Version 1.7

TOWARD A BIO-INTEGRATED ECONOMY : THEORY OF HOMEOSTATIC ECONOMICS

Overview

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Abbreviations

HE = homeostatic economy

EXEC = exo-economy

ENEC = endo-economy

BDI = biodiversity indicator

EFI = Ecological Footprint Indicator

NRRI = non-renewable resource indicator

DEI = dynamic equilibrium indicator

ST = State

ENT = companies

CIT = citizens

STD = dividend given to the state

ENTD = dividend given to a company

TENTD = total dividend given to companies

CITD = dividend given to a citizen

TCITD = total dividend given to citizens

CDEP = certified dynamic equilibrium projects

MCD = melting currency-donation

ICB = International Central Bank

IO = international organization

CMAC = Certification and Monitoring Agency for CDEPs

1 - Introduction

Bio-integrated economics or homeostatic economics[1] (abbreviated to HE), is a macroeconomic model inspired by thermodynamics, as well as biology, cybernetics and ecology, to design a sustainable economy with regard to issues related to human development. Thus, this model proposes to limit our environmental impact by implementing an ecologically balanced system, also promoting social justice in our human societies.

Following the previous work that have tried to integrate the laws of thermodynamics within classical economics, such as Frederick Soddy's proposals[2], Howard T. Odum's concept of emergy[3]; or work that attempted to gather thermodynamics, biology and economics, such as Georgescu-Roegen's[4] and Daly's[5] theories, the field of ecological economics[6] or more recently François Roddier's proposal[7], homeostatic economics proposes a continuity of this various work while deploying a singular and innovative approach. However, this theory does not intend to transpose the laws of thermodynamics or biological phenomena into an economic system. It proposes to draw inspiration from founding principles in these fields to build a concrete and feasible application at the level of nations.

The objective of the HE is to propose viable short to long term solutions to the various and inherent problems met in capitalist systems. From this starting point, the model uses a bottom up approach to review the structural foundation of economics, e.g. the mechanism of monetary creation. It offers a functioning of the economy that is both close to what we know at present, but paradoxically very far in its consequences on society as a whole, as well as on our

[1] We consider the two terms as synonymous. In this overview, we will only use homeostatic, which is more precise and meaningful for scientists, whereas bio-integrated seems more clear for a broader audience.

[2] *Wealth, Virtual Wealth and Debt. The solution of the economic paradox,* Frederick Soddy, 1926

[3] Emergy or energy memory is the energy of a specific type incorporated into a good or service that is reduced to the energy provided by the sun. In other words, it characterizes all products and services in terms of solar energy equivalent, e.g. the amount of energy needed to design a certain task, considering that solar radiation is the only input. Exercise considerations are taken into account. The word comes from the English word em(bodied) + (en)ergy (grey energy). https://en.wikipedia.org/wiki/Emergy

[4] *The Entropy Law and the Economic Process,* Nicholas Georgescu-Roegen, 1971.

[5] *The steady state economics*, Herman Daly, Island Press, 2nd edition, 1991

[6] Ecological economics is a branch of economics that interfaces with ecology, studying the interdependence and co-evolution between human societies and ecosystems over time and space.
https://en.wikipedia.org/wiki/Ecological_economics

[7] *De la thermodynamique à l'économie. Le tourbillon de la vie,* François Roddier, 2018.

environment. However, the originality of the proposal requires the utmost caution in analysing the expected effects and potential negative externalities.

This document, apart from being intended for a more in-depth theoretical study, should also serve as a first draft in order to generate constructive criticism. In this sense, it does not in any way present a finalized model, but a proposal with several objectives. Our first priority is to obtain a review by economists who can assess the potential interest and feasibility of this economic theory. Then, if the opinions are positive, a working group should be set up with the task of perfecting the model and making it viable. Finally, the communication of this finalised work to a wider audience, notably through the writing of a popularisation book, the creation of video supports, as well as a specific communication aimed at policy makers.

We hope the subject will fascinate you as much as it has captivated us and continues to do so by the positive effects it could have on our societies and, more globally, on the future of humanity.

2 - Issues related to capitalist economic systems

Numerous observations and criticisms have been raised throughout history to describe the harmful consequences of capitalist systems, such as the moral problems, the hazardous nature of the theoretical foundations[8][9], the capture of wealth and the creation of inequalities intrinsic to the functioning of deregulated systems[10], the organisation of work, which inevitably tends towards an acceleration in the demand for productivity, the absence of "pure and perfect" competition[11] or the damage caused to the environment as a result of economic growth that doesn't encourage the rational use of resources or the preservation of natural environments[12].

[8] *Debunking economics: the naked emperor of the social sciences*, Steve Keen, Zed Books Ltd, 2001.

[9] https://en.wikipedia.org/wiki/Cambridge_capital_controversy

[10] *Capital in the twenty-first century,* Thomas Piketty, Harvard University Press, 2013.

[11] *The new industrial state*, John Kenneth Galbraith, Princeton University Press,1967.

[12] *The Entropy Law and the Economic Process,* Nicholas Georgescu-Roegen, Harvard University Press, 1971.

We can add two more to the list of these critics, which will be expressed in very different forms throughout history,

The first is **the inability of capitalist systems to maintain a state of equilibrium between human societies and their environment**[13]. Indeed, these systems focus exclusively on the products of capture and their capitalisation. Everything that is not accounted for in the economy has no intrinsic value and what is extracted from the natural world cannot be paid back to nature, nor can it be returned after its use. In other words, everything that does not enter the human economy is not accounted for, although it may be exploited or disturbed by human activity. Economically speaking, if we do not exploit a particular species, it will get no consideration from us, it will remain inexistent to our eyes. This phenomenon of "economic blindness" means that a species could go extinct without us realizing it, even if it provides countless unmeasured ecosystem services to us through its interactions with its environment.

The second criticism is **the capture of resources without a counterpart,** inherent to the very functioning of economic systems. Indeed, when we need resources, we do not make an exchange with them, strictly speaking, but we proceed to a pure capture. We do not give credit to the forest to take its wood, we do not pay the mines to extract the ore, nor do we pay the ocean to take the fishes that live in it. We take all these resources for free. We are not accountable to our environment and the monetary system prevents us from being able to trade with living things, by sharing some of the profit from our exploitation back to the natural world. This is simply impossible, because that would be a non profitable action, a pure loss. Capitalist systems, among others, therefore prevent any possibility of returning part of the resources we have taken and push us to continue their exploitation with no regard for our environment and therefore for our long-term survival.

[13] The term environment defines all the natural and cultural conditions that can affect living organisms and human activities.

3 - Auto-organisation and homeostasis

To obtain a proper comprehension of the model and the ideas that compose it, we need to clarify certain concepts and to define them properly. The advancements of knowledge in sciences enlighten us with the properties of our wolds, and the way it functions. Particularly in physics, where a field of research is dedicated to understanding what is energy, a fundamental notion in every known system, biological systems included. This field is called thermodynamics and was developed during the XIXth century, reinforcing the Industrial Revolution with a better understanding and optimisation of steam machines operation. These fertile scientific studies provided us with a much deeper look on this notion of energy, which follows specific rules : the laws of thermodynamics. The most relevant here are the first and second ones[14].

The first law stipulates that energy quantity in a delimited and finite system never changes. The second law completes the first one and integrates the notion of quality. It can only deteriorate over time, leading to a decrease in useful energy at disposal. A new function is introduced to represent this degradation : entropy. Every known system is subject to entropy and degradation, as it increases over time. They all reach (or will reach) a final stage of homogeneity where all potentials are equalized, uniformized. It is a state of thermodynamic equilibrium in which no observable events occur.

