 30). Hence, the early 1970s threatened to mark a shift from US-regulated oil prices to their determination by non-US actors (Ortiz, 2016), notwithstanding the occurrence of oil shocks (Mitchell, 2011).

As the dollar's global currency status became threatened by individual attempts to sell oil in other currencies (El-Gamal and Jaffe, 2009), safeguarding the US monetary hegemony without an

underlying energy sovereignty required an entirely new paradigm to replace the fossil-fueled 'Fordist-Keynesian' regime that had prevailed since the end of World War II (Mitchel, 2011; Sager, 2016; Smith-Nonini, 2016). Indeed, being able to price key commodities such as oil in dollars is a considerable privilege: "not only does that imply that there cannot be an insufficient source of dollars to import [them], but also, a depreciation of the dollar does not have the impact of increasing the price of imports" (Fields and Vernengo, 2013: 752). Considering the critical role of oil in "fueling" (Huber, 2013a) the social relations of modern capitalism, this element is all the more important.

In this context, it was recently suggested that the financialization of the global economic system since the 1970s was not only the result of the financial system's inherent dynamics—as in Minsky's (1986) financial instability hypothesis—but also a response to stronger biophysical constraints to the endless pursuit of capital accumulation in the 'core' of the world-system. In particular, financialization may represent a key instrument for maintaining, at least temporarily, a country's hegemony in the world-system—as suggested by Wallerstein (2011)—and in this case a new way to ensure control over the energy sources that support an entire mode of capitalist regulation[29]. In particular, Moore (2015) considers that the financialization of the global economic system since the 1970s contains two dimensions that should be assessed symbiotically. On the one hand, financialization enabled the financial sector to avoid the energetic limits to capital accumulation of the Golden Age by restoring profits through speculative activities and rent extraction—e.g. through privatizations in sectors such as education, health and biodiversity protection. On the other hand, it allowed capital owners in the core of the world-system to benefit from greater capital mobility in order to push the appropriation and exhaustion of new "commodity frontiers" (Moore, 2015)—in a similar fashion to Malm's "fossil capital hypothesis"—such as Chinese coal or the "oil frontiers of the North Sea, West Africa, and the Gulf of Mexico"

[29] Other authors have argued that financialization should not be understood merely as being generated by the financial system's inherent dynamics, but also as a reaction to events occurring in the 'real economy' (see Foster and McChesney, 2010; Palley, 2010). However, to our knowledge, their assessments do not account for biophysical patterns.

(Moore, 2012: 245). Financialized capitalism would have therefore "emerged, and sustained itself, by appropriating what free gifts remained for the taking" (ibid).

To exemplify how financialization may have been beneficial to US "fossil capital", it has been argued that financial innovation and deregulation have allowed capital owners at the 'core' of the world-system to reestablish previous levels of profit rates by increasingly benefitting from the reinvestment of fossil fuel-generated profits, from Saudi Arabia's petrodollars in the 1970s to Chinese 'coal-dollars' since the 2000s (Sager 2016; Smith-Nonini, 2016). Petrodollars deposited with US banks (El-Gamal and Jaffe, 2009) were partially reinvested overseas where they built up 'peripheric' countries' debts during the 1970s (Ortiz, 2016; Smith-Nonini, 2016) and exported financial fragility (Ussher, 2009: 404). Moreover, the increased reliance on debt leverage and speculative products driven by the financialized regime of capitalism (Lapavitsas, 2013) may have enabled oil corporations, at the forefront of financial innovation (Auzanneau, 2016: 579-81), to disguise global energy risk by permitting the production of non-conventional fossil fuels such as shale oil (Smith-Nonini, 2016), possibly through major Ponzi schemes (Crooks, 2018).

Whereas a detailed assessment of all the elements at play is beyond the scope of this paper, one cannot deny that, given the clear intricacy of financial instability, geopolitics and the control of natural resources since the 1970s, these elements cannot be satisfactorily assessed in silos (El-Gamal and Jaffe, 2009). As a general trend, Sager (2016: 35) observes that "market fundamentalism seems ascendant when energy resources, especially, become constrained". This does not mean that financialization was ineluctable, but rather that alternative solutions to the erosion of the 'Fordist-Keynesian' regime should have paid considerable attention to the physical and geopolitical dimensions of natural resources. In other words, the notions of financial instability and crises found in endogenous approaches to money—which have often emphasized a 'Minskyan' approach—may remain incomplete until they more accurately account for the endogeneity of human-nature relations.

This kind of analysis remains largely overlooked by endogenous monetary theorists. Most of them acknowledge that the 1970s oil shocks contributed to ending the social compromise of the Golden Age period (Hein et al., 2016) but do not consider the broader underlying forces at play with regard to energy. A notable exception is found in the work of Galbraith (2014)[30], who identifies resource scarcity as one of the four main causes for the long-term trend towards the end of high growth rates in the United States—along with the massive scale of financial fraud, the nature of recent technological innovations and the diminishing economic benefits of military superiority. Galbraith's assessment has important consequences, as he suggests that "the institutional, infrastructure, resource basis, and psychological foundation for a Keynesian revival no longer exist [...] More gas in the engine will not make it go" (Galbraith, 2014: 168). Such insights are even more striking if we factor in the need to move away from fossil fuels and the constraints involved in such a path, as discussed in section 3.

In fact, the abundance of natural resources and of relatively unpolluted natural sinks—e.g. lower levels of CO2 atmospheric and oceanic concentration—that prevailed during the Golden Age may have shaped the Keynesian mental representations with regard to how the economy works and how finance can be regulated. According to Mitchell (2011), the central Keynesian notion that the economic system is composed of monetary flows has even contributed to neutralizing the critical importance of biophysical flows to the understanding of macroeconomic dynamics, although this biophysical blind spot can also be traced further back, for instance to the Industrial Revolution (Hornborg, 2013; 2014). The era of carbon may even have shaped our mental representations of broader aspects of life such as our vision of personal success—largely measured through the individual ownership of fossil-enabled goods such as personal cars and houses (Huber, 2013b)—and may have determined the very structure of Western democracies (Mitchell, 2011).

As the global socio-economic system needs to transit away from a carbon-intensive era, the main quest of ecological macroeconomics may be much more complex than assumed. In particular, it

[30] We thank an anonymous reviewer for pointing this out.

involves much more than mobilizing Keynesian-oriented countercyclical policies and prudential regulation in order to redirect monetary flows from speculative and fossil-intensive assets toward 'real' and 'green' ones. Similarly to the concept of investment, the very structure and functions of the monetary and financial system need to be revisited for the purpose of achieving a systemic socio-ecological transformation. This calls for the development of "a third position as regards the discursive battle" between neoclassical and Keynesian approaches (Røpke, 2016: 238). The next section explores how such a third position could emerge from integrating existing institutionalist perspectives on money, thus paving the way to re-embedding monetary and financial processes within those of finite resources and complex ecosystems.

4.6 Revisiting endogenous money theory for a finite planet

4.6.1 Money as an institution - Towards 'fully' endogenous money theory

Money is endogenous not only to economic dynamics, as emphasized by ecological macroeconomists, but also to social ones, as stressed by institutional perspectives on money—including Regulationist ones although they have generally not connected their monetary work to ecological issues (but see Aglietta et al., 2016). Indeed, money is one of the most fundamental institutions shaping social relationships, acting as a language that creates commensurability and comparability among the different goods and services that exist (Aglietta et al., 2016: 43) within but also outside the marketplace, e.g. payments to ensure the delivery of public goods such as health and education are made in the same unit of account as the one used for commercial transactions (Harribey et al., 2018: 38). Embracing the endogeneity of money therefore not only permits a better understanding of macroeconomics, as evidenced by ecological macroeconomists, but also a better comprehension of the broader social environment in which monetary systems exist and evolve.

Aglietta et al. (2016: 46) define money as a social construct, embodied in a common medium, through which the community that uses it rewards[31] its members to the level that it considers to have benefited from her/his activity. It follows from this that it is through the language of money that value is created and institutionalized, leading Desan (2017) to describe money as a constitutional project: "societies produce it by structuring claims of value in ways that make those claims commensurable, transferable, and available for certain private as well as public uses" (Desan, 2017: 111). The construction of a monetary order therefore appears to be closely related to the construction of a supreme form of authority governing a polity, i.e. monetary systems are embedded in ideal-types of sovereignty (Aglietta et al., 2016). With this perspective in mind, it is not surprising that money appears in history around the same time as the first legal documents written in ancient Mesopotamia, as rulers started affirming sovereignty upon their subjects (Aglietta et al., 2016: 15).

Once it is established that money is embedded within specific institutional and ethical principles of sovereignty, one is better disposed to recognize how monetary orders have always evolved along with their broader economic, social and natural environment: "as societies change the way they engineer money, they change its character and the market it makes" (Desan, 2017: 111). In other words, monetary orders emerge and evolve as social constructions resulting from competing views over what represents value (Lietaer, 2013; Orléan, 2015). Indeed, the symbol or medium used to measure value contributes to shaping the very value that is being measured under a specific light (Hornborg, 2014). Hence, the power related to money has to do not only with who owns it, but also with who has the power to create it and make it acceptable to others, i.e. to enforce monetary sovereignty. The history of monetary creation over several millennia reflects the evolution of societies themselves (Graeber, 2014), unveiling a myriad of monetary organizational models (Gómez, 2018: 1).

The concept of "monetary contestations" (Ould Ahmed and Ponsot, 2015) emphasizes how struggles to challenge existing monetary orders throughout time have been at the forefront of

[31] This 'reward' does not exclude the critical role of power relations, as discussed below.

broader socio-economic evolutions. Desan (2017) argues that the institutionalization of capitalism took place precisely through the 'contestation' of a previous monetary order, as the British government "put the self-interest of commercial actors at the heart of money creation and established the networked liquidity that supports modern finance" (Desan, 2017: 121) over the course of the eighteenth century. Other scholars came to similar findings, although they locate the origins of this 'commercial banking-money' back to the Middle Ages (Aglietta, 2002; Braudel, 2011 [1985]; Graeber, 2014; Le Goff, 1956). In any case, the generalization of interest-bearing debt money and transferable credit through the banking system represents a historical shift in the history of money and society (Fantacci, 2010).

The construction of the modern monetary order can therefore be understood as a hybrid of "public money" and "business money" (Blanc, 2018): while sovereign states and their institutions such as central banks are essential to the maintenance of trust in national systems of payments interconnected within an international monetary system, the vast majority of money is in fact issued by private banks for the purpose of commercial expansion and profits (Ryan-Collins et al., 2012). From this originates the ambivalent nature of money and its double capacity of public good and the object of unlimited desire for private accumulation (Harribey et al., 2018).

The question of modern monetary order evolution has barely penetrated the field of ecological macroeconomics through the 'monetary growth imperative' debate[32], which has overlooked institutionalist approaches. Among the few notable exceptions (e.g. Lietaer et al., 2012) to this situation, A. Hornborg (2014) has aimed to connect the monetary—or semiotic (Hornborg, 2014: 12)—and biophysical dimensions of the economy within a comprehensive analytical framework.

[32] Some ecological economists (e.g. Farley et al., 2013; Lietaer et al., 2012) have argued that since modern money is created by private banks through interest-bearing debt, this would force the economic system to perpetually grow in order to repay existing debts. As a result, some ecological economists have supported a 'nationalization' of monetary creation through specific versions of full-reserve banking (see Røpke, 2017). In response, some scholars with post-Keynesian views have demonstrated that under certain conditions, interest-bearing debt money is compatible with a steady-state economy (e.g. Cahen-Fourot and Lavoie, 2016; Jackson and Victor, 2015b). However, neither side has focused on the institutional dimensions of the debate.

He suggests that as societies moved away from agricultural economies powered by solar flows towards fossil fuels, it became more difficult to keep sight of how land and labour still provided the ultimate resources allowing the economic system to function, since those could then "be invested in "capital" in the form, for instance, of agricultural terraces, irrigation canals, livestock, roads, ships, armies, and temples" (Hornborg, 2013: 43). With this increasing complexification of societies, "money became the more abstract and elusive "value" that seemed to flow through and empower mercantile societies" (ibid) making one forget the fundamental role of energy and material flows.

All in all, the assessment of the interconnectedness between biophysical and monetary flows remains in its early stages and will require much more transdisciplinary work. However, as we are moving closer to ecological tipping points, building a better understanding of the multiple connections at play seems essential. Indeed, both failing to act on ecological crises and engaging in an uncertain transition will pose significant risks to the stability of the current monetary and financial system, as increasingly acknowledged by central bankers and supervisors (e.g. Carney, 2015). Contrary to the measures that could be taken if a new financial crisis occurred, such as monetary and fiscal policies and even more radical measures such as a debt jubilee (Keen, 2017: 49), degraded ecosystems will remain unresponsive to the injection of cash (Dron, 2018), whether it comes from public or private sources.

4.6.2 An institutional ecological macroeconomics engaged in the search for monetary alternatives?

In this context, the key task from an institutionalist perspective on money is to explore which "monetary contestations" (Ould Ahmed and Ponsot, 2015) should be promoted to foster the emergence of a new ideal-type of sovereignty for a fair and 'sustainable' socio-economic system (Aglietta et al., 2016: 142; Ament, 2019). In other words, the question is: what ideal-type of monetary order could facilitate the emergence of new institutions that embrace the limited substitutability and incommensurability between human-made capital and nature's processes?

Whereas exploring the multiple possible co-evolutions between monetary orders and broader societal transformations is beyond the purpose of this paper and would probably remain a futile exercise if done unilaterally, we focus on a promising research avenue towards a monetary system for the commons. Indeed, a growing transdisciplinary body of theories and practices across natural and social sciences has found that, in order to protect the endangered commons of our planet, important changes in our institutional arrangements are needed. Such changes require overcoming the dualistic view of a society composed of states and markets (Ostrom, 2009; 2010). In particular, a significant research stream found that the effectiveness in managing common-pool resources does not depend so much on the property regime itself—public or private—as on the formal and informal rules governing their uses (Bromley, 2007; Dron and Espagne, 2018; Muradian and Rival, 2012; Paavola, 2007; Ostrom, 2009; 2010; Vatn, 2010).

Of particular importance, the concept of commons underlines the right to co-use a specific 'thing' according to specific norms—from a fishery to access to free information on the Internet—rather than the rights attached to owning it, i.e. to its property (Dardot and Laval, 2014; Giraud, 2014). Moreover, protecting the commons requires thinking both beyond the horizon of nation-states—e.g. handling global problems such as climate change—and beneath it, accounting for the fact that each ecosystem requires a different governance. The ethical principles of cooperation and flexibility that are necessary to the governance of the commons have now surpassed the governance of natural resources and are increasingly mobilized by citizens engaged in a large range of commercial and non-commercial activities (see Coriat, 2015).

In this context, seeking institutional arrangements that could recontextualize money—in its capacity to signify value—to serve the protection of the commons, may be an essential task ahead. In other words, protecting the endangered commons that support all human and non-human life on a finite planet requires new approaches to monetary creation, circulation and destruction—that is, new "monetary contestations" (Ould Ahmed and Ponsot, 2015)—that transcend the modern dialectics of money between private accumulation and public regulation.

In this search, several proposals have started to emerge, some of them being outlined below to illustrate different potential research avenues.

At the local scale, numerous experiences have aimed to tie the creation of value to varied forms of local sovereignty (Lietaer et al., 2012). Blanc (2018) calls for developing a third type of money, beyond "public" and "commercial" ones, based on "associative" purposes. This places local currencies—acknowledging their variety—in a privileged position to build better correspondence between monetary and territorial stakes. Many of these currencies aim to support local economic dynamics while promoting more sustainable relationships with human's natural environment (Hornborg, 2016), in addition to fostering different relations among humans. For example, monetary accumulation is often discouraged by imposing an 'artificial' carrying cost on money, as suggested by Gesell (1958 [1929]) and discussed by Keynes (2013 [1936]: 234). This institutional arrangement aims to deter rentier's behaviors and encourage the circulation of money within the community (Aglietta et al., 2016: 191), without promoting consumerism due to higher rates of consumption out of income (see Loehr, 2012).