The famous physicist Erwin Schrödinger explained in his book "*What is Life*"[15] that living systems are able to temporarily avoid this thermodynamic equilibrium. Living beings decrease their own entropy by exporting it in their environment, with the use of available energy. The Belgian physicist Ilya Prigogine added a piece to this contribution by describing dissipative structures[16] that forms by energy transformation. In order to do that, he uses the Bénard cells

[14] These laws have various formulations, depending on the frame of reference or use
First law : $\Delta U = W + Q$ (with U = internal energy ; W = work ; Q = heat)
Second law : $dS >= \delta Q/T$ (with S = entropy ; T = temperature)

[15] *What is Life? The physical aspect of the living cell*, Erwin Schrödinger, Cambridge University Press (1944)

[16] Dissipative systems can explain the phenomenon of auto-organisation in living beings, the balance of exchanges (energy exchange, entropy generation), and the apparition of a spontaneous breaking in spatial symmetry that enables the emergence of spontaneous organisation of the system.

experiment[17]. These dissipative systems are maintained far from the thermodynamic equilibrium by a flow of energy, and possess the required conditions for auto-organization. Yet, the difference between biological and physical auto-organization lies in information integration, communication, regulation processes, and logic operations that emerge in biologic complexity, whereas natural physical organisation emerge from spontaneous processes of self-organization [18]. Living systems integrate numerous mechanisms of precise control on the information they receive from their environment, or from their own milieu.

They are constrained by two effects : those of entropy and the relation to a dynamic, variable environment. To fight against entropy, they use a constant flow of matter and energy to maintain themselves in a state of equilibrium, far from the thermodynamic one[19]. To remain adapted to environmental variations, this biological equilibrium must be dynamic and always corrected. It includes various physiological parameters (temperature, ion concentration, blood pressure, etc…) that will be modulated depending on internal and external conditions. If one of these parameters gets far from its vital value[20] (around 37°C for temperature, 0.9g of glucose per litre of blood for glycemia, etc…), biological mechanisms are triggered to initiate behaviors that will correct this deviation, returning the system back to the equilibrium state. These mechanisms are called “negative feedback” (fig.1).

[17] https://en.wikipedia.org/wiki/Rayleigh-Bénard_convection

[18] *La Vie de la vie*, Edgar Morin, Le Seuil, 1980

[19] One should be cautious as to clearly distinguish between the notion of thermodynamic equilibrium - where the entropy is at its highest level, a state similar to biological death - and the state of biological equilibrium, also called far from (the thermodynamic) equilibrium, where the entropy is kept at low levels by a constant flow of energy, such as food.

[20] Here the normal human values. They can vary depending on the location, the time of the day, the physiological conditions, the morphology, the species, etc…

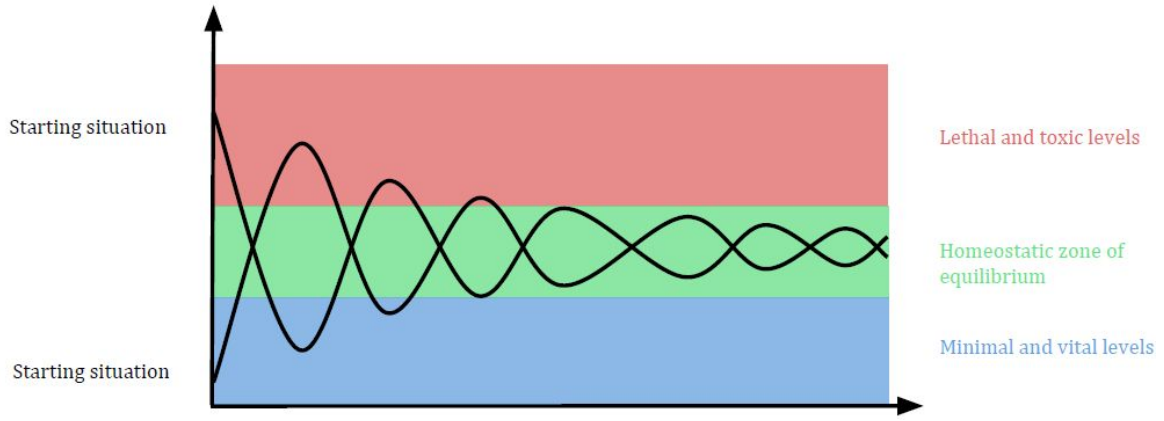

Figure 1. Drawing representing negative feedback. Both situations converge toward a zone of equilibrium, the deviations are corrected back to balanced values. These phenomena are quite common in living beings, especially for maintaining self-organization. (adapted from Joël de Rosnay ; Le Macroscope, vers une vision globale, Seuil, 1972).

This optimal state, in which the vital parameters are within the equilibrium window, is called homeostasis[21]. Originally introduced by the French physiologist Claude Bernard[22] in 1866, coined by the American physiologist Walter Cannon[23] and further improved with knowledge from cybernetics[24], this notion is vital for any auto-organized complex system. We can draw a simple diagram to get a visual cue, by adding the different physiological parameters, leading to a form with three concentric circles or a doughnut shape[25] (fig.2). The intermediate circle represents the homeostatic window in which any living being tries to hold thanks to negative feedback.

[21] *Human physiology : From cells to systems,* Lauralee Sherwood, Cengage Learning, Inc, 9th edition, 2014

[22] *Introduction à l'étude de la médecine expérimentale*, Claude Bernard, J.B. Baillière, 1865

[23] *The Wisdom of the Body*, Walter B. Cannon, New York: W. W. Norton, 1932

[24] *Cybernetics : or control and communications in the animal and the machine*, Norbert Wiener, Camb. Mass. (MIT Press), 1961 [1st edition, 1948]
An introduction to cybernetics, William Ross Ashby, Chapman & Hall, 1957

[25] A shape that is clearly close to the doughnut economy, theorized by the economist Kate Raworth (see *Doughnut Economics: Seven Ways to Think Like a 21st-Century Economist*, Kate Raworth, Random House Business, 2017). Both the analysis of the situation and the foundation for her theory are similar, the propositions found in the homeostatic economy extend those found in the doughnut economy such as : stabilization of our economies within boundaries (chap.5), demurrage or melting (chap.10) or regeneratives companies (chap. 12).

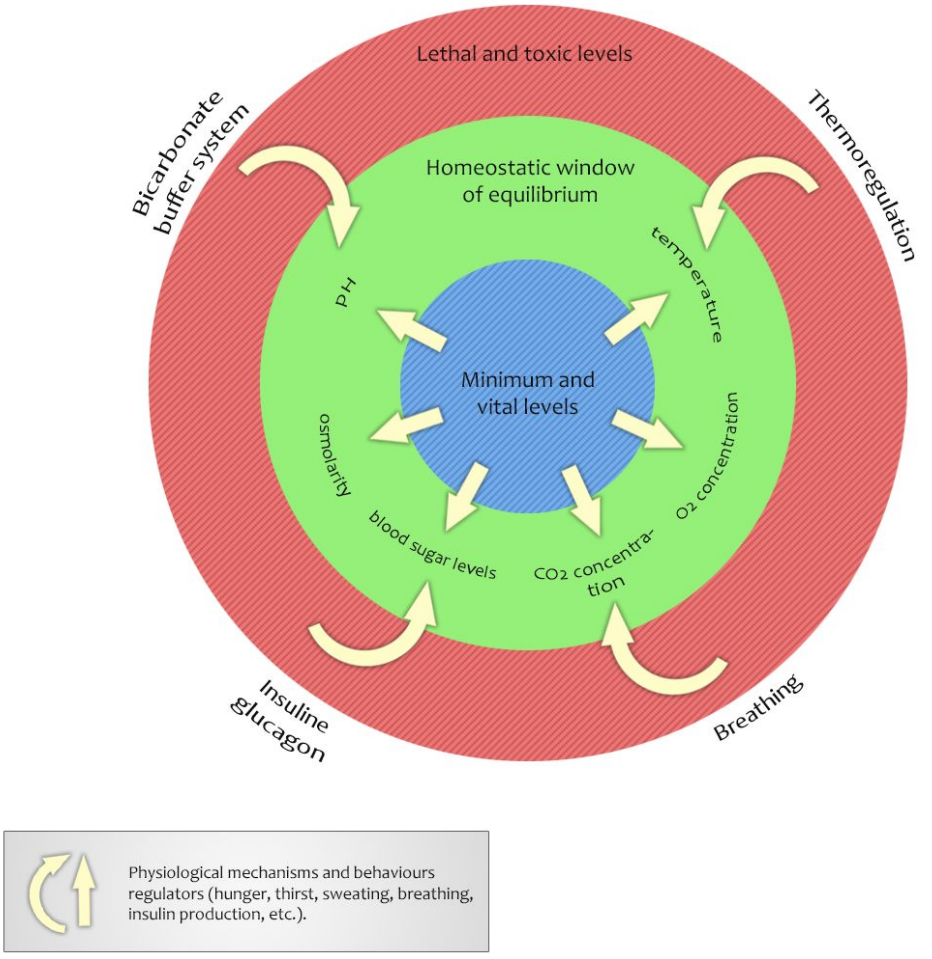

Figure 2. Simplified and schematic view of the homeostasis in living beings. By using negative feedback (represented by the arrows), biological systems maintain themselves within a homeostatic window of equilibrium, in which physiological parameters are neither too low (minimum and vital levels in blue), nor too high (maximum and lethal levels in red).

We will describe the principles in "Principle of homeostatic economics (HE)" the economic system inspired by the function of self-organization.

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4 - Starting assumptions

Scientific observations and consensus are clear[26] : human development has adverse consequences on the environment as well as on our survival rate, becoming one of the most serious and complex problems our species is facing. Although many analyses[27] tend to converge on the need to transform the way we consume, produce and use our renewable and non-renewable resources, it seems difficult to not consider these possible changes as epiphenomenal if our maro-economic system remains as it is today. Perhaps one of the major problems in resolving this situation is the fact that our species lives in as a closed system in an open system[28]. Indeed, our species thrives on a planet considered as an open system which are the most efficient[29] for perpetuating the self-organizing processes of living beings over time[30].

In this open system, the constant interaction between the biocenosis[31] and the biotope allows the perpetual exchange of information, matter and energy. At the individual scale, this results in a dynamic equilibrium maintained according to the changing conditions of the environment. It is the aforementioned phenomenon of homeostasis. At the population scale, ecosystems also reach a limit to this process. An equilibrium point that emerges after an ecological succession is called climax[32] in ecology. It defines a "limit" beyond which energy and matter only serve to maintain a

[26] On climate : https://www.ipcc.ch/assessment-report/ar5/ ; on land uses : https://www.ipcc.ch/srccl/ ; on biodiversity : https://ipbes.net/global-assessment

[27] See “blue”, “symbiotic” or “circular” economy, “green growth”, or the plethora of carbon emissions regulation mechanisms (markets, quotas, etc…)

[28] An open system is a system that constantly interacts with its environment. It exchanges matter, energy and information beyond its own boundaries, as opposed to closed systems that exchange only energy and information. A third type of system is called ”isolated” : such systems are theoretical as they don’t exchange any element with their environment, leaving them undetected by measurements.

[29] The definition of an open system assumes that there are energy resources that cannot be exhausted. In practice, this energy is supplied by a source in the surrounding environment, which can be considered infinite depending on the study. https://en.wikipedia.org/wiki/Open_system_(systems_theory)

[30] Isolated systems tend irreversibly to increase entropy. Closed ecological systems seem less resilient than open ecological systems in maintaining the balance of life over long periods of time. A few experimental projects have studied the possibility of making humans live in space through closed ecological systems (Biosphere II, MELiSSA and BIOS-3). https://en.wikipedia.org/wiki/Closed_ecological_system

[31] In ecology, biocenosis is the set of living beings coexisting in a given ecological space, plus their organisations and interactions. Together, the biotope and the biocenosis form an ecosystem. https://en.wikipedia.org/wiki/Biocoenosis

[32] Ecological succession is the theoretical set of stages describing - in time and space - a theoretical and complete evolutionary cycle within a given ecological space. As an evolutionary consequence of competition and cooperation, succession is assessed from the point of view of the ecology of the environment and therefore, in a systemic way, in

state of dynamic equilibrium. In order for the biocenosis to reach this state of equilibrium, a distribution of matter and energy must take place between the different species of the biome, the waste of some becomes the food for the others. The matter that makes up the bodies of some becomes the energy necessary for others, through a trophic network[33] made up of vast interconnected food chains. These ecosystems manage to maintain billions of individuals alive, for extremely long periods of time.

In this biocenosis, humanity does not follow these principles, in fact it bypasses them. Its positive participation in this virtuous circle is very low, for the reason that our capture of matter from living beings and inanimate matter is not or barely redistributed to the biosphere. A large part of our waste (70 to 75% in France[34]) is simply not assimilated by biological organisms. Our plastics from petrochemicals, our processed metals of all kinds, our electronic, nuclear, industrial and construction wastes and a whole range of other residues cannot be used to balance any ecosystem[35].

This consequences of our development can only generate various imbalances in our only habitable open system, a spaceship called Earth[36]. Proof of this is the sixth mass extinction of species which is, as we know today, the consequence of the development of *Homo sapiens*[37]. According to the UN and the World Convention on Biodiversity [25], there are five causes for this extinction: habitat modification, overexploitation, pollution, introduction of invasive alien species and finally climate change. In the case of the Holocene extinction, all of these major

terms of species but also in terms of the structures of occupation of the space. This cycle also corresponds to a succession of habitats and living communities. https://en.wikipedia.org/wiki/Ecological_succession

[33] A food web is a set of interconnected food chains within an ecosystem through which energy and biomass circulate (exchange of elements such as carbon and nitrogen between different levels of the food chain, exchange of carbon between autotrophic plants and heterotrophs). https://en.wikipedia.org/wiki/Food_web

[34] Rapport de l'ADEME sur les déchets (2016) [FR]. https://www.ademe.fr/sites/default/files/assets/documents/dechets-chiffres-cles-edition-2016-8813.pdf
Déchets : le casse-tête du tri à la source des biodéchets

[35] On plastic pollution: https://ourworldindata.org/plastic-pollution ; on electronic wastes : https://www.who.int/ceh/risks/ewaste/en/

[36] Kenneth E. Boulding, *The economics of the coming spaceship Earth*, in H. Jarrett (ed.) 1966. Environmental Quality in a Growing Economy, pp. 3-14., Johns Hopkins University Press.

[37] Nature's Dangerous Decline 'Unprecedented'; Species Extinction Rates 'Accelerating', Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), 2019.

causes are linked to our ability to capture matter from our environment, resulting in increasingly significant negative externalities on natural areas.

The reason for this capture of matter and energy without redistribution to the ecosystems could be related to the ability called *exo-somatization*[38] by the mathematician Alfred James Lotka. It is a process emerging from the biological systems, allowing the deportation of a species' physiological function outside itself. Tools, constructions and more generally technology are exo-somatizations that allow us, for example, to design deported legs (wagon, boat, car, plane), deported skin and homeothermic system (clothing, dwelling), deported digestive system (the use of fire to cook food), deported means of communication (telegraph, fax, telephone, internet, smartphone), deported eyes (torch, lamp, camera), etc… According to him, this ability is specific to the animal kingdom, and omnipresent in our species. The more we develop our exosomatization, the more our technological means develop, the more we need to extract materials from our environment and the more energy we consume to manufacture these technologies. The consequence is an increase in the extraction of material that is not redistributed to ecosystems, although it is the primary condition for the self-organization of living things. In this context, the decline of life is inevitable. The decrease in matter and energy available to living species no longer allows them to maintain their self-organization processes. Individuals die or move and, ultimately, some species go extinct.

Starting from this working hypothesis, our questioning was to envisage means that would make it possible to solve the problem of the non-redistribution of matter and energy to living beings, through a new economic model and by taking inspiration from the concept of self-organization. We can imagine the scale of such a wide and deppe project and what it entails, but the challenge before us cannot be satisfied with small adjustments or anecdotal reforms. As the global situation is deteriorating year by year, it seems vital to us to propose a model that can respond, through its ambition, to this immense challenge.

[38] Alfred J. Lotka, *The law of evolution as a maximal principle*, Human Biology, 1945 https://www.jstor.org/stable/pdf/41447607.pdf?seq=1#metadata_info_tab_contents

5 - Principles of homeostatic economics (HE)

These questions have led us to formalize three founding principles inspired by the concept of self-organization. These principles are the foundation on which the homeostatic economy is based.

1 - The economy must provide the necessary conditions for its resilience and adaptation to disturbances of the Earth system over long term periods. It must tend toward a stable state of "homeostasis", which corrects deviations via self-regulating mechanisms.