As such, and acknowledging their practical limitations (e.g. Dittmer, 2013), these currencies can serve as a blueprint for a broader co-evolution between money and sovereignty at a larger scale. In this regard, and following the precursory work of Soddy (1926, 1934), proposals for nationalizing money creation are commonly found in ecological economics (e.g. Farley et al., 2013; Mellor, 2015). However, their socio-ecological benefits remain unclear (Lietaer et al., 2012; Pettifor, 2017; Røpke, 2017). For example, some proposals aimed at creating money free of debt do not account for the fact that money has always existed in the form of debt, and this would remain the case even if its creation were to be nationalized. Instead, Fantacci (2013) suggests that in order to avoid the intrinsic instability of the financial system and to decommodify the institution of money, banks should be forbidden from trading credits and securitizing their loans—a hallmark of today's "originate and distribute" banking model—and forced to hold all their loans until maturity. In other words, banking activity would be strictly restricted to granting

loans and building "a relationship between borrower and lender" (Fantacci, 2013: 344), and would be stripped from other functions such as storing value and ensuring access to liquidity.

However, in such a system, banks could no longer transform maturities in order to guarantee economic agents' access to liquidity, which would therefore need to be ensured through new institutional arrangements. For instance, Fantacci (2013: 353) calls for the development of national clearing systems inspired by Keynes' International Clearing Union and by existing initiatives such as the WIR in Switzerland (Vallet, 2016). Under these systems, clearing houses fund trading activities between different firms through credits and debts that are not convertible into national currencies. In addition, more innovative schemes can be envisioned to grant access to liquidity for citizens without involving banks, all the while tying it to ecological purposes. In particular, Hornborg (2016) proposes that nation-states issue local currencies directly to citizens in the form of a guaranteed income. This currency could then be used to acquire specific goods and services that are produced at the local scale while respecting specific environmental and social criteria; it would be destroyed or removed from circulation as needed through taxation. Lietaer et al. (2012) also suggest mechanisms aimed at benefitting from the innovations of local dynamics while guaranteeing stability through the hierarchical and ethical trust provided by nation-states. While these hybrid arrangements may seem inapplicable at first sight, they have in fact existed in countless forms throughout history (Gómez, 2018; Lietaer, 2013) and have shown successful outcomes even in recent times (Théret and Zanabria, 2007). Such institutional arrangements must be further explored for the purpose of a systemic socio-ecological transition. Yet, to date they have been ignored by ecological macroeconomists.

However, given the global dimension of many of the environmental—e.g. climate change and biodiversity loss—and financial—e.g. risk of systemic crisis—issues at stake and their growing interconnectedness (Carney, 2015), nothing less than an ecological reform of the international monetary system (IMS) should also be explored. In this respect, incipient yet critical steps towards an ecological IMS have been proposed. In particular, Special Drawing Rights (SDRs), at the heart of the IMS envisioned by Keynes at the end of World War II, could play a much more

active role—see Ferron and Morel (2014) for a summary of proposals on 'green' SDRs. For example, instead of imposing on countries the accumulation of reserves in dollars to cover their exchange risk, the International Monetary Fund (IMF) could take the role of a lender of last resort through the issuance of SDRs, which would be conditioned on countries' contribution to emission reductions (Aglietta and Espagne, 2018). While ambitious, this kind of measure—in line with older proposals around international commodity-based currencies (Ussher, 2009)—could help integrate the question of global liquidity with the protection of global public goods and commons, including but not necessarily limited to climate change mitigation.

4.7 Conclusion

This paper has found that although ecological macroeconomics' models and policy proposals are preferable to neoclassical models and austerity measures from an economic, social and ecological standpoint (Røpke, 2016; 2017), they do not satisfactorily address the technical, social and ethical dimensions underlying ecological degradation at the global scale. In particular, biophysical dimensions are not simple inputs and outputs of the 'monetary economy of production' but internal to processes such as capital accumulation (Huber, 2013a), global socio-economic and ecological inequalities (Hornborg, 2014) and financial instability (Moore, 2015). Re-historicizing capitalism's regimes of accumulation through the inclusion of human-nature relations could lead to a field of ecological macroeconomics that does not simply aim to improve ecological economists' training in macroeconomics, but also enriches endogenous monetary theorists' existing approaches to their own field of expertise.

In its current state, it remains unclear whether ecological macroeconomists' conceptual frameworks and proposals represent a form of second-best option—given the difficult task of aiming for structural change—or an 'illusion of concreteness' based on a set of measures and tools that have worked in a very specific institutional context and for very specific ends—including environmentally-destructive capital accumulation and GDP growth—that do not apply to the challenges ahead. As such, we have asserted that the field of ecological macroeconomics as it currently stands belongs to a "shallow" (Spash, 2013) version of ecological economics,

insofar as it does not address the need for more radical institutional reforms to modify human-nature relationships.

In order to fill the gap between post-Keynesian and ecological economics, Vatn (2009: 131) suggests that including a third institutionalist perspective is critical: it can contribute to developing "ideas concerning institutions that could secure sustainability along its various dimensions, that is, the environmental, economic and social" while providing a clarification on which 'kind' of ecological economics one wants to develop. For example, he suggests that "securing the space there is for growth for those in greatest need" (Vatn, 2009: 130) demands making "less room for the profit motive and more emphasis on cooperative structures" (ibid: 131).

Given the emphasis of this paper on endogenous money, we have stressed how such an institutionalist approach can be applied to monetary questions. Money is not only endogenous from an economic standpoint but also from a social one. Monetary orders are institutional arrangements that reflect broader power dynamics but also worldviews and ethical principles shaping life in society, and the existing monetary order seems incompatible with the emergence of a much-needed new ethics of human-nature relationships (Brown, 2012; Descola, 2005; Latour, 2004; Moore, 2015). In particular, understanding that 'green' investments will only be a limited factor in the transformation of our social relation to the environment, calls for surmounting the modern dialectics of money between private accumulation and public regulation. Protecting the endangered commons that support all human and non-human life on a finite planet requires developing alternative approaches to monetary creation, circulation and destruction—new "monetary contestations" (Ould Ahmed and Ponsot, 2015).

Our argument in this article has not aimed so much at defining *how* the monetary system should be transformed, but rather at providing evidence that such considerations are essential and should be acknowledged by ecological macroeconomists. Ultimately, it is the nature of endogenous money that needs to be revisited for a new ecological era.

4.8 Acknowledgments

The authors would like to thank David Barmes for his useful comments and outstanding work as research assistant, as well as Peter G. Brown, Elisabeth Danon, Charles Guay-Boutet, Nicolas Kosoy, Stefano Menegat, Nelo Molter Magalhães and Raphaelle Occhietti for their comments on previous versions of the manuscript. We are also grateful to two anonymous reviewers for their extremely helpful comments and criticisms on a previous version of this article. The research leading to these results has received funding from the Social Sciences and Humanities Research Council of Canada. All errors are exclusively our own.

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Connecting Text

The following chapter furthers the discussion of the merits and limitations of ecological macroeconomics by revisiting the so-called "monetary growth imperative" debate through institutional approaches to money. The post-Keynesian endogenous view of money – at the heart of ecological macroeconomics – shows that, in contrast to the claim of monetary growth imperative proponents, there is no mechanical impossibility to maintaining interest rates in a non-growing economy. That is, there would be no monetary growth imperative.

However, the post-Keynesian critique remains incomplete insofar as it dismisses the historical reasons that led to the generalization of interest-bearing debt and their connection to the pursuit of endless accumulation, which is incompatible with the reality of a finite planet. The following chapter thus unveils the limitations of the post-Keynesian approach and emphasizes the finding of the previous chapter: institutional approaches to money will be essential to overcome the limitations of ecological macroeconomics and to explore deeper monetary reforms tailored to our ecological predicament.

This chapter was accepted for publication as a book chapter: 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, J., Kubiszewski, I. (Eds.). *Sustainable Wellbeing Futures – A Research and Action Agenda for Ecological Economics*. Edward Elgar. ISBN: 978 1 78990 094 1.

Chapter 5 – Money, interest rates and accumulation on a finite planet: Revisiting the 'monetary growth imperative' through institutionalist approaches

"Money is mysterious. Unlike matter and energy, it *can* be created and destroyed, evading the laws of thermodynamics." (Daly and Farley 2004, p. 245, italics in original).

5.1 Abstract

Ecological economists have often argued that the very nature of modern money, created by banks through interest-bearing debt, forces our socio-economic system to seek perpetual growth if we are to avoid a systemic collapse. The foundations of this so-called 'monetary growth imperative' suffer from theoretical weaknesses, as shown by several scholars who have used post-Keynesian theory and models to support their claims. However, this critique relies on an incomplete assessment of money, missing its institutional dimensions. The way money is created, circulated and destroyed is the result of social constructs, and historical accounts indicate that the progressive generalization of interest-bearing debt money since the thirteenth century marks a distinct development in the institutionalization of capitalism and its multiple growth imperatives. As such, "monetary contestations" (Ould Ahmed and Ponsot 2015) aimed at diminishing the importance of interest rates remain critical to achieving a post-growth socio-economic system.

Highlights:

- Ecological economists have developed the concept of a 'monetary growth imperative'
- This concept has been criticized through post-Keynesian theory and methods
- The post-Keynesian critique fails to consider the institutional dimensions of money
- Generalized interest-bearing debt money is inherent to capitalism's growth imperatives
- "Monetary contestations" remain critical to achieving a post-growth economic system

5.2 Introduction

Since the 2007-08 Global Financial Crisis, it has become increasingly evident to ecological economists that money and finance—which have historically received relatively little attention in the field—are of pivotal importance for the promotion of a post-growth socio-economic system. This has led to a flurry of contributions which recognize, as a starting point, the incapacity of mainstream macroeconomics—based on the assumed neutrality of money—to capture the dynamics of the monetary and financial system and its critical impacts on ecological, social, and economic systems. These dynamics and impacts are an essential component of ecological economics' research agenda (e.g. Ament 2019; Svartzman et al. 2019), but too complex to cover in a single chapter. Instead, we will focus on one particularly important question currently dividing the ecological economics community: does a non-growing economy require a structural modification of the monetary system? Specifically, does the issuance of interest-bearing debt money by private banks engender a 'monetary growth imperative' that is structurally at odds with a non-growing economy?

The heterodox theories of money and finance upon which scholars draw largely determine their positions on this question and their ensuing policy proposals. Scholars who rely on post-Keynesian economics' theory and methods (e.g. Cahen-Fourot and Lavoie 2016; Jackson and Victor 2015) argue that a 'monetary growth imperative' does not exist. As a result, this group tends to favor policies that do not challenge the foundations of the current monetary and financial system. We refer to this as the 'reformist' approach. In contrast, ecological economists who are influenced by the works of Frederick Soddy (1926; 1934), generally argue that a post-growth socio-economic system is incompatible with money created in the form of interest-bearing debt (e.g. Farley et al. 2013). These scholars argue that monetary and financial systems require a deeper transformation, such as banning commercial banks from creating money, or creating new monetary institutions such as complementary currencies. We term these the 'transformative' approaches. We emphasize the plurality in these 'approaches' as their proposals are different and sometimes at odds with each other (see Dittmer 2013; Lietaer et al. 2012), but

they still emerge from the common understanding that ‘money as it exists’ is not compatible with a non-growing system.

The position one adopts with regard to the 'monetary growth imperative' debate has major implications. As argued by Jackson (2017, p. 179), the ‘reformist’ approach to which he belongs allows for the formulation of proposals that do not pose a fundamental challenge to the capitalist system; in contrast, its ‘transformative’ counterpart demands systemic change.

This chapter outlines a research agenda on the relationships between money, finance and a post-growth economy. Rather than taking a side in the debate described, Section 2 offers an overview of both sides. This includes, importantly, a discussion of the Post-Keynesian critique of the monetary growth imperative informed by its understanding of the money supply as endogenous to the economic system. For the purpose of this chapter, we refer to this as the ‘economic’ endogeneity of money. Several items for a research agenda emerge from this discussion. However, the main purpose of this chapter is to show that bringing institutionalist perspectives into the ‘monetary growth imperative’ debate can lead to more nuanced positions than those developed so far and help empirically ground future research. Section 3 explores these institutionalist approaches to money, relying on the work of anthropologists and historians who conceptualize money as a “total social fact” (Théret 2008, p. 834). We argue that, by ignoring what we call the ‘social’ endogeneity of money, the post-Keynesian critique of the 'monetary growth imperative' fails to acknowledge that the generalization of interest-bearing debt is intrinsically related to the birth and reproduction of capitalism’s multiple growth imperatives. Section 4 merges the ‘economic’ and ‘social’ endogeneity of money to suggest new avenues for a research agenda on money in ecological economics. In particular, the arguments in favor of or against a 'monetary growth imperative' seem less effectual than a discussion on the role of interest rates and broader “monetary contestations” (Ould Ahmed and Ponsot 2015) in building the kinds of creditor-debtor relationships required for a post-growth socio-economic system. Section 5 concludes, arguing that while post-Keynesian theory has brought much to ecological economics with regards to money and finance, it has tended to inadequately transpose its

methodological tools to explore questions that require alternative ontological frameworks—and therefore alternative methodologies. Envisioning new ontologies of money will be essential to lay the foundations for a rich new research agenda.

5.3 Money's 'economic' endogeneity and the 'monetary growth imperative' debate

5.3.1 From exogenous to endogenous money

Mainstream economists imagine that "money arose because of the inconvenience of barter" (Ragan and Lipsey 2011, p. 695). Most economics textbooks portray money as the most efficient means to indulge in what Adam Smith saw as a natural human "propensity to truck, barter, and exchange one thing for another" (cited in Graeber 2014, p. 25). This view holds that money simply acts as a veil on exchanges taking place in the 'real' economy of goods and services.

This perspective posits that money is best assessed when treated as an exogenous variable, as if dropped from a helicopter or magically appearing as manna from heaven (Friedman [1969] 2009). For mainstream economists, although money matters in the short term (e.g. Mankiw 2009), it remains neutral in the long term. In this view, money can also be defined according to its functions: as a medium of exchange—a lubricant that facilitates the exchange of goods and services in the market—as a unit of account and a store of value. This narrative of money acting as an efficient veil on real exchanges has not only become a cornerstone of mainstream economic theory, it has "become simple common sense for most people" (Graeber 2014, p. 28).

The problem with this view is that there is no evidence that societies dominated by barter ever existed, while there is "an enormous amount of evidence suggesting that [they] did not" (Graeber 2014, p. 28). As found by historians and anthropologists, money has always existed in the form of credits and debts (Graeber 2014; Rochon and Rossi 2013). Heterodox economists, especially in the post-Keynesian tradition, have long acknowledged this point and have argued that, contrary to the mainstream myth of money being given exogenously, money is endogenous. In a process that is "so simple the mind is repelled" (Galbraith 1975, p. 18), when a commercial bank

generates a loan, it increases the borrower's deposit account by entering a number equal to the amount of the loan into a computer; and when that loan is repaid, money is destroyed (Godley and Lavoie 2012; Wray 2015).

Moreover, the popular conception that deposits create loans and commercial banks act as intermediaries between savers and borrowers is, thus, backward: loans create deposits (Ryan-Collins et al. 2012) and banks act as the main money creators in capitalist economies. Economists from central banks have acknowledged in recent years that this is the primary way in which money is created and destroyed, and have stated that most economics textbooks take an incorrect perspective on the matter (e.g. McLeay et al. 2014).

5.3.2 Ecological economics' 'monetary growth imperative' and the 'transformative' approaches to money

Although not all ecological economists working in the field of money believe that money is always endogenous—such as in post-Keynesian theory—they all acknowledge one of its foundations: modern money is mostly created by banks when they issue loans at compounded rates of interest (e.g. Farley et al. 2013). Following this, and inspired by the work of Frederick Soddy (1926; 1934), many ecological economists have argued that the modern monetary system structurally embodies a 'growth imperative' that is incompatible with a steady-state economy (Binswanger 2009; Daly 2013; Douthwaite 2000; Farley et al. 2013; Lietaer et al. 2012).

The argument is that since principal is necessarily less than principal plus interest, the rate at which investments increase output must exceed the interest rate on the loans that finance them; it follows that in order to ward off crisis, an economy using money created through interest-bearing debt must always grow at a rate sufficient to pay the interest. For example, Farley et al. argue that "debt grows exponentially, obeying the abstract laws of mathematics. Future production, in contrast, confronts ecological limits and cannot possibly keep pace…Eventually,

the exponentially increasing debt must exceed the value of current wealth and potential future wealth, and the system collapses" (2013, p. 2809).

In response to the apparent unsustainability of the monetary system, several leading ecological economists have advocated for varied—and potentially conflicting—'transformative' alternatives to private, interest-based money creation. The logic is that since the source of many socio-ecological problems appears to be the power of commercial banks to create money using interest-bearing debt—"an absurd human convention" (Soddy, cited in Daly and Farley 2011, p. 288)—removing this power would address many of our problems at their source. For example, various Full-Reserve Banking (FRB) proposals, whose ultimate goal is to prevent banks from creating money, have gained traction and generated debates amongst ecological economists (see Dittmer 2015; Røpke 2017). The aim of FRB proposals is for the government to become the sole issuer of the national currency and allow banks to act simply as intermediaries between depositors and borrowers—precisely the role that macroeconomic models currently ascribe to them.

Others have suggested that the 'monetary growth imperative' can be resolved by developing local and complementary currencies (e.g. Lietaer et al. 2012). Such currencies are designed to circulate alongside the national currency to protect local livelihoods (Michel and Hudon 2015) and pursue sustainability goals at the local scale. Many of these currencies do not carry interest rates and some even bear a negative interest rate that makes it burdensome to accumulate them. In short, for these proposals, changing the nature of money is a precondition to addressing our ecological predicaments.

5.3.3 The post-Keynesian critique and ecological macroeconomics' 'reformist' approach to money

In contrast with this view, several post-Keynesian scholars and ecological economists who have drawn upon post-Keynesian endogenous money theory (e.g. Jackson and Victor 2015) have criticized the argument that interest-bearing money engenders a growth imperative. One of the

main critiques argues that ecological economists reverse the causality between interest rates and growth. In this view, the money supply is not supply-led, as many ecological economists seem to imply, but demand-led: credit-money permits the production process or, as Keynes wrote, “credit is the pavement along which production travels” (Keynes, cited in Monvoisin 2017, p. 192). This suggests that the growth in economic output is not caused by banks but, rather, is anticipated by producers before they require loans. Accordingly, post-Keynesians claim that interest rates *respond* to economic agents' growth anticipations in the ‘real’ economy rather than *driving* economic growth itself (Cahen-Fourot and Lavoie 2016, p. 164).

In order to test whether interest-based money engenders a growth imperative, several scholars have also modeled steady-state economies to include monetary systems with interest-bearing debt, based on post-Keynesian stock-flow consistent models. They find—sometimes to their own “surprise” (Jackson 2017, p. 180)—that "with a suitable choice of initial values, a stationary state economy is possible” (Jackson and Victor 2015, p. 40) in the presence of interest-bearing debt.

Among the patterns that emerge from these modeling efforts are positive interest rates that can seemingly support a non-growing system as long as firms' retained profits and households' propensity to save are low. For example, "if creditors spend their interest income for investments or consumption, money flows back into circulation and is available for repayment, so exponential growth of debt and deposits does not happen" (Richters and Simoneit 2017, p. 115). Moreover, it is the stock of debt, not the flow of interest rates, that needs to be addressed in a non-growing economy. In other words, the need to grow in order to repay existing debts depends on the financing needs of the economy: the lower the total outstanding debt, the lower the pressure on economic growth. In this respect, it is argued that ecological economists who contend that there is a 'monetary growth imperative' "somehow confuse stocks and flows" (Cahen-Fourot and Lavoie 2016, p. 165).

Hence, it seems that there is "no categorical ‘growth imperative’ embedded in the structure of a credit-based money system with interest-bearing debt" (Jackson and Victor 2015, p. 40) and real

growth imperatives must exist elsewhere, for example in firms' profit maximization, asset price speculation, or consumers' aspirations for ever-increasing income and wealth. It is therefore not surprising that interest-bearing debt money existed in economies that did not focus on or experience constant economic growth, as in ancient Mesopotamia (Hudson 2002).

The answer to whether or not money creation necessitates growth has critical implications. For example, Jackson argues that if the 'monetary growth imperative' argument is correct, “a postgrowth economy simply could not live inside any recognisable form of capitalism” (2017, p. 179).[33] Therefore, the results of his model, which suggest that “it is not necessary to eliminate interest-bearing debt per se” (ibid., p. 180), lead him to conclude that “one more impossibility theorem against a post-growth economics turns out to be false” (ibid., p. 180). Instead, he writes, “countercyclical spending, social investment and public sector employment play a vital role not just in the protection of social wellbeing but in the fundamental dynamics of the post-growth economy” (ibid., p. 182).

In line with this analysis, a 'reformist' field of ecological macroeconomics has emerged over the past decade, relying strongly on post-Keynesian economic theory. It has emphasized avenues of reform that aim to realign financial flows with ecological priorities. This approach claims to be implementable within the current institutional framework without threatening the stability of our socio-economic system as ‘transformative’ approaches to money might (Strunz et al. 2017, p. 350)

Two ranges of measures have been proposed according to this ‘reformist’ approach. The first involves a strongly regulated financial system to which environmental dimensions would be added by orienting financial flows toward ‘green’ endeavors. For example, a 'brown penalizing factor' could raise capital requirements for banks exposed to fossil fuel and other highly polluting

[33] Cahen-Fourot and Lavoie (2016) do not share this view: they consider that although money does not generate a growth imperative, a post-growth system remains incompatible with capitalism. However, as we argue in the next section, capitalism and modern monetary creation seem to be more related than what their position implies.

companies (Campiglio et al. 2018). Second, authors have called for different forms of a 'Green New Deal' characterized by, among other things, sharp increases in government expenditure (Ekeland and Sæther 2017; Jackson 2011). For example, they have promoted the creation of public development banks (Campiglio 2016) or even government-led programs of 'green' full employment (e.g. Lawn 2010).

5.4 Money's 'social' endogeneity and the institutionally-generated 'monetary growth imperative'

The post-Keynesian critique of the 'monetary growth imperative' has emphasized the 'economic' endogeneity of money and aimed to show why 'transformative' approaches to money may be unnecessary to achieve a non-growing stable socio-economic system. We argue, however, that the application of post-Keynesian theory to the field of ecological economics is insufficient insofar as it fails to explore the institutional dimension of money, which we call its 'social' endogeneity (section 5.4.1). In particular, the generalization of interest rates that emerged during the Middle Ages represents a historical shift in the institutionalization of money, one that is intricately related to the establishment of capitalist socio-economic systems whose main goals are to endlessly accumulate money (section 5.4.2).

5.4.1 Money as 'total social fact'

While it is true that money operates through a system of debts and credits—as emphasized in post-Keynesian theory—it is also an evolutionary social construct through which value is defined, shaped and institutionalized. As articulated by anthropologists and historians of money, but also by some institutional economists, a monetary order is the result of a social compromise and it represents the prevailing conception of the common good and how life in community should be organized (e.g. Aglietta et al. 2016; Ingham 2004a; Ould Ahmed and Ponsot 2015). Put differently, money is a socially-sanctioned symbol that signals to a community of users what has value (Aglietta et al. 2016). Under this conception, money's primary 'function' is to serve as a unit of account (Keynes, in Ponsot and Rossi 2009) that imposes itself as a measure of all other economic

values; not only in the sphere of markets but also for non-market purposes, such as payments for health, education and other public goods (Harribey et al. 2018, p. 38). For example, the first historically recorded form of money, the Shekel, was a unit of account embedded in social relationships of power as it was used for accounting the indebtedness of the peasantry toward central powers in Ancient Mesopotamia (Bower 2018). Interestingly, the invention of these accounting practices emerged at roughly the same time that Mesopotamian rulers affirmed their sovereignty over their subjects through the writings of the first legal documents (Aglietta et al. 2016, p. 15).

Hence, throughout their history, the realms of money, debt, and power have been deeply intertwined, and this remains the case in modern nation-states. As argued by Wray (2014, p. 17): "the money of account ("the description") is chosen by the state, which is free to choose that which will qualify as money ("the thing" that answers to the description)". Moreover, the state can impose the use of the same unit of account to all agents by accepting it in payment of taxes, "which then creates the incentive for private credits and debts and then for markets" (ibid., p. 11). Money can therefore be considered through its ambiguous nature as both a private and public good (Harribey et al. 2018). 'Money-things'—whether they are made of gold, paper or digitized numbers—can be considered as a form of private good, since their possession by one agent through market activities excludes other agents from holding them. The monetary system as a whole, however, can be considered as a public good insofar as the creation, accumulation, circulation and destruction of 'money-things' respond to evolving collective norms and rely on the existence of a sovereign with tax-raising powers.

It follows that the power related to money has to do, not only with who owns it, but also, perhaps more importantly, with who has the ability to produce it and convince others to accept it for specific purposes (Ingham 2004a; 2004b). In this respect, Orléan (2015) argues that money is a social construct that emerges from a political process composed of conflicting views over what will represent value. Although a unit of account can be imposed by the state through taxation—making money “a creature of the state” (Tcherneva 2005, p. 2) according to neochartalists—

money cannot be fully explained by its relationship with taxes. For example, Aglietta et al. (2016) identify three levels of trust that explain the adoption of money by a community: methodic trust, based on the mimetic behavior of multiple individuals using the same unit of account; hierarchical trust in the authorities that issue and guarantee the value of money and the system of payments; and ethical trust, based on broader philosophical and symbolic values shared within a society. Hence, beyond the government's ability to impose a unit of account, the circulation of money requires shared beliefs and faith in the existence and viability of the community itself (Simiand [1934] 2006). In this sense, money is as much a creature of the state as the state itself is a "creature of money" (Beggs 2017).

Moreover, evolutions in monetary orders have always accompanied broader transformations related to sovereignty. Many political conflicts have been, at their root, about different conceptions of how money should be issued, circulated, and destroyed (e.g. Aglietta et al. 2016, pp. 144-8, p. 395). Ould Ahmed and Ponsot (2015) refer to the concept of "monetary contestation" to emphasize how these transformations in the institutionalization of money lie at the core of broader societal transformations; they both trigger and result from other evolutions, hence the evolutionary dimension of money.

Money can therefore best be understood through its performativity and its evolutionary dimensions. It is a semiotic aspect of the economy (Hornborg 2014, p. 12) that results from multiple social interactions, signaling value to all members of a continuously evolving community. It also shapes such interactions towards specific goals, behaviors and even collective passions (Simmel [1907] 2011). In other words, economic value does not pre-exist money, but emerges from, and is transformed by, money. Following Marcel Mauss ([1925] 1966), money can be seen as a "total social fact" (Théret 2008, p. 834), an institution that encompasses the economic, political, and cultural dimensions of a society all at once.

5.4.2 Capitalism as a pro-growth socio-economic system institutionalized by interest-bearing debt

Institutionalist approaches that emphasize the ‘social’ endogeneity of money represent a critical oversight in the post-Keynesian critique of the 'monetary growth imperative' and in the ensuing policy proposals of ecological macroeconomics. In particular, institutional perspectives enable an understanding of how the progressive generalization of interest-bearing debt money, beginning in the Middle Ages, was intricately related to the legitimization of money in its function as a store of value, which in turn increased the propensities to save and accumulate that are incompatible with a non-growing economy.

Since the thirteenth and fourteenth centuries, the use of depersonalized bills of exchange by long-distance European traders represents the most critical invention for the future development of capitalism (Braudel [1985] 2002; Ingham 2004b; Le Goff 1956). These new financial instruments and the power they conferred to an emerging social class of "merchant bankers" (Le Goff 1956) progressively freed them from the monetary power of the monarchs. For example, by the fifteenth century, private units of account were widely used despite royal bans, and "monarchs…had to reckon with the vigour of private finance. Merchant bankers wrested franchises and organised themselves into merchant cities in Italy, along the Rhine and in the Hanseatic ports" (Aglietta 2002, p. 40).

These new financial institutions first kept gold on behalf of merchants before beginning to issue credit that was transferable between economic agents. In other words, the banks' role progressively moved from that of a bookkeeper for other agents' mutual debts and credits, to that of a 'money creator' that issued its own liabilities that were accepted by others. Eventually, such credit instruments “became detached from both goods and persons … and … woven into deep and complex layers of debt" (Gómez 2018, p. 7) that were soon systematically organized into coherent systems of payments with the creation of the first central banks in the seventeenth century. Therefore, it is precisely in the growth of private credit—serving trade and geographical expansion—that capitalism finds its origins (Aglietta 2002, p. 41; Braudel [1985] 2002).

While a complete review of the historical specificity of the intertwining of capitalism and depersonalized credit instruments would fill volumes (e.g. Arrighi 2009; Graeber 2014; Ingham, 2004), it seems that "the legitimization of the rate of interest [through the consolidation of banks] represents a historical turning point" (Fantacci 2010, p. 79) in the long evolution of money. Three important consequences can be outlined here. First, the rate of interest is precisely what gives money a price and makes it a commodity[34] capable of being stored and accumulated infinitely (Fantacci 2013, p. 139). If we conceptualize capitalism as the dream of perpetually accumulating money through the use of money (Aglietta et al. 2016), the rate of interest is precisely what makes this dream possible. Graeber (2014, p. 319) argues that the origins of capitalism lie in "how an economy of credit was converted into an economy of interest" through the figure of "the financier, whose entire operations are organized around producing steady, mathematical, inexorable growth of income". Before famously arguing that "the love of money is detestable", Keynes ([1930] 2010, p. 330) himself acknowledged that the principle of compound interest was intimately related to this affection and reflected a quest for immortality, i.e. a negation of the limits to human life.[35]

Second, interest-bearing debt money enabled credit to become "unlatched from real relations of trust between individuals" (Graeber 2014, p. 337), which provided bank money with a certain "autonomous agency" (Hornborg 2013, p. 55). While this feature of modern banking systems may have been critical to capitalism's innovations according to Schumpeter (Gómez 2018, p. 7) and to the democratization of access to credit (Pettifor 2017), Graeber reminds us that the horrors committed by the conquistadores can only be fully understood by considering their relationship to this newly institutionalized role of finance.[36] More broadly, the generalization of

[34] This can be directly related to Polanyi's ([1934] 2011) concept of commodification of money.
[35] For instance, Keynes ([1930] 2010, p. 330) argues that "perhaps it is not an accident that the race which did most to bring the promise of immortality into the heart and essence of our religions has also done most for the principle of compound interest and particularly loves this most purposive of human institutions".
[36] He notes, for example, that the "relationship, between the daring adventurer [i.e. the conquistador] on the one hand ... and on the other, the careful financier ... lies at the very heart of what we now call "capitalism"" (Graeber 2014, p. 318).

interest-bearing money issued by banks was “not only a facilitator of exchange but a ‘transformative power’” (Ingham 1999, cited in Gómez 2018, p. 7) that entailed radically new relationships between creditors and debtors. It seems that “once credit became unlatched from real relations of trust between individuals (whether merchants or villagers), it became apparent that money could, in effect, be produced simply by saying it was there” (Graeber 2014, p. 337). In other words, banking institutions’ powers arise from their transformation from financial intermediaries into credit creators who can largely dictate how money—that is, economic value—is created. Therefore, the very unique power of banks lies in their "ability to fund their own indebtedness in view of making money for themselves – the financing and refinancing of others being a means to this end" (Sgambati 2019, p. 5).

Third, sovereign states and financial institutions have become deeply entangled. Despite the growth of private finance, governments still define the unit of account and provide homogeneous spaces for currency circulation, thereby providing stability (Aglietta 2002, pp. 46-7; Gómez 2018) and allowing bank money to be transformed into government money (Ingham 2004a). This is in contrast to previous ages when money was "a tool of empire ... [U]nder the newly emerging capitalist order … political and military power were then gradually reorganized" (Graeber 2014, p. 321) around the figure of the banker, who became “the capitalist par excellence” (Schumpeter 1934, cited in Festré and Nasica 2009). Accordingly, contemporary monetary orders should be understood as hybrids of public money in which trust is enabled by the power of the sovereign, and business money issued by banks. As Blanc (2018, p. 57), argues "behind the deceptively generic term of ‘national currency’ are diverse agents through whom a public good (money) is essentially created and managed by private agents for their own self-interest”. In his view, the public-private dualistic nature of money is a hallmark of industrialized societies.