Homeostatic economics draws its root in the biological homeostasis and negatives retro-actions (fig.3), regulating processes allowing living beings to maintain physiological factors within a vital window of values for organisms (temperature, blood pressure, glycemia, pH, etc...). This principle is also inspired by the phenomenon of the adaptability of living beings and ecosystems to the disturbances they may encounter. For example : the resilience of a forest ecosystem after a fire appears thanks to to the stock of seeds in the soil, the seeds brought by the wind, water or animals, which make it possible to reconstitute a flora and trigger an ecological succession[39].

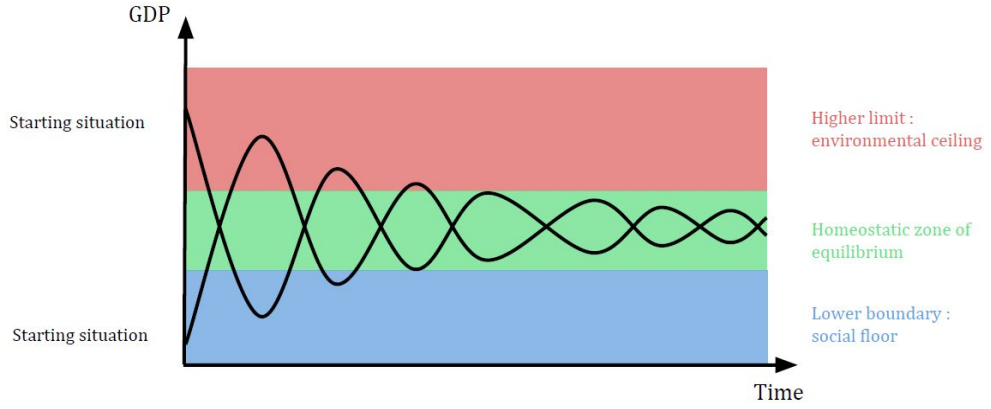

Figure 3. Theoretical drawing representing the evolution of GDP within a homeostatic economy. The human activity, measured with GDP, is corrected and kept in a zone of sustainability, where human basic needs are satisfied and ecological boundaries are not crossed. GDP quantification is used as an actual referentiel for comprehension, but will be replaced in the framework of HE, with more precise and systemic indicators.

[39] C. S. Holling, « Resilience and Stability of Ecological Systems », *Annual Review of Ecology and Systematics*, 8 janvier 2013

2 - The economy must contribute to the exchange and distribution of matter, energy and information between individuals and species by limiting the phenomena of capture.

Self-organization is exercised in an open ecological system where the phenomenon of matter and energy capture without reciprocity is low. When these phenomena increase, ecosystem collapsing occurs, as in the case of biological invasions, which are now considered to be the second most important cause of biodiversity loss at the global level[40]. We can also mention deforestation[41] or overfishing, which prevents the renewal of marine animal populations.

3 - The economy must reach this homeostatic equilibrium state by a limited and controlled growth, and should be able to return to this state (reversibility) over an indefinite period of time.

As precedently explained, when ecosystems reach the climax, energy-matter is theoretically only consumed and shared to maintain the dynamic equilibrium[42]. This means ecosystems don't rely and operate on an endless exponential growth, but rather, on a limited and precisely controlled growth which tends toward stability. The same goes for individuals, as shown by recent studies[43] describing an "allometric law", linking tightly physiological characteristics (such as body mass, metabolism or growth) to biophysical parameters (vascular system dimension, bone size, surface to volume ratio, etc…). But growth seems to be the most important factor[44]

[40] Kolar C.S. and Lodge D.M. 2001. *Progress in invasion biology: predicting invaders*. Trends in Ecology and Evolution 16: 199-204
Crawley M.J. 1987. *What makes a community invasible? In: Gray A. J., Crawley M. J. and Edwards P. J. (eds), Colonization, succession and stability*. Blackwell, Oxford, UK, pp. 429-453
Vitousek P. M. et al. 1996. *Biological Invasions as Global Environmental Change*. American Scientist. 84: 486-478
Olden, J.D., Poff, N.L., 2003. *Toward a mechanistic understanding and prediction of biotic homogenisation*. American Naturalist 162, 442-460.

[41] Fahrig L (1998), *When does fragmentation of breeding habitat affect population survival ?* Ecol. Modell

[42] Rameau, J.-C., Mansion, D., Dumé, G., Timbal, J., Lecointe, A., Dupont, P., & Keller, R. (1989), *Flore Forestière Française Guide écologique illustrée tome 1 Plaines et Collines*. Institut pour le Développement forestier, Paris

Bardat, J. (1993), *Phytosociologie et écologie des forêts de Haute-Normandie. Leur place dans le contexte sylvatique ouest-européen.* Publication de la Société Botanique du Centre-Ouest, Jarnac.

[43] https://en.wikipedia.org/wiki/Metabolic_theory_of_ecology

[44] Hatton, I.A. *et al*., Linking scaling laws across eukaryotes, Proceedings of the National Academy of Sciences Oct 2019, 116 (43) 21616-21622; DOI: 10.1073/pnas.1900492116

for living beings, as it highly relies on metabolism, and remains limited for any organism. Some scientists refer to this biophysical relationship as a "biological law of growth[45]".

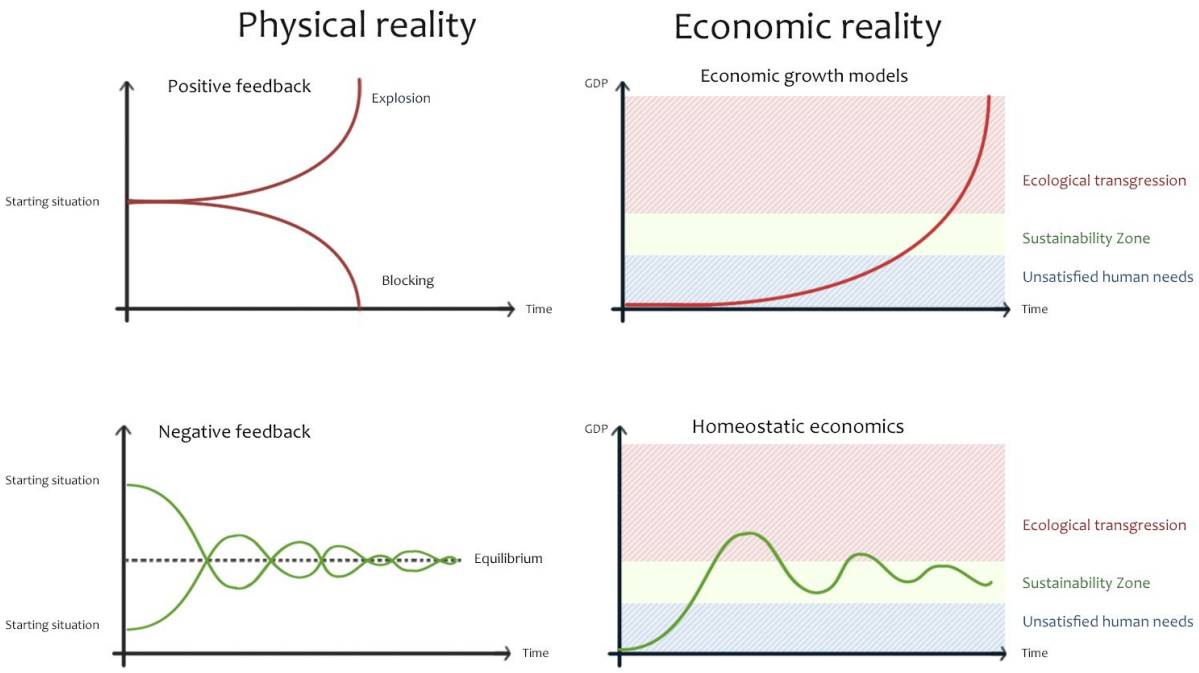

Figure 4. Graphic representation of positive and negative feedback, with economic analogies. Modern economies are based on an infinite growth that follows an exponential trend, typical of positive feedback (upper panel). They are characterized by a destabilizing amplification of the system's state leading to an explosion (depletion of resources) or a blockage (pollution of the milieu). They are unsustainable in the long run. On the other side, homeostatic economics is inspired by negative feedback, which are very common in living beings for their capacities to stabilize physiological parameters in a homeostatic zone, over long periods of time (lower panel).

[45] Hatton, I.A. *et al.*, ibid.

6 - Exo-economy and Endo-economy

The Homeostatic Economy takes the form of a system with homeostatic regulation mechanisms, inspired by biology[46], cybernetics[46] and system dynamics[47], where the various interactions between the coupled elements are designed to ensure the self-regulation of the system in the long term (fig.5).

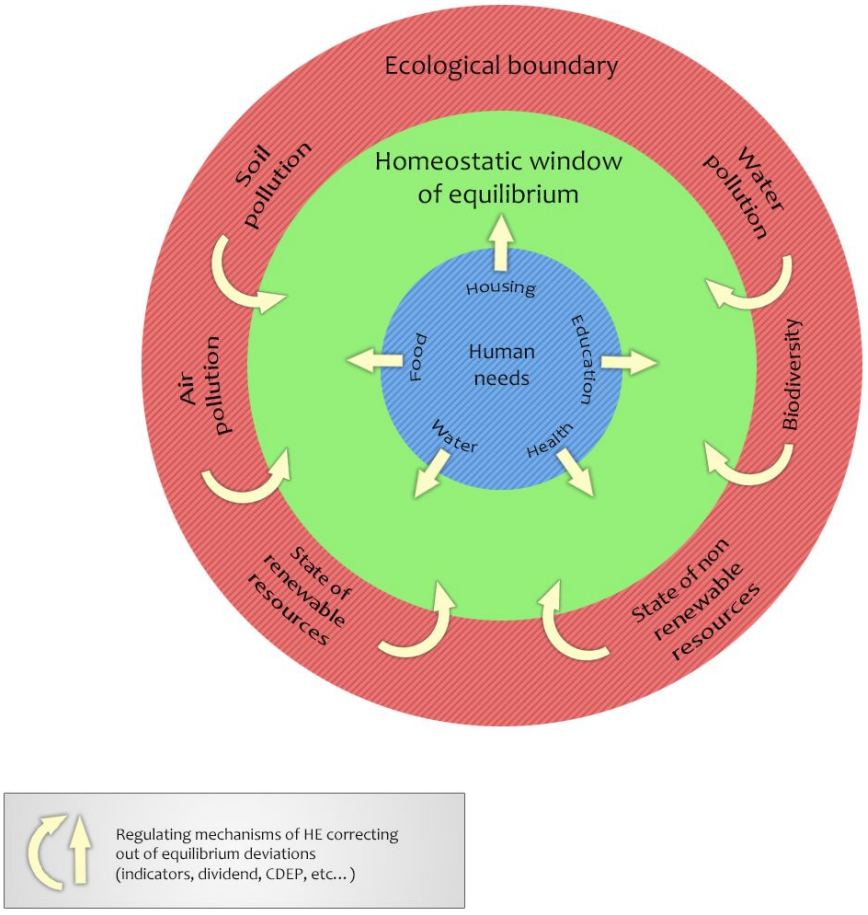

Figure 5. Drawing representing the homeostatic economics, inspired by homeostasis (see figure 2). The blue zone represents unsatisfied human needs, the red zone represents transgressed ecological boundaries. The regulating mechanisms of HE correct these deviations toward a zone of equilibrium (in green), where human needs are satisfied, and environmental boundaries are not crossed.

[46] See Chapter 3

[47] *General System Theory*, Ludwig von Bertalanffy, Georges Braziller, 1968

By taking the same visual representation used for the homeostasis (fig.2), we can describe an economy bounded by two founding principles that we must absolutely respect in order to ensure stability over long periods of time : a social floor[48] that determines the vital minimum any human has the right to, and an environmental ceiling representing the ecological sustainable bounds that can be provided by ecosystems and available resources. The system operates on a coupling between two elements : the exo-economy and the endo-economy.

6.1 - The exo-economy

The exo-economy[49] (EXEC) is everything that is not usually accounted for in non-reciprocal economic systems of capture, e.g. our environment. It includes the resources we exploit, but also life itself. Given the constraints inherent in capitalist systems - notably the inability to maintain a state of equilibrium between human societies and their environment, as well as the need to base wealth on the capture of resources - the exo-economy no longer appears as an external parameter dissociated from our economy, but as the very engine of our economy. Indeed, while production is achieved through labour and capital, it cannot take place without an adequate environment and a balanced management of resources. **The richness in biodiversity, the quality and quantity of renewable and non-renewable resources and the ecological pressure exerted by our species on the environment should be the basic indicators on which our economy could operate.** The exo-economy is composed of three indicators (biodiversity, ecological footprint and non-renewable resources indicator) that directly influence the monetary creation of an economic zone, which will be detailed in part 11.

6.2 - The endo-economy

The endo-economy (ENEC) corresponds to the human economy and is directly influenced by the indicators of the exo-economy (EXEC). HE is a system with two subsystems that interact with each other. The interaction of these two systems forms the homeostatic economy. One of the

[48] The social indicators used in the previous figure constitute a strict minimum independent of political or cultural contexts found in some countries or regions. These can vary in space and time, they are thus subject to the national political decision, which is the most likely to judge local and specific features. The whole group of social and environmental indicators should be the topic of deeper reflexions, especially on the calculation methodology.

[49] Exo-economy (outside the economy): defined in this framework by that which is external to the human economy, which does not participate in market and monetary exchanges. Conversely, the endo-economy is what is inside the economy.

distinct characteristics of the human economy is the transformation of matter and energy from the environment into monetary value. When we extract gold, oil, trees, animals, rice or any other raw material or living being, we put a monetary value on it. But we also need funds to buy tools, machines, premises or to pay the staff. All of this is essential for the extraction, processing and sale of the products of these extractions. In short, money conditions our ability to act on the surrounding world. **For this reason, money could be considered as an equivalent of our capacity to act on the exo-economy, on the resources available and on living organisms.** Consequently, monetary exchanges within the endo-economy should be impacted by the availability of resources and the state of equilibrium of ecosystems, which are a vital necessity for perpetuating the endo-economy. In the diagram below, an overview of the coupling between the exo-economy and the endo-economy is shown.

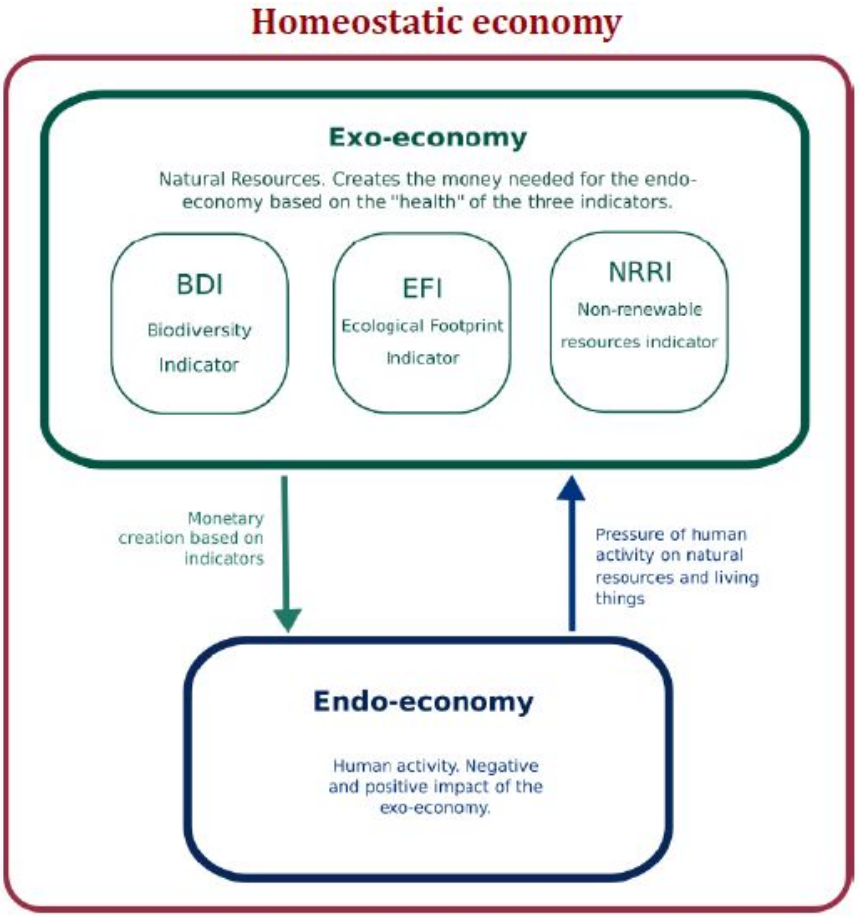

Figure 6. Coupling between the exo-economy and the endo-economy.