These insights nuance and undermine the conclusions held by the scholars who have criticized the 'monetary growth imperative'. In particular, it seems that they have artificially separated the issuance of interest-bearing money—considering it “a-historical” (Cahen-Fourot and Lavoie 2016, p. 164)—and the willingness to indefinitely accumulate money, considering it a ‘non-monetary’

phenomenon. For example, Cahen-Fourot and Lavoie (2016, p. 168) argue that rather than changing interest-bearing debt money, "what instead needs to be changed are the productive structures of our economies and the social relations of production so as to get rid of output growth as the foundational basis and organizing principle of our societies". Richters and Simoneit (2017, p. 114) argue that "if the stationary state is unstable, it is caused by agents' decisions, not by structural inevitableness". Strunz et al. (2017, p. 350) write that the growth imperative is "interestingly… mostly posited in the context of money, as if there were no [other]" factors such as culture.

Such claims become partially irrelevant once we consider that social relations of production, agents' behaviors, and cultural factors are intrinsic to the very institutionalization of money. The rise of interest-bearing debt money is precisely what reshaped the productive structures of our economies and realigned the social relations of production toward a capitalist goal of perpetual accumulation and growth. This calls into question the assumption in stock-flow consistent models that agents will not accumulate interest—an essential condition to reach a steady state—and why, if this assumption is applied, the model considers bank-created money in the first place.

5.5 Which and whose money for which sovereignty? Toward a new research agenda

The question we need to ask, therefore, is not whether interest-bearing debt money *is* or *is not* compatible with a non-growing economy, but rather, what should and could be the role of interest rates in a new monetary order that promotes alternative relationships between debtors and creditors? A closely related question is who should benefit from the power to create money and for which purposes? In other words, we see particular relevance for future research that would explore *which monetary order is needed to enable the emergence of a new ideal-type of sovereignty* (Aglietta et al. 2016, p. 142), one that is compatible with a post-growth socio-economic system.

5.5.1 Reforming vs. transforming money – Questions for future research

Accordingly, future research should explore critical questions that are absent from the critique of the 'monetary growth imperative' and, more broadly, from ecological macroeconomics' theory and models. These include:

- If private investments are to play a less important role in a non-growing ecological society, why should we assume that the financial infrastructure—e.g. the interbank lending market in Lawn (2010)—should remain identical in such a different socio-economic system? Jackson (2017) achieves a critical first step by reckoning that the "ecological portfolio of investments" will deliver lower returns along a longer time horizon, but seems to assume that these returns will be positive and compatible with the time horizon of a long-term investor. However, what would happen if returns do not flow to those who invested, or if they are actualized on a horizon that lies beyond the investors' lifetime?
- Along similar lines, what could be the nature and motivation of investments in a post-growth society? Ecological macroeconomists Campiglio et al. (2018) assume that Schumpeterian creative destruction will remain the major force explaining socio-economic change, without any discussion of other theories of change that may be more adequate for envisioning an ecological macroeconomy. For example, the question of ownership—e.g. of renewable energy (Burke and Stephens 2017)—is central to ecological thought and to developing strategies for socially- and environmentally-sustainable economies (Mellor 2016). Could municipal and state-owned banks guarantee public and common forms of energy ownership and restore the benefits of money creation to the public sector so as to serve public interests? Should public banks replace or complement private ones?
- In light of the previous point, can government countercyclical spending really be a fundamental force of the post-growth economy (Jackson 2017, p. 182) when such investments are usually theoretically justified by their ability to 'crowd in' private investments and foster economic growth—including 'green' growth (e.g. Mazzucato 2011)? Shouldn't other ways of guaranteeing access to liquidity without tying them to credit and investments be considered? For instance, Hornborg (2016) suggests that governments could decentralize monetary creation with regional currencies, which would

be distributed to citizens in the form of a guaranteed income and could be used to purchase local goods and services and to pay taxes.

- If existing technologies allow us to bring the cost of organizing the system of payments close to zero—e.g. by creating personal electronic accounts with central banks—what would then be the institutional justification for systematically tying monetary creation to the charging of a rate of interest?

The questions above amount to asking whether it is institutionally realistic to use tools for post-growth that have been developed precisely to boost economic growth. As Fantacci writes, "in order to overcome the endemic instability of capitalist economies it will not suffice to adopt sounder policies or to provide incentives for more virtuous behaviors, but it will be necessary to embark on a *radical reform*[37] of monetary institutions" (Fantacci 2013, p. 141, italics added). Asking this question seems even more urgent in the case of a non-growing economy. Addressing it will likely require an institutionalist approach to ecological economics, which may be critical for overcoming the limitations of post-Keynesian ecological macroeconomics.

5.5.2 "Monetary contestations" for an ecological economy

In the hope of offering a platform for future research that overcomes the limitations of post-Keynesian ecological macroeconomics, and without aiming to be exhaustive or claiming to provide 'better solutions', we suggest some avenues of "monetary contestations" (Ould Ahmed and Ponsot 2015). These consist of envisioning other forms of creating, circulating, and destroying money that can help promote alternative socio-economic systems. In particular, we suggest research that develops new ways of accessing liquidity that are not tied to interest-based private money and not justified by the 'crowding in' effect of public spending. Such attempts could contribute to minimizing the will of perpetual accumulation that lies at the very core of our societies' growth imperative, and provide new ways of defining and measuring value in an

[37] Fantacci's concept of a 'radical reform' may provide a compromise between the 'reformist' and 'transformative' approaches presented above.

ecological and non-growing socio-economic system. Table 5.1 below summarizes the different approaches to money assessed above and those explored in the rest of this chapter.

Table 5.1: Summary of approaches to money

	Neoclassical Economics	**Post-Keynesian Ecological macroeconomics**	**Institutional Ecological macroeconomics**
Ontological Presupposition	Prices, not money, signal individual preferences	Money enables the production process	Money as a symbol that both signals and shapes value
Money Is…	**Exogenous** Neutral commodity arising from the inconveniences of barter	**'Economically' Endogenous** Credit created by commercial banks and potentially by government entities (e.g. central bank)	**'Socially' Endogenous** • Credit issued under varied institutional arrangements, resulting from political conflicts over the definition and appropriation of value • A 'total social fact'
The Money Supply causality	Deposits create loans	Loans create deposits	• Loans create deposits, but... • Bank money has "autonomous agency" (Hornborg 2013)
Banks…	Allocate money between savers and borrowers	Create the money supply	Institutionally engender capitalism
Interest rate and growth imperative	NA (natural rate of interest to balance output with inflation)	Interest rate does not generate a growth imperative, as shown with stock-flow consistent models	• Bidirectional causality, and ... • Inseparable from other growth imperatives • Interest rate as reflection of a quest for immortality (Keynes [1930] 2010)
Approach to Solutions…	NA	**Reform** Government spending and financial regulation	**Transform or radically reform** Open to "monetary contestations" (Ould Ahmed and Ponsot 2015) triggering or resulting from other societal transformations. Evolutionary perspective

In this quest for alternative monetary systems, Blanc (2018) argues that developing new types of relationships between creditors and debtors that can prioritize long-term relationships and relatively symmetrical mutual obligations requires fostering a third type of money. This type

would be designed to overcome the limitations of relying upon the dualistic monetary system of nation-states' sovereign money and profit-based private money. Such an "associative money" (Blanc 2018)—which we may also call 'commons money'—may be used for special purposes, involve specific actors, and be designated for specific goods and services.

Local and complementary currencies that circulate within a limited region can be designed precisely to serve particular environmental goals such as encouraging local agriculture (Lietaer et al. 2012), promoting ecological improvement (ibid.), and discouraging monetary accumulation (Gesell [1929] 1958). Local and complementary currencies have the potential to distinguish between different values, rather than ascribing to a hegemonic institutional value, and stimulate local economies by reestablishing bonds between humans and the spaces they inhabit (Hornborg 2016, pp. 129-50). While their weaknesses have been well documented (e.g. Dittmer 2013), these practical failures should not be seen as proof that such currencies are doomed to insignificance, but rather as an invitation to think about how to upscale their principles, in particular those related to constraining the role of interest rates.

In this respect, Keynes' views on Gesell's demurrage-based money are particularly interesting. Keynes argued that those who support the imposition of an artificial cost on money, in order to deter its accumulation, "have been on the right track; and the practical value of their proposals deserve consideration" (Keynes [1936] 2013, p. 234). This has direct implications for the fundamental role of compound interest and the ensuing function of money as a store of value. Complementary currencies that apply the principle of demurrage can thus provide a framework for considerations of non-interest-bearing national monies. Rather than being dismissed at first sight—as in Fontana and Sawyer (2016)—such radical monetary proposals could be assessed precisely for their ability to foster new types of creditor-debtor relationships that do not rely on the desire to endlessly accumulate money.

Importantly, most of the ecological debates on money have taken place at the local or national scale and thus omit the biophysical complexities of the International Monetary System (IMS). In

this respect, Hornborg (2014; 2016) notes that money and energy seem to be inversely related, as 'peripheral' countries in the world-system tend to export more 'embodied nature' than they import from 'core' economies. Through the differential value of nations' currencies, an "ecologically unequal exchange" (Hornborg 2014) can be organized at the global scale. Money, in its capacity of signifying value at the international scale, is therefore an important component of ecosystems' matter and energy flows (Hornborg 2013), and the organization of the IMS is closely related to issues of environmental justice. Accordingly, the extremely difficult yet essential starting point for a worldwide ecological transition may lie in the relationship between currencies on the world-system stage.

While it is far beyond the scope of this chapter to discuss this issue in depth, Fantacci's (2013) perspective on Keynes' bancor plan offers a framework for future research in this direction. By aiming to make bancor a 'specific-purpose money' to be used only for trade, and by suggesting a "symmetric distribution of charges between creditors and debtors" (Fantacci 2013, p. 136) to make members' balances converge towards zero, bancor would correspond to a claim on embodied nature and not on money itself. Interestingly, one of the main strengths of such an international currency lies in the fact that it does not bear interest rates, thereby making it meaningless to accumulate.

Beyond these subnational, national, and supranational forms of monetary contestations, the question of interest rates can also be addressed through debt jubilees, which effectively erase the power of interest rates on a regular basis. Indeed, in many societies in the past, debt-cancellations were "not only common, but had a successful social stabilization function" (Hudson and Goodhart 2018, p. 2). A recurrent problem in these societies was precisely that "the mathematical principle of compounded interest [increased] the volume of debt exponentially, much faster than the rural economy's ability to pay, [thus] absorbing the surplus and transferring land and even the personal liberty of debtors to creditors" (Hudson and Goodhart 2018, p. 4). In this context, debt jubilees provided a mechanism to periodically restore solvency among debtors. While calling for a debt jubilee today could generate massive instability, alternative mechanisms

can be designed (see Hudson and Goodhart 2018; Keen 2017) and should also be considered a part of a research agenda.

Finally, future research in ecological macroeconomics could find inspiration in non-Western ontologies showing how debt jubilees could be contextualized within a much-needed new relationship between humans and nature (Brown 2012). For example, Rappaport's (1968) account of the Tsembaga Maring farmers in Papua New Guinea describes a complex socio-ecological system of ritualized homeostasis between humans, pigs, and land in which pig herds increase until conflict begets a thinning of the herd. In other words, the Tsembaga Maring contract an implicit debt with the soil and repay that debt with a ritualized slaughter that helps maintain homeostasis in this socio-ecological system. Further research could consider ritualized forms of debt repayment and elimination in a non-growing monetary system.

5.6 Conclusion

This chapter confirms the post-Keynesian view that there is no mechanical impossibility to maintaining interest rates in a non-growing economy. However, we have argued that focusing strictly on the 'economic' endogeneity of money fails to account for money's 'social' endogeneity. In particular, we argue that the generalization of interest-bearing debt money marks a distinct development in the institutionalization of capitalism and its multiple growth imperatives. The generalized issuance of money at interest, and the will of agents to endlessly accumulate that money, are thus *two sides of the same coin*.

In this context, aiming to tame the will of accumulation simply through government countercyclical measures and financial regulation may be insufficient. Therefore, rather than reforming the institutional arrangements that support the goals of perpetual accumulation, we argue that a research agenda should consider transforming those institutions through "monetary contestations" (Ould Ahmed and Ponsot 2015) that seek ways of issuing non-interest-bearing debt money in a manner that promotes a more balanced relationship between debtors and creditors—a form of Polanyian double movement on the commodification of money.

More broadly, the manner in which the monetary growth imperative has been treated by the post-Keynesian literature seems to confirm that the ontological divergences between post-Keynesian and ecological economics have not yet been satisfactorily addressed (Spash and Schandl 2009). At the very least, institutional perspectives are needed to bridge the gap between the two schools (Vatn 2009) and perhaps create a field of ecological macroeconomics that does not simply transpose post-Keynesian theory upon ontologically-divergent questions. Such perspectives could provide guidance on how to revisit the monetary system in the context of alternative relationships amongst humans, and between humans and their natural environment.

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Connecting Text

The three previous chapters identified that a reform of the international monetary system (IMS) will be an essential component of a global ecological transition. In fact, an increasing number of scholars and policymakers emphasizes that a reform the IMS will be needed to address two global risks: ecological risks – including climate change – and existing global imbalances, which notably prevent Peripheral countries from attracting the long-term investments necessary for their development paths.

The following chapter therefore explores the existing proposals to reform the IMS through the lenses of the different disciplines and approaches informing this thesis, such as institutional approaches to money, post-Keynesian economics, the world-ecology approach and ecological economics and ethics. In doing so, it seeks to provide a political ecology of global imbalances, i.e. an ecologically-embedded theoretical framework to understand the question of money and finance in the world-system.

This chapter was submitted to the peer-reviewed journal Review of International Political Economy, submission N° RIPE-2020-0098.

Chapter 6 – Greening the International Monetary System? Not without addressing the political ecology of global imbalances

6.1 Abstract

Addressing ecological crises such as climate change within the current International Monetary System (IMS) will be impossible. International monetary relations are built upon a hierarchy between currencies, which generates structural Core-Periphery imbalances and prevents Peripheral countries from attracting the long-term investments necessary for an ecological transition. While propositions have emerged to reform the IMS in order to address both global imbalances and ecological crises, they typically approach these issues as separate phenomena. In contrast, this paper develops a political ecology of global imbalances to explore how currency hierarchies are constituted and maintained through ecological hierarchies: monetary dominance depends upon the continuous and uneven flow of resources from Peripheral to Core countries. This connection between monetary and ecological hierarchies is particularly visible through the *Chinamerica* relationship, which has linked the international dominance of the US dollar to China's coal-powered development. China is now transitioning away from its Peripheral status by seeking to reconfigure currency and ecological hierarchies to support its own resource-intensive growth, but the latter also increases the likelihood of systemic ecological crises. This suggests that the quest for a balanced and ecological IMS requires a dramatic shift away from the Core-driven *imperial* modes of production and living.

6.2 Introduction

Policymakers – including central bankers and financial supervisors – and the academic community increasingly acknowledge that the rise of ecological crises such as climate change, soil erosion and biodiversity loss could threaten the stability of the global economic and financial system (e.g. Bolton et al., 2020; Carney, 2015; NGFS, 2019; Valantin, 2020). For instance, it has

been pointed out that the depletion of natural habitats by human activity contributes to the outbreak of infectious diseases such as COVID-19, which could just be the first of several mass pandemics (Vidal, 2020).

In parallel, a growing number of scholars points to another potentially systemic risk: the financial globalization of the past decades has cemented global imbalances, which can be broadly understood as a situation of high and persistent current account deficits in some countries and surpluses in others. Their existence entails both domestic and global economic risks. In particular, it leaves Peripheral[38] economies vulnerable to short-term international capital flows and unable to implement long-term development strategies, in contrast to Core countries that can accumulate large trade deficits and/or focus on high-value added exports (e.g. Bonizzi, Kaltenbrunner & Powell, 2019; Ocampo, 2017).