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7 - Exo-economic indicators

These three environmental indicators will link the endo-economy to the exo-economy (fig.7), so far absent in our socio-economic systems. Interactions between the two sub-parts will act as a regulatory and stabilising mechanism.

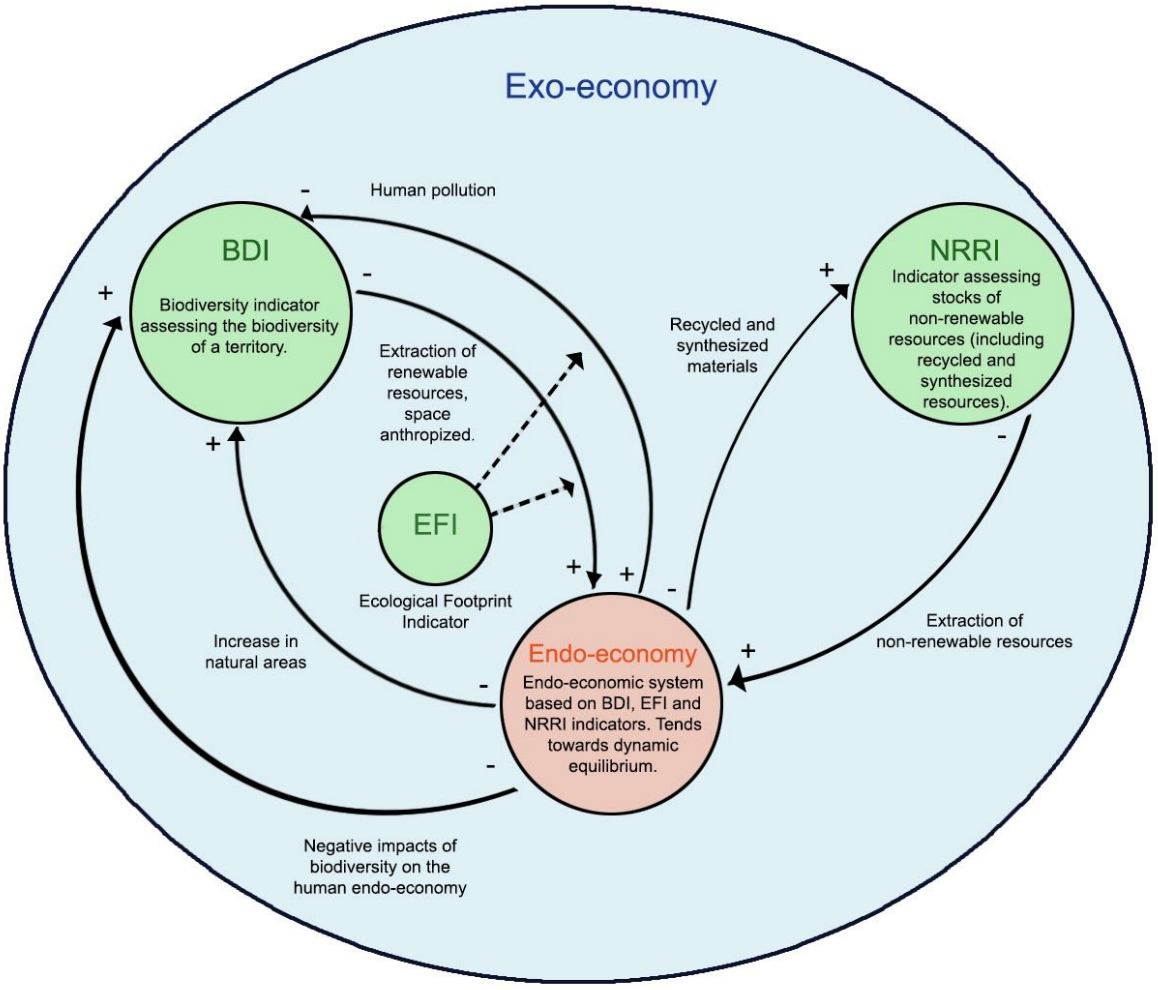

Figure 7. Interaction of the exo-economic indicators with the endo-economy in a HE.

BDI: corresponds to the biodiversity index. It is calculated in relation to the level of biodiversity and the population size of the species in a territory. This index should be calculated over the geographical area of a country and should therefore require scientific work to establish the desirable level of biodiversity for each country. It should necessarily tend towards an aggregation of natural environments, if not towards the maintenance of climaxes ("limit" beyond which energy and matter only serve to maintain a state of dynamic equilibrium in an ecosystem).

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EFI: corresponds to the Ecological Footprint Index. This index measures the pressures of human activities on the environment and renewable resources. It therefore includes pollution, the consumption of renewable resources according to their renewal rates and the anthropisation of territories[50]. This index exists but could be reworked to correspond to a fine reading of the extent of negative externalities linked to human development. Also, importations will necessarily have to be accounted for in this index to avoid the phenomenon of deported pollution (having polluting goods produced in a third country in order to preserve its own indicators). Pollution exports will also have to be accounted for. The EFI applies to an economic zone corresponding to a State and will have to be established on the basis of analyses led by the concerned disciplines.

NRRI: corresponds to the non-renewable resources index. It measures the consumption of non-renewable resources by a state, its companies and its citizens and positively includes recycling and resource synthesis. This index could be based on the "sustainable" amount of non-renewable resources consumed per person per year, in view of the world's available resources. A calculation could be made, resource by resource, by comparing the total consumption of the country according to its number of inhabitants. This too will have to be established on the basis of analyses of the relevant disciplines.

[50] Anthropisation is the transformation of spaces, landscapes, ecosystems or semi-natural environments through human action.

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8 - Dynamic balancing of indicators

We saw earlier that, in the HE, the exo-economy and the endo-economy form a coupled system in which the three indicators of the EXEC directly impact the ENEC. The homeostatic zone corresponds to an optimum, a window in which all the economic processes satisfy the humans needs, while respecting the ecological boundaries. This equilibrium found by our societies in this window is influenced by internal and external conditions : it is therefore dynamic and can vary. It can also cross the social or ecological boundaries. In order for the regulating mechanisms to correct these crossings, and to redirect the deviations toward the homeostatic zone of equilibrium, we need indicators measuring the human state of our societies, and its impacts on our environment. To achieve this, we will use the three indicators previously described : BDI, EFI and NRRI.

They are calculated on a range of values from 0 (worst possible situation) to 2 (best possible situation). Ideally, if the indicators are below 1, it means that the country is overexploiting resources, degrading its environment and not allowing ecosystems to regenerate. Above 1, the country is "under-exploiting" resources. The value 1 of the indicators is therefore an ideal to be reached, it is the pre-established dynamic equilibrium state for each indicator.

8.1 - Dynamic equilibrium and coupling with money creation

The average value of the indicators has a direct influence on the country's money creation. Thus, if this mean value of the indicators declines from one year to the next, the newly created money supply decreases, the country becomes poorer, resources are depleted, consumption and production decrease. This "decline" has an impact on the indicators because it directly affects the Ecological Footprint (EFI) and Non-Renewable Resource Consumption (NRRI) markers. When the average of the indicators increases, the newly created money supply for the country increases, the country becomes richer, allowing for greater consumption, thus greater production, and so on. Together, indicators and money act as negative feedback regulating our societies, in order to keep it within the sustainable zone of optimum, defined by the homeostatic window of equilibrium.