Recently, some calls have emerged to significantly reform the International Monetary System (IMS) so that it can take these two issues into account and pave the way towards a balanced and sustainable IMS (e.g. Aglietta & Coudert, 2019; UNCTAD, 2019). In particular, a reformed IMS could theoretically address the problematic hierarchy – or power asymmetry – among currencies (Prates, 2017) which prevents Peripheral countries from attracting long-term finance because of the limits imposed on their balance of payments by international markets and institutions. This financing is seen as imperative for the global ecological transition and to reducing their vulnerability to climate change (UNCTAD, 2019).

While addressing global imbalances and ecological challenges will be essential to preserve systemic stability and provide for meaningful development opportunities in the coming decades,

[38] Following world-systems theory (Arrighi, 1994; Wallerstein, 1974), we use the term "Periphery" to refer to countries that are often called "developing" or "emerging" economies. We use the terms "Center" and "Core" interchangeably to refer to countries that are often called "advanced" or "developed" economies. This terminological choice emphasizes the dialectical relationships between nation-states within the global economy, avoiding more linear and atomistic views of development (e.g. Rostow, 1960).

existing proposals treat these issues separately: global imbalances and ecological unsustainability are perceived as two isolated problems that now need to be resolved at the same time.

In contrast, this paper suggests that looming ecological crises are closely tied to the political ecology[39] of international monetary relations. In particular, the currency hierarchy that impinges on Peripheral countries' development paths is inextricably related to an ecological hierarchy: Peripheral countries are systematically driven to export more "embodied nature" (Hornborg, 2014) – e.g. energy and materials – than they import, thereby being stuck in the subordinated position of providing Core economies with low value-added resources. This not only impinges on Peripheral economies' development path, it also enables the Center to engage in an "imperial mode of living" (Brand & Wissen, 2018) which degrades natural environments throughout the world and particularly in Peripheral countries (Martínez-Alier, 2002; Moore, 2015).

The link between these monetary and ecological hierarchies can be appreciated by examining the "Chinamerica" (Valantin, 2020) relationship, which refers to the *hybridization* of the Chinese and US economies during the past decades of financial globalization. This relationship contributed to the extraction and transformation of colossal flows of materials and energy, which are deeply connected to our ecological predicament. Moreover, China's ongoing transition (de Graaff, ten Bring & Parmar, 2020) from the "factory of the world" (Zhang, Wang & Chen, 2016) to a Core power is now reshaping the international monetary hierarchy but also accelerating global environmental degradation (Meng et al., 2018; Zhang et al., 2018). These patterns could generate systemic ecological crises and geopolitical conflicts for access to dwindling resources in a degraded Earth system.

These findings suggest that the quest for a truly balanced and ecologically-sustainable IMS cannot be dissociated from a profound transformation of lifestyles in Core countries and from new

[39] As indicated by the Environmental Justice Organisations, Liabilities and Trade global research project (ejolt.org): "this burgeoning field has attracted scholars from the fields of anthropology, forestry, development studies, environmental sociology, environmental history, and geography. Its practitioners all query the relationship between economics, politics, and nature".

ontologies of human emancipation and (post)development agendas (e.g. Kothari, Salleh, Escobar, Demaría & Acosta, 2019) for the whole community of human beings inhabiting our finite planet.

This article is structured as follows. Section 2 reviews why the challenges posed by ecological risks such as climate change necessitate a major overhaul of the IMS. Section 3 shows that such an overhaul will not be able to succeed if it does not address the political ecology of the IMS, and in particular the nexus between the hegemonic currency and the key resources which support a specific regime of accumulation[40]. Section 4 applies this analytical framework to assess the "Chinamerica" relationship (Valantin, 2020) and its possible evolutions, as China's economic rise is transforming existing monetary and ecological hierarchies. Section 5 discusses how current patterns seem to lead us to systemic ecological crises and argues that avoiding them requires deep changes in lifestyles, including degrowth in Core countries. Section 6 concludes.

6.3 The international political economy of climate change

6.3.1 Ecological stability as an international coordination problem

It is increasingly acknowledged that climate change (IPCC, 2018), among numerous other ecological crises which threaten the future of life on our planet (e.g. Ripple et al., 2017; Steffen et al., 2015), will pose new and significant global risks. Its impacts such as rising sea levels, extreme weather, droughts, floods and soil erosion are projected to increase with time (IPCC, 2018), leading to unprecedented stresses on ecosystems and human systems across the world.

[40] In the French Regulation School (Aglietta, 1979), "regimes of accumulation" refer to distinct patterns of economic evolution that are relatively stable during specific historical periods. A regime of accumulation is embedded in a mode of regulation, which refers to a set of institutional forms – a money form, a competition form, a wage form, a state form, and an international regime – providing the context and establishing the rules of the game for each regime of accumulation (Boyer & Saillard, 2002).

In doing so, climate change will pose significant international coordination problems. It will notably probably increase global inequality and could reverse the trends of income growth made over the last 50 years, as the worst consequences of climate change will likely be concentrated in low-income countries (Diffenbaugh & Burke, 2019; Human Rights Council, 2019). Inequalities of *vulnerability* to climate change stand in stark contrast to the inequalities in *lifestyle* which drive it: the wealthiest 10% of individuals on the planet is responsible for 45% of total greenhouse gas emissions, while the bottom half of the global population in terms of income emits only 13% (Chancel & Piketty, 2015).

In turn, avoiding the worst impacts of climate change raises significant issues of fairness across nations. Despite growing recognition of the uneven causes and consequences of a rapidly deteriorating environment, international climate negotiations have failed to catalyze a truly global movement to significantly reduce emissions (Brand & Görg, 2008; Ciplet, Roberts & Khan, 2015). For instance, while many of the wealthiest countries committed to mobilize US$100 billion per year in climate financing by 2020 to accelerate mitigation in the Periphery (UNFCCC, 2015), current pledges remain unfulfilled (OECD, 2019a) and will in any case fall far short of what is necessary. Another example of the difficulty of designing international mechanisms can be found in Ecuador's proposed Yasuni-ITT initiative. In 2007, the Ecuadorian government asked for US$3.6 billion from foreign governments to sustain a moratorium on oil drilling in an Amazon rainforest preserve; after receiving little more than US$100 million in pledges, the plan was abandoned in 2013 (Kingsbury, Kramarz & Jacques, 2019). In this context, ambitious individual-country measures could lead to free-riding behaviors from others, potentially offsetting the gains in one country with an increase in greenhouse gas emissions elsewhere (Krogstrup & Oman, 2019). As a result, the principle of "common but differentiated responsibilities" (UNFCCC, 2015) enshrined in international climate negotiations remains largely ineffective.

Moreover, even a concerted effort away from fossil fuels could trigger new geopolitical tensions. A move towards renewable energies would radically shift the balance of power between countries, remake global trade flows, and alter the geopolitical landscape (IRENA, 2019). While

oil-related conflicts may diminish, new conflicts related to access to minerals, and rare earth elements in particular, may arise (Vidal, Rostom, François & Giraud, 2017). China, for example, already started to exercise its political power through a tight control over the supply of minerals essential for the production of renewable energy (Pitron, 2018).

A peaceful, equitable and rapid transition to a low-carbon global economy will therefore require an unprecedented level of international cooperation, including significant fiscal and technical transfers between countries (Althouse, Guarini & Porcile, 2020). However, despite the growing awareness of the global character and destructive consequences of climate change, the existing multilateral order seems incapable of living up to the challenge. In this context, scholars and policymakers increasingly recognize that addressing climate change and other ecological issues may be impossible if the multilateral order is not *fixed* in the first place. In particular, reforming the International Monetary System (IMS) appears to many as a prerequisite to a global ecological transition.

6.3.2 Addressing monetary hierarchies in the age of climate change

Given the absence of an international currency that would replace national currencies and would correspond to a universal form of sovereignty – a *post-nation states world* –, the capitalist world-system has historically relied on a monetary hierarchy (Aglietta, 2018), i.e. on a geopolitics of currencies (e.g. Cohen, 2019; Hardie & Maxfield, 2016; Norrlof, 2014). The institutions which guide international relations of investment, trade, production and consumption attribute different levels of trust to each national currency (Palludeto & Abouchedid, 2016; Angrick, 2018). The four historical cycles of accumulation in the capitalist world-system – the Genoese, Dutch, British and American ones – are marked by the hegemon's ability to convince others, through coercion and consent, to use their currency (Arrighi, 1994). For instance, as noted by Fields & Vernengo (2013):

> *During the mercantile phase of capitalism bankers had the power to enforce the repayment of debt in a particular token. For that reason the key reserve currencies were over time associated with the main trading empires and their merchant bankers, i.e., the Venetian ducat, the Dutch guilder and the British pound. . . . The central or hegemonic states manipulated international money markets, controlling exchange rates or disrupting the functioning of financial markets, to subdue weaker countries in the periphery. It is the power to coerce other countries that is central for monetary hegemony* (pp. 7-8).

Monetary hegemony – i.e. the ability to impose a unit of account to other nation states – can today be measured by the relative liquidity of national currencies, which corresponds to the willingness of all agents in the system to hold them (Prates, 2017). At the top of the currency hierarchy, the US dollar has the highest degree of liquidity, highlighted by the fact that it is the unit of account used in most international trade and demanded as a store of value by most agents. For example, the US dollar was involved in 88% of all foreign exchange transactions in 2016, and represented 62% of official foreign exchange reserves in 2018 (Aglietta & Coudert, 2019). By producing the international monetary standard, the US faces no foreign exchange constraints and enjoys an “exorbitant privilege” (Eichengreen, 2010) in terms of products that can be claimed in exchange for US dollars. Other regional or national currencies such as the euro, the Japanese yen, the British pound and the Swiss franc (Vallet, 2016) benefit from similar features, although to a smaller extent than the US dollar.

At the bottom of this hierarchy are the currencies issued by most Peripheral economies; these are non-liquid currencies, which carry higher risks for investors who may accept to hold them only at higher rates of return (Prates, 2017). The political and economic autonomy in the Periphery is restricted by their inability to issue a universally accepted currency. Hence, whereas the Center economies – particularly the larger ones – are “business-cycle makers”, Peripheral economies are "business cycle takers" (Ocampo, 2002): the flows of capital toward Peripheral countries depend on exogenous factors, such as the interest rate set in the Core – e.g. by the US Federal Reserve – or the subjective confidence of investors at any particular point in time. These

flows can lead to massive exchange rate movements that are largely disconnected from domestic economic conditions (Kaltenbrunner & Painceira, 2018). As a result, Peripheral countries are often unable to attract long-term foreign finance, due to the limits imposed on their balance-of-payments by international markets and institutions (Rochon & Vernengo, 2003).

In this context, the financial globalization of the past decades – which includes increases in foreign direct investments and, to an even greater extent, short-term trading in international financial markets – has cemented the subordination of Peripheral economies (Bonizzi et al., 2019). They are more subject to short-term cross-border speculative movements (Villeroy de Galhau, 2019), as any arbitrary change in international liquidity preference can generate flights to currencies higher up in the currency hierarchy (Bortz & Kaltenbrunner, 2017). Moreover, the lower liquidity premium of Peripheral currencies "requires them to offer higher interest rates and/or profitable exchange rate movements in order to maintain investor demand" (Kaltenbrunner & Painceira, 2018, p. 294) in highly competitive currency markets. The international monetary hierarchy under financial globalization therefore imposes a "survival constraint" on peripheral economies (Angrick, 2018): they are under constant pressure to attract foreign financing to overcome the limits imposed by their balance-of-payments position.

As a result of this survival constraint, the realm of domestic autonomy open to peripheral countries is circumscribed (Palludeto & Abouchedid, 2016): the Periphery must generate sufficient net liquidity inflows to avoid growing indebtedness in foreign-denominated currencies. Even when they manage to accumulate massive foreign exchange reserves and thereby better resist to external shocks (Grabel, 2018) – e.g. during a commodity boom – the reserves accumulated rarely benefit the productive economy as they tend to be invested in US treasury bills as a hedge against future shocks (Ocampo, 2017).

To relieve these permanent pressures on their balance-of-payments, Peripheral countries are generally led to develop short-term export-led strategies for products with low added value (Vernengo, 2006) such as agricultural commodities, natural resources, and/or light

manufactures. This prevents them from developing long-term industrial strategies focused on high value-added production that are more competitive in world markets. In contrast, Center economies can accumulate large trade deficits with virtual impunity and/or focus on long-term industrial strategies that prioritize high-value exports.

As a result of these structural imbalances, climate change and other ecological crises are likely to worsen in the absence of significant changes in the architecture of the international monetary system. Given the survival constraint to which they are subject, Peripheral countries will remain unable to develop the long-term strategies that would be necessary to handle a low-carbon transition (UNCTAD, 2019). Moreover, since Peripheral countries will likely be more affected by climate change, it is also probable that climate-related shocks in the Periphery – e.g. droughts, storms, crop failure – will generate flights to safety that could further strengthen their balance-of-payments growth constraints. Finally, even a shock affecting the Center could lead to capital flights away from Peripheral countries, as happened immediately after the outbreak of COVID-19 (Tooze, 2020).

6.3.3 Toward a *green* International Monetary System?

In response to this state of affairs, several calls have emerged over the past few years to engage in a major overhaul of the IMS. The latter would seek to achieve a *win-win-win* situation, one that would provide Peripheral countries with better access to funding while stabilizing the financial system and solving the climate problem. For instance, UNCTAD's (2019, p. II) proposition for a "Global Green New Deal" seeks to "reverse the polarization of income . . . across countries, create a stable financial system that serves the productive economy . . . and undertake massive investments in clean energy, transportation and food systems".

To this end, reviving Keynes' proposal for an international clearing union (ICU) – i.e. a system comprising the imposition of a global unit of account that would be used for international trade (Kregel, 2015) – could become an absolute necessity. A global unit of account used only for trade,

along with a “symmetric distribution of charges between creditors and debtors” (Fantacci, 2013, p. 136), would make currency union members’ balances converge towards zero and alleviate the debilitating external constraints faced by Peripheral countries (Ocampo, 2002). In other words, the ICU could rebalance the current IMS while providing Peripheral countries with the means to fund long-term investments aimed at developing their economies.

In order to better account for ecological issues when reforming the IMS, inspiration can be found in some proposals that have been made to tie global liquidity to a biophysical standard, while improving Peripheral countries' access to their financing needs. In particular, Nicholas Kaldor (1964) proposed a commodity reserve currency (CRC), composed of a basket of dozens of commodities, which would be managed at the international level and could benefit from countercyclical mechanisms. Kaldor sought to provide Peripheral countries with an independent and stable source of growth, without depending on the US as provider of liquidity “in last resort” (Ussher, 2009).

Given that a major overhaul of the IMS may remain unattainable in the short-term, more operational policies have been proposed, in particular with regard to the development of a green version of special drawing rights (SDRs), the IMF-managed international reserve asset based on a basket of key international currencies. Several proposals (Bredenkamp & Pattillo, 2010; Ferron & Morel, 2014; Aglietta & Coudert, 2019; Aglietta & Espagne, 2018; Ocampo, 2019; Svartzman, Dron & Espagne, 2019; UNCTAD, 2019) have aimed to expand the use of SDRs while linking them to environmental objectives such as maintaining global warming below 1.5°C above pre-industrial levels. For instance, Aglietta & Coudert (2019) suggest that unused SDRs could be lent to Peripheral countries to finance their low-carbon transition, thereby addressing jointly these countries’ vulnerability to cross-border capital flows and the need to finance low-carbon infrastructure. Such a system would notably require that the International Monetary Fund (IMF) takes the role of a “green” international lender of last resort, by issuing SDRs in exchange for excess reserves held by central banks and governments (ibid).