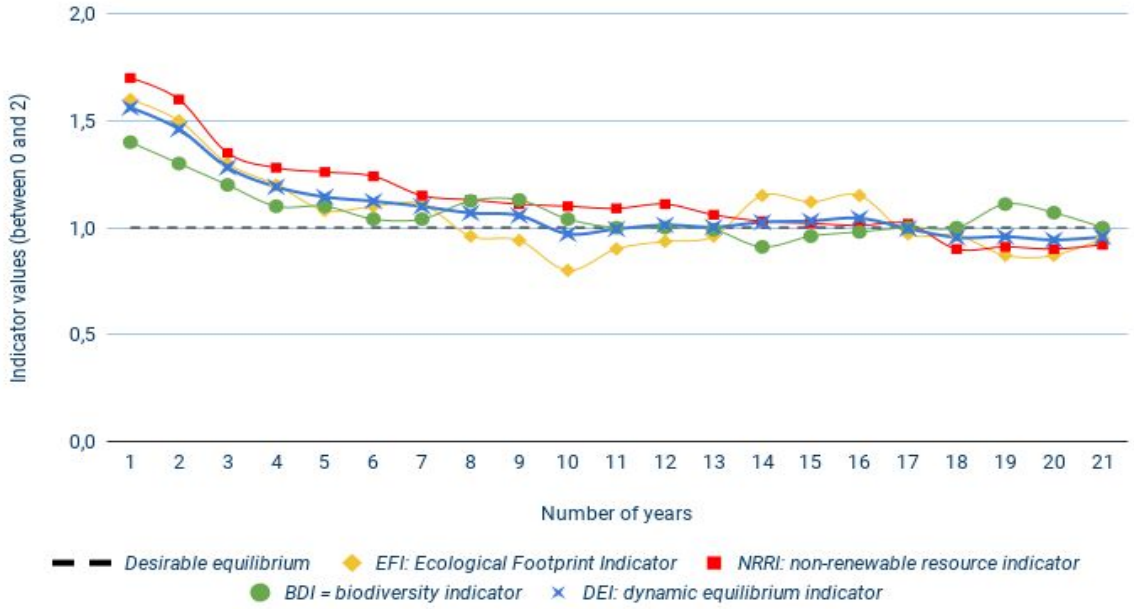

Figure 8a. Evolution of exo-economic indicators. DEI is the geometric mean of the three indicators and is used as a reference point for money creation.

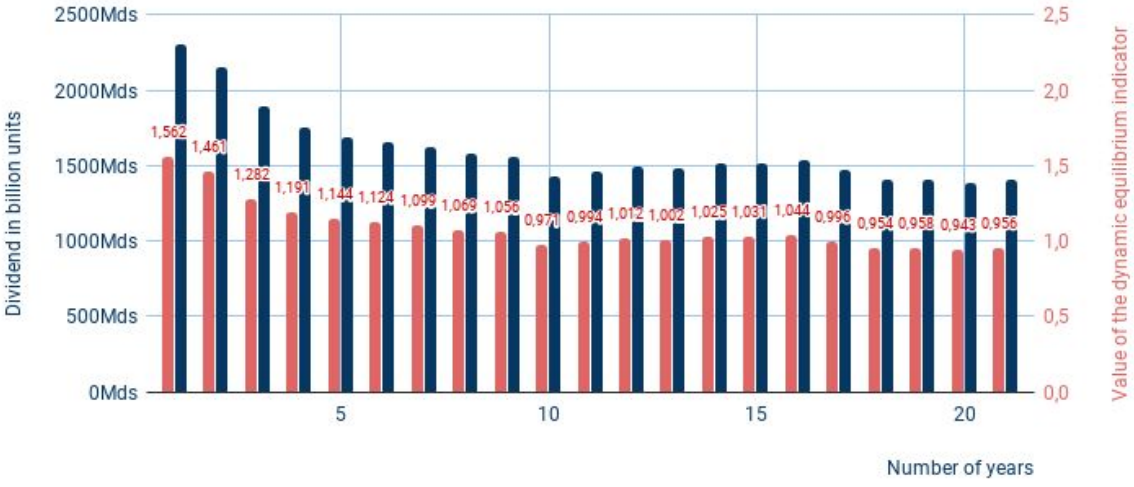

Figure 8b. Evolution of the money created for a state, according to the DEI. It directly influences the money creation of a State.

Figure 8a shows the evolution of the four indicators (BDI, EFI, NRRI and DEI). The curves tend towards the desirable equilibrium (defined by the value 1), thanks to the influence of these markers on the money creation of an economic area, as shown in Figure 8b. When the DEI indicator (average of the other three indicators) increases, the money created also increases. Thus, the population can consume more, companies can produce more, which presupposes greater resource consumption, a larger ecological footprint and more heavily impacted biodiversity. This cycle of economic growth stops when indicators of biodiversity, non-renewable resources or ecological footprints decline. In Figure 8a, we see a decline in these indicators, which is reflected in Figure 8b by a decline in money creation. This decline continues until a balance is achieved between human activity and the maintenance of ecosystem balances, as well as a reasoned consumption of resources.

8.2 - Dynamic equilibrium indicator (DEI)

The Dynamic Equilibrium Indicator (DEI) formulates the situation of the country in relation to the desired optimum. It is calculated using the geometric mean of the BDI, EFI and NRRI indicators to allow a better estimation of the central tendency of the data. Using a geometric mean gives a more representative average value of all the indicators. With this formula, if one of the three indicators has a low value, it will hardly be compensated by the other values.

For example, let's imagine two countries : one of which has three indicators in equilibrium (all of which have values of 1) ; the second country has one indicator at 0.9, another at 0.1, and a third at 2. Its average value will also be 1 with an arithmetic mean. However, the two countries actually have indicators that do not indicate the same thing at all.

Conversely, a geometric mean would indicate 1 for the first country and 0.56 for the second. The indicator at 0.1 would cause the average to drop completely and would necessarily require suitable values to be obtained for all three indicators.

Here's the formulation for the calculation : $DEI = \sqrt[3]{BDI \times EFI \times NRRI}$

Indicators	State A	State B
BDI	1	0,9
EFI	1	0,1
NRRI	1	2
DEI arithmetic average	1	1
Geometric mean DEI	1	**0,56**

Table 1 - Comparison of two countries' indicators calculated with an arithmetic mean and a geometric mean.

In short, the more the country degrades its environment, its biodiversity and overconsumes available resources, the poorer the country becomes and on the contrary, if it saves resources, increases its biodiversity and reduces its ecological footprint, the richer the country becomes. This phenomenon of self-regulation creates a dynamic balance between the endo-economy and the exo-economy. The mechanism of money creation will be described in more detail in Part 11.

9 - Endo-economic architecture

The endo-economy (ENEC) represents what we consider nowadays as the economy, e.g. the monetary exchanges that we create. In a homeostatic economy, the endo-economy is entirely regulated by the indicators of the EXEC, which reduces the need for regulation within it. It is therefore a self-regulated system as mentioned in the first principle of a homeostatic economy (HE).

As we have seen in the section on the three pillars of HE, the system must be able to distribute the money supply to the different economic actors, in order to correspond to the second principle of HE, which must allow the exchange and distribution of energy, matter and information between human beings. Thus, the overall money supply given to a country is divided into three : one part is allocated to the State, one to the citizens and one to the companies. Each part is calculated according to different criteria, but all are impacted by the

EXEC indicators. We will see in section 11.1 what are the formulas on which the monetary creation for each part is based.

Finally, the system must be able to reach the homeostatic window and maintain a "dynamic equilibrium" according to the new data available to correspond to the third principle of an HE. We have just seen how this equilibrium is organised and how it interferes with the mechanism of monetary creation. After having described the framework, we can now look more deeply into the functioning of money, its creation and its destruction in a HE. Below is the general endo-economic architecture of money creation (fig.9) :