6.4 Towards a political ecology of international monetary relations

While the proposals discussed above would undoubtedly be welcome, they nonetheless often implicitly rest on the fundamental assumption that providing the Periphery with sufficient financing for a *green* or *sustainable* development path can take place, all other things being equal for Core countries. In other words, while existing proposals do acknowledge that the Periphery lacks critical access to long-term funding for more ecologically sustainable forms of development, they do not tie this to how Core countries benefit from this situation. Such views, however, obscure the geographic reach and ecological needs of global capitalism (Christophers, 2012; Moore, 2015; Patnaik & Patnaik, 2017). Any hope for a balanced and ecologically-sustainable IMS must reckon with the political ecology of international monetary relations, as discussed below.

6.4.1 The international political ecology of capitalism

While economic activity is most frequently measured through monetary flows, economic systems function by transforming flows of energy and materials, while generating waste and transforming the natural environment in which human and nonhuman societies live (e.g. Georgescu-Roegen, 1971; Daly & Farley, 2011; Jackson, 2017). Despite growing awareness of this fundamental insight, most economists continue to "treat the environment as an optional extra, an area for specialists, outside the central concerns of the profession, rather than of fundamental importance to understanding economic systems, their organization, operation and reproduction" (Spash & Smith, 2019, p. 215).

The world-ecology perspective (Moore, 2015), which builds on world-systems theory (Arrighi, 1994; Wallerstein, 1974), provides an insightful framework to reconnect the dynamics of global capitalism to the energy and material flows that support it, i.e. to unveil what could be called the international political ecology of capitalism. This approach notably highlights how countries at the Center of the world-system are fundamentally dependent on a continuous inflow of raw materials from Peripheral frontiers of resource extraction (Moore, 2015).

Hence, the four historical cycles of accumulation in capitalist world-systems described above are not only characterized by different forms of monetary hierarchies, but also by corresponding ecological hierarchies. For instance, the hegemony of the Dutch Republic would not have been possible without "a world-ecological regime that delivered cheap grain (from Poland) . . . and cheap timber (from Norway and the Baltic)" (Moore, 2015, p. 103). At a more massive scale, British industrialization relied on the appropriation of "an ecological footprint several times the size of its entire national territory, and . . . the toil of a workforce several times larger than its national population" (Hornborg, 2016, p. 22).

In the same manner, the exceptional economic expansion of the US and Europe during the Golden Age of capitalism were not only enabled by collective wage negotiations and the preeminence of the welfare state – as extensively covered in the literature (e.g. Lipietz, 2013) – but also by "multiple appropriations of human and extra-human natures" (Moore, 2015, p. 69) such as the "the forests, fields, and resource veins of the colonial and semi-colonial worlds" (ibid). Likewise, the transition from the Golden Age to financial globalization after the 1970s is also marked by profound ecological changes (Cahen-Fourot & Durand, 2016). Those are largely related to the outsourcing and offshoring of resource-intensive production to Peripheral countries, as discussed in the next section through the US-China relationship.

The above indicates that Core-Periphery relations are often characterized by an "ecologically-unequal exchange" (Frey, Gellert & Dahms, 2018; Hornborg, 2014): Peripheral economies tend to specialize in extractive and pollutive industries found at the beginning stages of value production. In doing so, they often find themselves locked in the position of providing Core economies with cheap resources, without benefitting much from international trade. In addition, the degradation of Peripheral countries' natural environments tends to limit their development capacities (Wackernagel, 2019) while generating numerous socio-environmental conflicts (Martínez-Alier, 2002). Meanwhile, Core countries consume the vast majority of the world's

resources and capture the final stages of value-added production (Piñero et al., 2019)[41]. By extension, their natural environments remain relatively spared by outsourcing the most pollution- and resource-intensive aspects of production (Frey et al., 2018).

6.4.2 Currency and ecological hierarchies – A self-reinforcing loop

In short, Peripheral countries' development paths are not only constrained by the currency hierarchies described in the previous section, but also by ecological hierarchies. Moreover, the two are self-reinforcing: the stability and power of the dominant currency both enables, and is supported by, a continuous outflow of material and energy resources from the Periphery to the Center (Aglietta & Coudert, 2019; Koddenbrock, 2019; Patnaik, 2009; Patnaik & Patnaik, 2017). As Aglietta & Coudert (2019, p. 1) argue, "since its genesis in the industrial revolution, the key currency has been the currency of the country dominating the primary energy resource, e.g. the commodity most traded worldwide. The pound sterling was linked with UK dominance in coal, the dollar with US dominance in oil".

Ecologically-unequal exchange is therefore closely related to "the distribution of money in the world-system" (Hornborg, 2014, p. 12): Core countries, whose currencies are located at the top of the currency hierarchy, have captured increasingly distant resources that are essential to their own socio-economic reproduction, largely by maintaining Peripheral countries in the role of exporters of such resources. Moreover, when agents become used to trade key resources in a specific unit of account since all other agents do the same – what Aglietta (2018) calls the "methodic" trust in money – this reinforces the existing monetary hierarchy.

[41] As Hornborg (2014, p. 14) puts it, "the existence of historically privileged and sparsely populated nations richly endowed with natural resources (e.g., Canada, Australia, Scandinavia, Saudi Arabia) has enabled some extractive zones of the world-system to escape economic impoverishment. This in no way contradicts the definition of 'unequal exchange'". In particular, these countries are not vulnerable to short-term capital flows in the same way as Peripheral countries. Moreover, they can develop high value-added products in addition to natural resources, i.e. they are not constrained by their role or resource providers.

In particular, it appears that a keystone to the US dollar's "exorbitant privilege" (Eichengreen, 2010) over the past decades has consisted in the ability of this currency to serve as unit of account for a critical resource supporting the global economy, oil (El-Gamal & Jaffe, 2009; Hudson, 2003; Mitchell, 2011; Naylor, 2004). For instance, Fields & Vernengo (2013) remark that as long as key commodities like oil are priced in US dollars in international markets, the US cannot face an insufficient source of dollars, and a potential depreciation of the US dollar would not lead to an increase in the price of imports. This ability to determine the trade of key currencies in a specific unit of account is obviously enabled by specific geopolitical and military strategies[42] (El-Gamal & Jaffe, 2009; Mitchell, 2011; Smith-Nonini, 2016; Valantin, 2017) although those are not further discussed here.

This oil-dollar standard (Mitchell, 2011) has had wide-ranging implications, not least because energy prices are also fundamental in the extraction, processing, and transportation of virtually every other commodity such as food and consumption goods. The position of the US as the sole issuer of the world's global currency, and the denomination of oil in that currency – including for oil derivatives, through a long-term strategy actively supported by the US government (Faudot & Ponsot, 2016) – therefore confers the US with distinct powers in terms of trade and monetary flexibility, not to mention the significant advantages it provides for global policy-making in the world-system (Patnaik, 2009; Cohen, 2019). Fields & Vernengo (2013, p. 748) argue that "in this sense, it is the ability to determine that key commodities and particular contracts are settled in dollars, not the specific currency reserve holdings that determines which currency is dominant".

In this context, the limited room for maneuver of Peripheral countries seems even more structurally binding than is often envisioned: the capacity of the Core to continue accumulating capital is contingent on the availability of, and access to, cheap resources provided mostly by the Periphery (Moore, 2015; Patnaik & Patnaik, 2017). In other words, if Peripheral countries

[42] For example, Smith-Nonini (2016: 63) reminds that the US government efforts to control the supply of oil flows "include the reflagging of Kuwaiti oil tankers during the Iran–Iraq War; the 1990 Desert Storm war with Iraq; . . . and the 2003 Iraq invasion".

specialize in "the exploitation and exportation of nature" (Brand, Dietz & Lang, 2016, p. 126), this is *not* because the IMS is dysfunctional, as often claimed (e.g. Ocampo, 2017), but rather because its structure favors the pursuit of economic growth and capital accumulation in the Core.

This advantage held by Core countries becomes particularly evident precisely when it is threatened, e.g. during commodity booms that tend to rapidly become unbearable for Core countries. For instance, Hamilton (2009) finds that rising oil prices in the early 2000s contributed to the rise in delinquency rates in mortgages that triggered the 2007-08 Global Financial Crisis, as poorer US households saw their average annual spending on gasoline more than double between 2003 and 2008 (Kallis & Sager, 2017). This does not suggest that oil prices caused the Global Financial Crisis, as the latter is rather to be found in the transformations of capitalism over the past decades (e.g. Aglietta, 2018; Bezemer & Hudson, 2016; Helleiner, 1995; Stockhammer, 2013). It rather indicates that the supply of cheap resources provided by the Periphery is fundamental to pursuit of capital accumulation in the Center.

Such an analysis has profound implications for Peripheral countries' development opportunities in the context of an ecologically-sustainable global economic system. A Global Green New Deal – or any proposal aimed at jointly addressing global imbalances and climate change – will not be able to succeed as long as it overlooks the connections that exist between ecological and monetary hierarchies and the currency-resource nexus. In this regard, the next section argues that, perhaps even more importantly than the US dollar-oil nexus discussed above, the past decades have been characterized by a more indirect US dollar-coal nexus supported through Sino-American trade and financial flows. The "Chinamerica" relationship (Valantin, 2020) describes an intricate relationship between US current account deficits and coal-powered Chinese surpluses, all of which are permitted by, and through, financial globalization. Assessing this "Chinamerica" relationship is therefore fundamental to better gauge the systemic roadblocks toward a balanced and ecological IMS.

6.5 "Chinamerica" and the future of the currency-resource nexus

6.5.1 The US-Chinese coal relationship and the climate crisis

Starting in the 1980s, outsourcing and offshoring became critical to restore profit rates and to increase the profit share of non-financial corporations (NFCs) in Core industrialized economies, following the crisis of the 1970s. The cost savings of offshoring alone are estimated at around 50% (Auvray & Rabinovich, 2019). The geographic reconfiguration of production enabled the price of imports in Core countries to decrease considerably, thereby supporting high levels of consumption despite stagnant wage developments. In the US, for example, prices decreased in the sectors where global value chains[43] are most developed since the 1990s, allowing globalized NFCs "to maintain and even increase cost mark-ups" (Milberg, 2008, p. 421).

The role of the US-China relationship is critical in this process. Indeed, China quickly became the "factory of the world" (Zhang et al., 2016) throughout the 1990s, supplying much of its goods to the US. Rising profit rates for NFCs, low-priced consumer goods, and sustained economic demand in the US has depended on growing US trade deficits since the end of the Bretton Woods era; its largest bilateral deficit is with China (Cohen, 2019). In 1991, China exported US$ 6bn of goods to the US and imported US$ 8bn, in return. By 2018, Chinese exports to the US had exploded to US$ 505bn, while imports rose to US$ 130bn (Valantin, 2020, pp. 72-3).

While these facts are well-acknowledged, the extent to which US capital flows toward China were driven by ecological considerations is far less understood. What motivated the geographic relocation of production to China in the past decades was not only cheap labor costs and weak labor and environmental regulations, but also the country's abundance of easily exploitable coal (Ciccantell, 2018; Malm, 2012). Chinese authorities were largely aware of the advantage that their coal resources offered: China invested heavily in energy transmission infrastructure to avoid

[43] Global value chains represent a new development in the global division of labor, which relies on outsourcing and offshoring to organize power relations amongst firms and capture higher stages of value (Carballa Smichowski, Durand & Knauss, 2016). Lead firms wield considerable power within global production chains and are largely able to set the prices, determine labor, technical, and product standards, and plan production processes for upstream firms (Rikap, 2018).

power shortages and, after joining the WTO in 2001, China deregulated the coal market – supporting the emergence of thousands of new mining sites (Malm, 2012). China's plan helped to attract immense volumes of foreign capital, which was integral to their export miracle: foreign-invested enterprises produced 0.1% of Chinese exports in 1980, compared with 70% in 2005, and over 90% for advanced technological products (Malm, 2012).

Although the outsourcing and offshoring of production to China helped restore profits in the Core of the world-system, this has come with a great environmental cost (Muradian, Walter & Martínez-Alier, 2012). Despite declining demand for coal in most Core countries, and growing recognition of the effects of coal production on air and water quality and greenhouse gas emissions, coal remains the lynchpin of growth in China. The country now consumes half of the world's coal (Ciccantell, 2018) and nearly 70% of the world's primary energy (Yang et al., 2016) to support the export of consumer goods and to feed its growing internal demand and middle-class lifestyles. As a result, China overtook the US as the world's largest emitter of as much CO_2 in 2009, and now emits twice as much (Muntean et al., 2018). Meanwhile, China and the US together now generate 42% of global carbon dioxide emissions (Valantin, 2020, p. 80).

In turn, the deepening of US economic and ecological ties with China reinforced the US dollar's role as a global currency (Stokes, 2014). As Sager (2016, p. 41) contends, "the rise of China and its coal-fired trade surplus in the 2000s also kept the dollar . . . as the master currency, through recycling . . . into US Treasury securities and currency". Indeed, as China rapidly accumulated US dollar reserves, this capital flowed back to the US just as quickly. The privileged status of US dollar-denominated assets as safe investments meant that, as of 2019, China held US$ 1.2tn in US Treasuries, amounting to about a quarter of US debt held by foreign agents (Valantin, 2020, p. 78). Hence, while financial globalization is linked to rising levels of inequality and financial instability in Core economies – e.g. by fueling asset values in the housing and information technologies sectors (Aglietta, 2018; Bezemer & Hudson, 2016; Stockhammer, 2013) – it has also proved useful to sustaining high rates of capital accumulation, consumption and production in Core countries and to preserve the status quo in the geopolitics of monetary relations.

The “Chinamerica” relationship therefore reveals an important aspect of the political ecology of the current IMS. The delocalization of production, financial globalization and ecological degradation seem to form a dialectical unity: together, these trends have enabled to maintain the monetary and ecological hierarchies and the pursuit of capital accumulation in Core countries. However, this status quo begun to crumble over the past few years (de Graaff, ten Bring & Palmar, 2020), as discussed next.

6.5.2 Toward a new Chinese-led currency-resource nexus?

Whereas the above has mostly focused on the role of China as Periphery serving accumulation in the Core, it is increasingly clear that China is no longer only the “factory of the world”. China is now developing a consumption-led regime, and may come to belong to the group of very few countries that managed to escape from their Peripheral role over the past decades (Kanchoochat, 2015). In material terms, China’s impressive yearly rates of growth require an unprecedented volume of resources. For instance, China used more cement between 2011 and 2013 than the US had during the entire 20th century (Beiser, 2016). Meanwhile, its production of steel grew 14-fold between 1990 and 2018 (Valantin, 2020).

In this context, the pursuit of Chinese economic development cannot materially occur without pumping in resources from the rest of the world. Much like the expansion of extraction toward China a few decades ago was required to sustain accumulation in the Core, the material and energetic necessities of China’s economic growth are now pushing it to extract increasing resources in new territories, thereby reconfiguring global resource flows. China is already highly dependent on resources from Peripheral countries in South Asia, Africa and Latin America (Muradian et al., 2012; Zhang et al., 2018), and has become the world’s largest importer of non-renewable resources, including oil (Potter et al., 2017, p. 278). It is also increasing its foreign direct investments in Latin America and in Africa, aimed mostly at extracting and transporting non-processed raw materials (Brand et al., 2016; Dahir, 2019).

From the perspective developed in this article, the two main questions that arise are: (i) whether China will be able to reshape existing monetary and ecological hierarchies in such a way that supports its own regime of accumulation, as Western hegemons have done in the past; (ii) what are the implications of such trends for the prospects of a balanced and ecological IMS. The answers to these questions depend largely on whether and how China will be able to tie its own currency, the renminbi (RMB), to the key resources of the twenty-first century. A third critical question – not explored in this paper – has to do with the type of multilateral order sought by China, which is not necessarily the same as the ones sought by the US or former Western hegemons in the past. Aglietta & Coudert (2019) argue, for example, that China is interested in a more balanced and regionally-based IMS. However, this paper emphasizes that regardless of the ideal of multilateralism pursued by the Chinese authorities, the material reality of China's economic development demands that the country acts as a global hegemon in order to access the resources necessary to its new production and consumption patterns.

Regarding the first question, Chinese authorities have made concerted efforts to internationalize the RMB, notably by including it in the IMF's SDR basket in 2016 (Aglietta & Macaire, 2019). Moreover, China's central bank openly questioned the predominance of the US dollar – through the voice of its Governor (Zhou, 2009) – and partially withdrew from the US bond market (Aglietta & Coudert, 2019). The launch in 2018 of oil futures contracts denominated in RMB can also been considered as an important step to challenge the dominance of current global benchmarks determined in London and New York: ultimately, foreign oil suppliers would be able to buy oil in RMB and to use their "petroyuans" (Mathews & Selden, 2018) to purchase Chinese government bonds in addition to Chinese goods and services.

Nevertheless, the efforts made so far have not been entirely able to move the RMB to the top of the monetary-ecological hierarchy discussed in this paper. For instance, oil exporters continue to privilege US Treasury markets as a safe haven to invest their profits (Steil & Della Rocca, 2018), thereby maintaining support to the current monetary and ecological hierarchy. For China, this

creates a “dollar constraint”, i.e. a limit to the ability to incur deficits without limits. This could become problematic if the Chinese current account surpluses continue to dwindle (Smith, 2018) as the country increasingly depends on foreign resources to build its demand-led growth regime.

In order to avoid this “dollar constraint”, China seems to have developed alternative strategies that could create new kinds of relationships between key resources and key currencies, especially as part of the Belt and Road Initiative (BRI) launched in 2013. China’s direct loans and trade credits have increased from almost zero at the end of the 1990s to US$ 1.6tn in 2018 – representing close to 2% of world GDP – in large majority toward low- and middle-income countries (Horn, Reinhart & Trebesch, 2019, p. 3). In particular, Chinese state-owned banks have often granted loans in US dollars to lower income economies that are backed by resource-based collateral, particularly oil (Horn et al., 2019; Tooze, 2020). Many African, Asian and Latin American countries have already negotiated debt reliefs through contracts promising the direct provision of natural resources (Brand et al., 2016; Dahir, 2019; De Conti, Pereira & Prates, 2019). In this process, new relationships of debt and dependence have already emerged between Peripheral countries and China. This includes a sharp increase in indebtedness among many peripheral countries (Kose, Nagle, Ohnsorge & Sugarawa, 2020), amid accusations that China developed a “debt-trap diplomacy” (Chellaney, 2017).

With regard to the second question above, i.e. the ecological patterns set by Chinese development, prospects are rather bleak. It is true that China has officially promoted the BRI as part of a broader ecological civilization project (Hansen, Li & Svarverud, 2018) and conducted foreign direct investments in many renewable energy projects using leading Chinese technologies (Chiu, 2017; Dahir, 2018). However, China’s BRI has also financed the construction of hundreds of new coal-fired power projects (Peng, Chang & Liwen, 2017) that are incompatible with the promise of a stable climate for future generations (UNFCCC, 2015). Many projects have also been financed within sensitive environments (WWF, 2017). For instance, the Democratic Republic of Congo, which hosts the second-largest tropical rainforest in the world after the Amazon, now exports 55% of its forest products to China, often in connection with illegal operations and

widespread deforestation (Nhantumbo et al., 2019). In Argentina, Chinese investments have further intensified the country's culture of single-crop farming – mostly of soybeans, to feed China's growing meat consumption –, provoking an increase in deforestation and biodiversity loss (Valantin, 2020).

Even if China and the global economic system were to undergo a rapid decarbonization in order to respond to the climate crisis, the question of ecological hierarchies would remain critical. For instance, the development of renewable energy capacity already entails massive extraction and transformation of raw materials usually provided by the Periphery, generating diverse forms of ecological degradation and socio-environmental conflicts (Pitron, 2018; Schandel et al., 2012; Vidal et al. 2017). In this respect, it is noteworthy that China plays the role of both a Peripheral and a Core country. On the one hand, it still produces the vast majority of the minerals needed to develop renewable energy capacity, thereby generating massive pollutions within its territorial boundaries (Pitron, 2018). On the other hand, it increasingly relies on the imports of some of these minerals – e.g. lithium from Bolivia (Sanderson & Schipani, 2016) and cobalt from the Democratic Republic of Congo (Gulley, McCullough & Shedd, 2019) – and exerts political pressures to control their prices worldwide (Mancheri, Sprecher, Bailey, Ge & Tukker, 2019).

In sum, much as the US and other Core countries outsourced their pollution- and resource-intensive industries to China in the past decades, China now seems increasingly capable of finding new Peripheries to service its material and ecological demands (Meng et al., 2018; Zhang et al., 2018) in order to support its own efforts to climb the international monetary and ecological hierarchies discussed throughout this paper.

6.6 The IMS, at the crossroad between systemic crisis and new (post)development agendas

The patterns discussed in the previous section are largely at odds with the prospects of a fair and ecological IMS, capable of handling the ecological crises ahead of us while providing poorer

countries with more decent living conditions. As a result, this section argues that our rapidly devolving ecological crises are likely to trigger systemic instability unless major changes in lifestyle take place in Core countries.

6.6.1 Toward systemic ecological crises?

While the transition of China from its status as the "factory of the world" to that of a Core country entails an uncertain redefinition of global monetary and ecological hierarchies, current patterns indicate that climate change, biodiversity loss and many other ecological degradations are sharply increasing. In this context, ecological degradations could lead to systemic financial crises (Bolton et al., 2020).

It is noteworthy that central bankers and financial supervisors are increasingly aware of the global financial risks posed by ecological crises such as climate change (Carney, 2015; NGFS, 2019; Villeroy de Galhau, 2019). For instance, with regard to climate change, two main contagion channels have been identified. First, physical risks could materialize because of the economic costs and financial losses due to the increasing frequency and severity of climate-related weather events – e.g. storms, floods or heat waves – and the effects of long-term changes in climate patterns – e.g. ocean acidification, rising sea levels or changes in precipitation. Second, transition risks are associated with the uncertain financial impacts that could result from a rapid low-carbon transition, including policy changes, reputational impacts, technological breakthroughs or limitations, and shifts in market preferences and social norms (NGFS, 2019). Moreover, the fat-tailed probability distributions of many climate parameters are such that the possibility of extreme values cannot be ruled out (Weitzman, 2011). This could place financial institutions in situations in which they might not have sufficient capital to absorb climate-related losses.

However, such work on the possibility of systemic financial crises has not yet been sufficiently connected to the question of global imbalances and to the "Chinamerica" relationship in particular. In fact, the foundations of this relationship and of the existing IMS are already

threatened by the physical risks of climate change, as both China and the US are increasingly impacted by extreme weather events and ecological degradation. For instance, the US have been impacted by a series of climate-related natural catastrophes over the past few years – including wildfires and ensuing drought in California, and superstorms such as Harvey and Irma – while China's socio-ecological systems are increasingly impacted by events such as flooding – in coastal areas – and by decreasing agricultural yields due to the massive use of pesticides and artificial fertilizers (Valantin, 2020).

Moreover, the two countries' global supply chains are also increasingly impacted by ecological events. For instance, the supply of soybeans to China that was supposed to be guaranteed through its trade deals with Argentina and Brazil, was seriously compromised in 2018 because of unprecedented droughts in these countries (Valantin, 2020, pp. 316-318). Such events could rapidly freeze entire global value chains, as the recent outbreak of COVID-19 showed (UNCTAD, 2020). As the worst impact ecological degradations are yet to come, the geopolitics of access to dwindling natural resources could also give way to new military conflicts between the two superpowers, China and the US (Valantin, 2020). In short, the multilateral order is increasingly exposed and vulnerable to an ecological breakdown.

6.6.2 Growth in the Periphery vs. degrowth in the Center, and the need for a postdevelopment agenda

In order to avoid such systemic crises and/or geopolitical conflicts, a major socioeconomic shift will be required. It will most notably involve finding development alternatives that do not rely on the myth of green growth (Jackson, 2017) that is largely promoted by international organizations (e.g. OECD, 2011; UNEP, 2011; World Bank, 2012). Indeed, evidence has accumulated over the past years that casts increasing doubt on the technical possibility to decouple global economic growth from environmental harm, including but not limited to CO_2 emissions (Hickel & Kallis, 2019; Parrique et al., 2019). The scarce instances of dematerialization and decarbonization within some advanced capitalist Centers have coincided with the growing concentration of resource-

and pollution-intensive industries in the Periphery (Frey et al., 2018; Kraussman et al., 2017; Schandl et al., 2018) discussed in the previous sections.

Instead, a sober and scientifically-grounded assessment of the current situation should acknowledge that there is limited remaining ecological space for global economic growth without putting Earth's ecosystems and the future of humanity at risk (Ripple et al., 2017; Steffen et al., 2015). This remaining space should be considered as a scarce resource to be used in priority by those in greatest need (Vatn, 2009) and through the principle of "common but differentiated responsibilities" (UNFCCC, 2015) discussed in section, 2. In this context, there is a "systemic roadblock" (Beddoe et al., 2009) to a fair and ecological IMS: if deaccumulation and degrowth policies are not implemented in the Center, the Periphery's prospects for meeting socially necessary consumption and investment needs will likely be significantly impaired (Althouse et al., 2020).

As a result, rebalancing the IMS consists as much in financing ecologically-sustainable forms of development in the Periphery as it does in deconstructing the "imperial mode of living" (Brand & Wissen, 2018) that has dominated in the Center: this mode of living has historically led a few countries to rely on vast amounts of resources provided by the Periphery, while degrading both local and global environmental commons. What is at stake, then, is not so much the rise of China *per se*, as the culturally dominant and imperial mode of development which valorizes the pursuit of unlimited economic growth and its associated consumer-lifestyles. Such lifestyles are intrinsically resource-demanding (Brand & Wissen, 2013), and meeting those demands increases socio-environmental degradation, territorial dispossession, and conflict (Harvey, 2006; Martínez-Alier, 2002; Moore, 2015).

Any meaningful reform of the IMS will therefore need to include a concerted effort towards degrowth in Core countries. The idea of thinking beyond growth is gaining rapid momentum

including in official arenas[44] (e.g. OECD, 2019b), but the conundrums it could pose to the multilateral order are still underappreciated. For instance, if Core countries were to design post-growth socioeconomic systems (e.g. Jackson, 2017; Kallis, 2019), these would result in a declining demand of commodities from the Periphery. This could rapidly leave Peripheral countries even more vulnerable to capital flights and balance-of-payments crises (Althouse et al., 2020). A major overhaul of global policies would therefore also be necessary to avoid an immediate and major contraction of income and employment in the Periphery. For instance, if Core countries were to share technologies and open their borders to migration, this could speed up technological absorption and reduce global income disparities while helping some Peripheral countries cope with looming climate-related impacts. In addition, if Core countries were to degrow, Peripheral countries would also need "to revise their expectations downward regarding their own growth" (Daly, 1991, p. 148).

It is without a doubt that such reforms would entail profound socio-economic changes in both Core and Peripheral countries. A global transition that lives up to the ecological challenges ahead of us will likely require opening the door to alternative ontologies of human emancipation and to (post)development agendas (Demaría & Kothari, 2017; Escobar 2015; Kosoy et al., 2012; Kothari et al., 2019; Sachs, 2017), which can better account for the need to cherish human capabilities while protecting our environmental commons (Dron, Espagne & Svartzman, 2020). Proposals along these lines are beyond the reach of what can be achieved within the existing institutional framework, yet they are essential if we wish to realistically safeguard the prospects of shared prosperity and a flourishing life within our planetary means.

6.7 Conclusion – Grasping the political ecology of international monetary relations

This paper builds on a growing literature which suggests that overcoming global imbalances while solving our ecological crises will require a profound reform of the IMS. While scholars have

[44] For instance, the European Parliament held a two-day conference on post-growth in 2018. See: https://www.postgrowth2018.eu

already rightly pointed to how the existing currency hierarchy under financial globalization prevents Peripheral countries from accessing the long-term *green* funding they urgently need (UNCTAD, 2019), this paper highlights that Core-Periphery structural imbalances and ecological issues are more entangled than assumed by most of the literature: the currency hierarchy that impinges on Peripheral countries' development paths is inextricably related to an ecological hierarchy, which maintains Peripheral countries in the role of providers of cheap resources to the Center (Hornborg, 2014; Moore, 2015).

The link between these monetary and ecological hierarchies can be best appreciated through the "Chinamerica" (Valantin, 2020) relationship that has prevailed over the past decades: financial globalization has proliferated by ensuring that the surpluses generated by coal-powered Chinese growth (Malm, 2012) were reinvested in US dollar-denominated assets (Sager, 2016). This relationship is a major driving force behind the ongoing ecological breakdown, and a clear expression of the inherently unsustainable features of the current IMS. As China is now transitioning away from its Peripheral status by seeking to reconfigure currency and ecological hierarchies to support its own resource-intensive growth, it is also accelerating the likelihood of systemic ecological crises.

This suggests that the quest for a balanced and sustainable IMS requires profound reforms not only in the structure of the system itself, but a dramatic shift away from the *imperial* modes of production and living (Brand & Wissen, 2013, 2018), including degrowth in Core countries (Althouse et al., 2020) and new ontologies of human emancipation and (post)development agendas for the whole community of human beings (e.g. Kothari et al., 2019). While such a shift may seem remote, it has now also become essential if we are to think seriously about the prospects of designing a socially just IMS for a finite planet.

6.8 References

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Chapter 7 – Main findings and conclusion

This research has advanced the scholarship on how the monetary and financial system both contributes to our ecological crises and is increasingly affected by them, and explored some possible reforms aimed at re-embedding monetary institutions within our planetary boundaries. In other words, it has unraveled some of the consequences of the finiteness of our planet on our existing monetary institutional arrangements. While these questions were barely on the map in the research community and policy arena at the onset of this thesis, things have evolved rapidly as my research unfolded. This may be because year after year, ecological crises have materialized further, while concomitantly, the 2007-08 Global Financial Crisis shattered conventional economic thinking about how the monetary and financial system works.

In particular, the financial community, including central bankers and financial supervisors (e.g. Carney, 2015; NGFS, 2018, 2019) and private financial actors (e.g. TCFD, 2017; Fink, 2020), became aware over the past few years that the monetary and financial system could become significantly affected by the materialization of ecological risks such as climate change and biodiversity loss. In short, the financial community can no longer disregard its biophysical milieu. Despite representing significant progress, this recent awareness remains largely grounded in the ahistorical and apolitical worldview of neoclassical economics, in which ecological crises are treated as negative externalities and money as a neutral tool enabling economic exchange. According to this worldview, sending the accurate price signals – e.g. through carbon taxes – and guaranteeing that ecological risks are transparently disclosed – e.g. through prudential regulation – would suffice for efficient markets to solve the challenges ahead.

This thesis departed from the neoclassical worldview and its ensuing approach to both ecological and financial risks by building on two largely disconnected streams of research, which have respectively re-historicized and re-politicized human-nature relationships and monetary institutions. By bridging these two streams of research, this thesis provided a single theoretical framework to jointly address current ecological and financial vulnerabilities.

The first stream is most notably composed of ecological economics (e.g. Daly & Farley, 2011; Georgescu-Roegen, 1971; Jackson, 2017; Martinez-Alier, 1987; Røpke, 2005; Spash, 2017) but also of related fields such as ecological ethics (e.g. Brown, 2012; Descola, 2005; Latour, 2004) and the recently-emerged world-ecology perspective (Moore, 2015). Together, these approaches offer an ecologically-embedded understanding of the ethical, economic and historical theories and narratives that have contributed to disembed our global socio-economic system from its planetary boundaries. While ecological economists have emphasized the need to transform economic systems so that they can remain functional and fair without relying on economic growth, ecological ethics and the world-ecology perspective point to the fact that such a quest will require a more fundamental transformation: revisiting our dominant value systems and corresponding institutional arrangements in ways that serve humans "while respecting and being constrained by the limits of Earth's life support systems and the well-being of other species" (Kosoy et al., 2012, p. 78). This may involve a process of "decolonization of our minds [to] move beyond a way of thinking about the economy which demonstrably ill serves us in the stormy Anthropocene" (Kosoy et al., 2012), including by finding inspiration in non-Western ontologies and struggles (Martínez-Alier et al., 2010).

However, the authors within these fields have rarely connected the need to revisit our value systems and corresponding institutional arrangements to the topic of money. The second stream informing this research shows that such a task will be fundamental. As shown by post-Keynesian scholars (e.g. Lavoie, 2014), the role of money is so fundamental to understand the dynamics of capitalism that the latter can be better understood as a monetary economy of production, meaning that "the purpose of production is to accumulate money" (Wray, 2013, pp. 139-40), rather than to exchange one thing for another as suggested by mainstream economics. Even more importantly for this thesis, institutionalist approaches to money (*à la* Aglietta, 2018) show that money is a "total social fact" (Théret, 2008, p. 834) that encompasses the economic, political and cultural dimensions of life in society. That is, whether one talks about capitalism or non-

capitalist systems, “value is recognized and established by way of the logic of money” (Aglietta, 2018, p. 33).

In this context, it becomes clear that revisiting our value systems in the Anthropocene requires revisiting the main institution through which we express value, i.e. money. Following Polanyi (1944), it may be time for a monetary countermovement[45] to protect humans and nonhumans from the accelerated commodification of money on our finite planet. However, given that the two streams of research informing this thesis remain largely disconnected – despite some notable exceptions –, this research’s main methodological challenge was having to start from a relative theoretical void. As a result, I opted for mobilizing the ecologically- and monetarily-informed approaches mentioned above to address four specific questions, which have already started being discussed by other authors. Addressing these four questions, therefore, corresponded to the four specific objectives of this thesis.

The first essay, chapter 3, *assessed the limitations of central banks’ theoretical framework and policy toolbox to face ecological crises and articulated the need for an epistemological rupture (Bachelard, 1938).* It did so by showing that the financial risks posed by climate change are not only too complex and nonlinear to be measured with precision, rendering existing financial risk models and climate-economic models largely useless, they are also impossible to hedge as long as system-wide action is not taken. This means that central banks, and with them, our existing monetary institutional arrangements, will unavoidably be dragged into uncharted waters because of climate-related risks. Addressing climate change – a prerequisite to preserve financial stability – will force them to increasingly engage with multiple stakeholders, central banks will need to put aside or significantly reinterpret the concept of independence on which they have been relying over the past decades.

[45] Polanyi (1944) identified a recurrent “double movement” in the history of capitalism: the liberal movement to disembed the economy from its socio-ecological environment and install a “market society” tends to become so extreme that a “countermovement” takes place in society to re-embed the economic sphere through the creation of social – or ecological – protections. As mentioned in the Introduction, the disembedding process takes place through the fictitious commodification of three pillars of life in society: labor, land and money.

The second essay, chapter 4, *gauged the insights and limitations of the incipient field of ecological macroeconomics.* This field, at the crossroad between post-Keynesian economics and ecological economics, stands as an exception in this thesis as it crosses the boundaries between the two streams of research that inform it. In doing so, it shows that a large range of policy tools – from fiscal policy to monetary policy and prudential regulation – that is not even acknowledged by mainstream environmental economics could, in fact, be used for an ecological transition. However, by focusing almost exclusively on the need for *green* investments, the field appears to belong to a "shallow" (Spash, 2013) approach to ecological economics, which falls short of addressing "environmental values and human relationships with Nature" and the political and economic implications of different possible transition paths (ibid: 352). This means that the other approaches that inform this thesis – ecological ethics, world-ecology perspective, and monetary institutionalism – remain absent from ecological macroeconomics, although they seem essential to envision ecologically-embedded futures.

As a result of this, the third essay – chapter 5 – found that ecological macroeconomists bring ambivalent insights into *the debate on whether the very nature of capitalist money is at odds with the finiteness of natural resources and ecosystems' carrying capacity*. Whereas post-Keynesian theory enables us to show that the existence of money created by banks in the form of interest-bearing debt is not mechanically incompatible with a non-growing economic system, the conclusion that the monetary and financial system as it exists can be tailored to an ecological society misses important institutional features. In particular, the generalization of interest rates is intricately related to the development of capitalism and its aspiration of perpetual – interest-bearing – monetary accumulation (Aglietta, 2018). Hence, if addressing our ecological crises demands redirecting our value systems away from this aspiration of infinite accumulation, then deeper transformations of monetary institutions than those envisioned through post-Keynesian theory will remain necessary. This essay, therefore, strengthens the findings of the previous one: thinking about monetary institutions for a finite planet requires overcoming the alliance between

post-Keynesian and ecological economists, notably by building on institutionalist approaches to both human-nature relationships and money.

The fourth essay – chapter 6 – merged all the approaches informing this thesis to explore what the previous three essays identified as a major roadblock: *the need to reform the international monetary system (IMS) through ecologically-informed perspectives*. While this essay supports the growing literature pointing to the fact that the IMS should be reformed to jointly address structural imbalances between Core and Peripheral countries and ecological issues such as climate change, it also finds that these two problems are much more entangled than assumed by most of the literature. The international currency hierarchy (Prates, 2017) that stands in the way of Peripheral countries' development paths is inextricably related to a form of ecological hierarchy (Hornborg, 2014), which maintains them in the role of providers of cheap resources to the Center and recipients of multiple forms of pollution. This essay, therefore, sheds light on the carbon-intensive nature of the IMS and its main driver over the past decades, the "Chinamerica" (Valantin, 2020) relationship. The latter, enabled by financial globalization, consists in ensuring that the surpluses generated by coal-powered Chinese growth are systemically reinvested in US dollar-denominated assets, thereby closely connecting the ecological and monetary hierarchy supporting the current world-system. Grasping this political ecology of global imbalances will be essential in the quest for a balanced and ecological IMS. Notably, it indicates that as China progressively assumes a new role in the world-system, it generates unprecedented socio-ecological pressures that increase the likelihood of related systemic ecological crises and/or new geopolitical conflicts over access to resources.

It follows from this last essay that the quest for a truly balanced and ecological IMS on a finite planet cannot be dissociated from radical socio-economic transformations, including degrowth in Core countries and new (post)development imaginaries for the whole community of human beings inhabiting our finite planet. This requires to transition away from Core countries' "imperial mode of living" (Brand & Wissen, 2018). The latter has thrived on a dualistic view of nature and society as two separate entities, thereby enabling to consider progress as the infinite expansion

of the human sphere upon its natural environment, while outsourcing most ecological degradations to the Peripheries.

The ultimate example of this imperial, dualistic and ecologically-disembedded worldview comes perhaps from the very person who enabled economists to appreciate the importance of money, the person who designed the blueprint toward a fair and balanced IMS and who contributed to saving capitalism from its own demise: John Maynard Keynes. As he put it almost exactly one century ago in one of the most important books ever written in the field of economics, "The Economic Consequences of the Peace" (Keynes, 1919/2019):

> *What an extraordinary episode in the economic progress of man that age was which came to an end in August 1914! […] The inhabitant of London could order by telephone, sipping his morning tea in bed, the various products of the whole earth, in such quantity as he might see fit, and reasonably expect their early delivery upon his doorstep; he could at the same moment and by the same means adventure his wealth in the natural resources and new enterprises of any quarter of the world […] He could secure forthwith, if he wished it, cheap and comfortable means of transit to any country or climate without passport or other formality, could despatch his servant to the neighbouring office of a bank for such supply of the precious metals as might seem convenient, and could then proceed abroad to foreign quarters, without knowledge of their religion, language, or customs, bearing coined wealth upon his person, and would consider himself greatly aggrieved and much surprised at the least interference. But, most important of all, he regarded this state of affairs as normal, certain, and permanent, except in the direction of further improvement, and any deviation from it as aberrant, scandalous, and avoidable. The projects and politics of militarism and imperialism, of racial and cultural rivalries, of monopolies, restrictions, and exclusion, which were to play the serpent to this paradise, were little more than the amusements of his daily newspaper, and appeared to exercise almost no influence at all on the ordinary course of social and economic life, the internationalisation of which was nearly complete in practice.* (pp. 50-1)

The above simply reminds us of the obvious: building new relationships toward an Earth citizenship that serves humans without impinging on the capabilities of future generations and nonhumans will require unprecedented compromises between – on the one hand – our quest for peace, freedom and material satisfaction, and – on the other hand – the need to revisit such concepts in entirely new ways. For instance, as Kallis (in Kallis, Mastini & Jackson, 2018, p. 1) puts it, we shall retain the Enlightenment's "quest for autonomy, our right to question our institutions and a refusal to accept truths as handed down from tradition or the gods", while fighting its deeply associated quest for conquering nature – as shown in Keynes' citation above.

As this conclusion is being written, the coronavirus disease 2019 – Covid-19 – is taking the world by surprise, suddenly laying bare the vulnerability of the global monetary and financial system to biophysical shocks in a world of interconnected global value chains and international financial flows. Whether or not this event can fall under the category of a "green swan" discussed in chapter 3 and whether or not its economic and financial impacts will be followed by an economic rebound, this pandemic is a harsh reminder of the interdependencies between human and natural systems. As countries close their borders and citizens are confined, it becomes clear that our ecologically-disembedded modes of development have already started to hit back as a boomerang (Bonneuil & Fressoz, 2016, p. 32) and to "hyper-besiege" (Valantin, 2017) us. In this sense, the coronavirus may only be a small-scale experiment of what is to come and may signal something new: the urgent need to embrace alternative value systems and corresponding institutional arrangements for a finite planet.

As we move toward an increase in the frequency and intensity of ecological disasters, it is a matter of time before even globalized financial markets reach their limits, as their fictions of valuation become increasingly disconnected from Earth's eroded life support systems. It is a matter of time before the unprecedented injections of liquidity by central banks are no longer sufficient to restore methodic, hierarchical and ethical levels of trust in money (Aglietta, 2018). For instance, as the coronavirus is spreading and central banks inject vast amounts of liquidity – e.g. the European Central Bank (ECB, 2020) announced a €750 billion Pandemic Emergency

Purchase Program on March 18, 2020 –, citizens may start to fundamentally question the underlying dynamics of the *magic money tree*: how is money available for certain purposes such as saving financialized global markets, yet not for others such as fighting climate change and providing universal health care systems? But it is also a matter of time before government-led stimulus, the option preferred by those who believe in the regulation of capitalism – e.g. in the field of ecological macroeconomics – also becomes insufficient to restore ecosystems and to trigger new post-imperial modes of living. Following the writer, poet and philosopher Paul Valéry (1871–1945), current events show us that "the age of the finite world has begun" (Valéry, 1931/1962, p.14).

In this context, this thesis aimed to contribute, to the extent possible, to a fundamental task of this century: building an ecologically-embedded political economy of money, one that can provide theoretical foundations to envision monetary institutions for a finite planet.

Chapter 8 – Contributions to knowledge, limitations, and recommendations for further research

8.1 Contributions to knowledge:

The work presented in this manuscript provides original contributions to the scholarship on the relationship between monetary institutions and their natural environment. Exploring the ways in which the monetary and financial system contributes to and is vulnerable to ecological crises has gained rapid momentum among scholars and policy makers. In fact, it has rapidly come to be seen by the international community as a crucial issue to guarantee systemic stability in the age of ecological risks (e.g. NGFS, 2018, 2019; UNFCCC, 2015). In this context, the main contributions of this dissertation are as follows:

1. It contributed to the development of an analytical framework tailored to a new area of research: the assessment of monetary institutions considering finite natural resources and dwindling ecosystems' carrying capacity. In contrast to both neoclassical and heterodox economic theories that have mostly transposed their pre-existing analytical framework to ecological questions, this thesis has focused on exploring the insights and limitations of each approach to handle the problem at stake. It found that revisiting the monetary and financial system in the age of ecological crises needs to integrate insights from different disciplines such as: ecologically-grounded approaches to ethics, economics, and history of capitalism; and post-Keynesian and institutionalist approaches to money.

2. Through this analytical framework, it showed some key connections between the semiotic and symbolic dimensions of money – its capacity to express and shape value – and the biophysical materiality of economic activity – its condition of an ecologically-embedded subsystem. In particular, it showed that the evolution of monetary institutional arrangements is deeply connected to the dominant ways of valuing human-

nature relationships. The commodification of money and of human-nature relationships has gone hand in hand.

3. Empirically, it unveiled the insights and limitations of the two main existing approaches to monetary institutions in light of ecological crises: the neoclassical approach grounded in theories of risks and externalities, and the post-Keynesian approach grounded in government-led interventions and more complex policy mixes between fiscal, monetary and prudential measures.

4. It identified the current International Monetary System (IMS) as one of the main roadblocks to an ecological transition, and expanded current knowledge by exploring how reforming the IMS in light of ecological considerations brings additional challenges that are disregarded by the existing literature.

5. It made the topic of money and finance accessible and relevant to several disciplines in both social sciences and natural sciences, which usually do not touch upon this issue. In doing so, it showed that the study of monetary institutions is critical to bridge the gap between natural and social sciences.

8.2 Limitations and recommendations for further research

The main identified limitations of this dissertation and corresponding recommendations for further research are the following:

1. This thesis did not seek to resolve the question of monetary institutions for a finite planet. As explained in the Introduction, the lack of any existing theoretical framework prevented to delve fully into potential solutions, thereby calling for alternative approaches. However, given that the reform of the IMS was identified as a priority, future research should focus on building on the insights of chapter 6. Some of the questions that could be explored include the following: How can the barriers identified to a fair and ecological

IMS be overcome? For instance, could, ecological regional currencies succeed in overcoming the current inertia that makes the IMS impossible to reform? And specifically, how could a monetary union like the Eurozone move toward a monetary order embedded in new human-nature relationships?

2. Although reforming the IMS may be the main task ahead, other potential solutions at the international, national and subnational scales may also be necessary to create an ecological monetary order. For instance, the rise of cryptocurrencies, digital currencies, and local currencies across the world shows that the existing monetary order is already being challenged by new monetary alternatives. Such developments are mentioned but not discussed in this thesis. Future research could further explore the insights and limitations of these alternatives in light of the socio-ecological challenges ahead and how they may relate to the need for a reformed IMS.

3. No ecological and/or economic modeling was used in this thesis, despite a focus on post-Keynesian stock-flow consistent (SFC) modeling. This is due to the fact that without a consistent political economy of money, existing modeling frameworks remain insufficient to embrace the complexity of an ecological transition. For instance, and as discussed in chapter 5, SFC models, when not informed by an institutional approach to money, can convey the spurious impression that the current monetary and financial system does not exert an inherent pressure on socio-economic systems to seek perpetual growth. Future research could seek to integrate the institutional approaches raised throughout this thesis into SFC modeling. For instance, Althouse et al. (2020) show that the institutionalist dimension critically missing in ecological macroeconomics can be overcome by including dynamics of ecologically unequal exchange in a post-Keynesian Center-Periphery model.

4. The thesis does not directly address the (in)compatibility between the capitalist mode of production and accumulation and the finiteness of our planet, although the question of the capitalist system emerges in several occasions through its relationship to modern

monetary institutional arrangements. By the end of this thesis, the question remains open as to whether strongly regulated forms of capitalism will suffice – at least as a more realistic option – to envision ecologically-embedded monetary institutions, or whether post-capitalist monetary systems will be a *sine qua non* of an ecological transition. While such a question may not be resolved anytime soon, future research on the political economy should further explore this question, notably by following Kalecki's (1943) political economy of full employment. The Polish economist showed that the main difficulty in reaching full employment – assuming here that it provides decent living conditions to workers – was not a technical problem but one of political economy. Indeed, full employment would mean that the ability of the capital owner to fire workers would no longer exert disciplinary power on them: since workers could find employment elsewhere, the very social position of capitalists would become threatened. In this context, "new social and political institutions which will reflect the increased power of the working class" (Kalecki, 1943, p. 331) become necessary. Furthermore, it is not clear whether capitalism can withstand such reforms: "If capitalism can adjust itself to full employment a fundamental reform will have been incorporated in it. If not, it will show itself an outmoded system which must be scrapped" (ibid). Such reflections could bring unique insights into future work on ecological monetary reforms, including for the field of ecological macroeconomics. Overcoming the myth of the neutrality of money, a foundational myth of modern capitalist economies (Servet, 2001), cannot take place *all other things being equal*. For instance, as central banks are about to inject trillions of dollars into the financial system once again to rescue it from the impacts of the Covid-19, claiming that such money could have been used to solve climate change has little to no meaning: doing so would simply annihilate the very foundations of existing institutional arrangements.

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