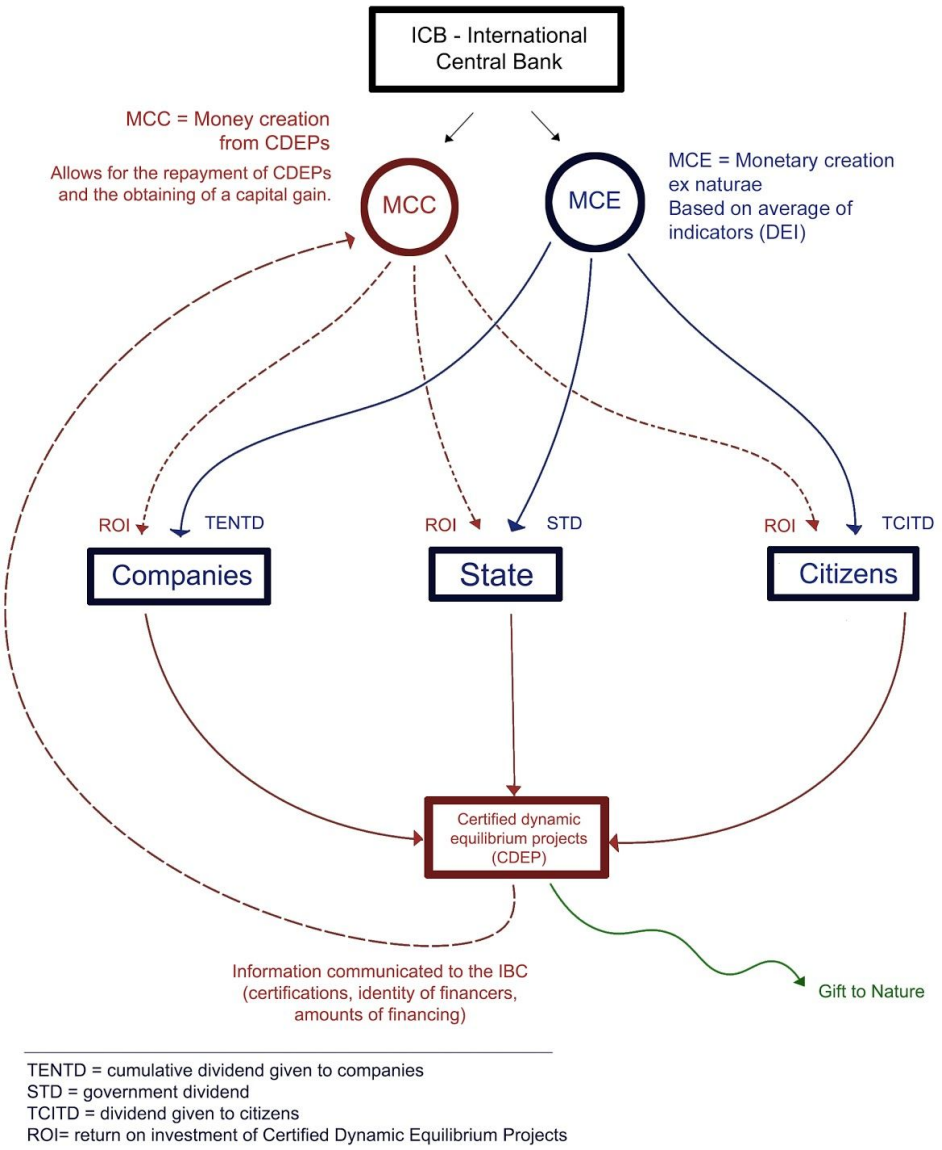

Figure 9. The two mechanisms of money creation in the endo-economy.

10 - Melting donation based currency[51]

In a homeostatic economy, **money is not created out of debt, it is given without any direct counterpart** (compared to what nature offers us). On the other hand, **it is created on the basis of EXEC indicators**. Therefore, **the economic mechanism that destroys money is its melting**.

The melting of a currency is its ability to degrade over time, like all physical elements in the real world: food rots, objects wear out over time, living things eventually die. In the physical world, all things, living or not, are subject to entropy, except money. The melting of a coin therefore provides to money the same properties as inanimate objects and living beings. By its progressive destruction, it too becomes subject to entropy, "simulated" by the rate of melting. The specific architecture of this currency, which is given to its creation and which is destroyed when melting down, requires a currency in electronic form to facilitate the automation of the melting system.

The advantage of such a currency is its behaviour over the long term, which tends towards equilibrium and therefore allows a cap on the maximum balance of a bank account depending on income, expenses and the meltdown rate (fig. 10).

[51] This phenomenon was described by Silvio Gesell in his book "*Die Natürliche Wirtschaftsordnung" (The natural economic order, available in english https://www.silvio-gesell.de/the-natural-economic-order.html).* Gesell originally used the term "*free money*" in German, also found in English and French. Eventually, its meaning changed in French where it became "monnaie fondante", translated to "melting currency". Another term may be more suited in English, but we will stick to "melting" in this overview to describe the periodic loss in quality of money, mimicking the physical degradation of entropy.

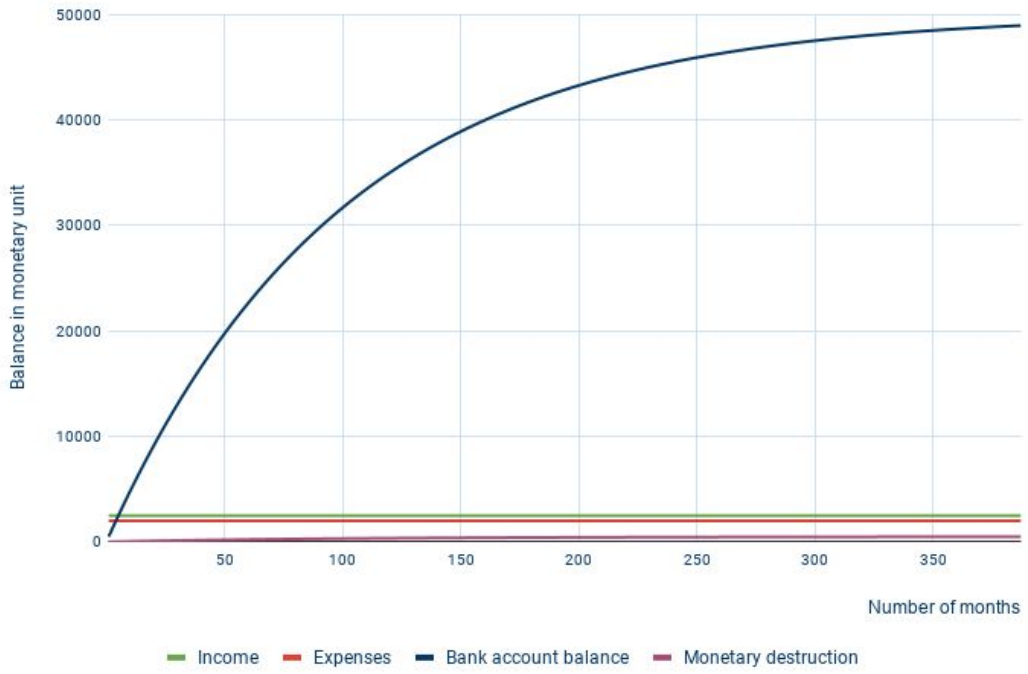

Figure 10. Behaviour of a melting currency in time. The conditions are : a fixed melting rate of 1% per month, a fixed monthly income of 2500 units and a fixed monthly expense of 2000 units.

In this figure, we observe a strong evolution of the balance at the beginning of the cycle, caused by the absence of money at the start of the simulation. Then, the bank balance tends towards stabilization, which is one of the characteristics of melting money. In the medium to long term, it tends towards a stabilisation (capping) of bank balances and, more generally, of the money supply in an economic area. In an economic zone with a pre-established money supply, money creation and melting will make it possible to achieve a "perfect" balance between the quantity of money vital to an economic zone and its real environmental impact.

10.1 - Stability and plasticity

Moreover, it must be taken into account that the new currency will be created by means of the EXEC indicators, which are themselves based on self-regulation that tends towards low variability in money creation[52]. In other words, an HE necessarily evolves towards an

[52]The variability of the money supply created is largely impacted by exo-economic indicators, which evolve with a certain inertia. In such a system, there can be no hyperinflation.

equilibrium, regardless of technological advances, available resources or geopolitical events, the economy will develop towards an equilibrium and not towards perpetual growth punctuated by global crises and economic euphoria.

However, the dynamic balance may change over time as scientific knowledge advances, new exploitable deposits are discovered, new technologies are developed or the population changes. This plasticity makes it possible to ensure a balance between the creation of money injected into the economy and the human impact on the environment.

10.2 - Overconsumption and cash flows

The melting nature of money also ensures a larger flow of money than an economy based on a debt-currency, which can also create overconsumption effects[53]. Since money is less attractive to hoard if it melts only from savings, we wanted to reduce the overconsumption caused by the melting of savings by giving the property of melting to the transaction and savings. Thus, savings are less disadvantaged compared to conventional melting exclusively for savings. If savings and consumption are both subject to melting leading to a stabilization of deposit accounts, it is to stimulate environmental oriented investments, the only way to get around melting. The HE provides for an investment mechanism called "certified dynamic equilibrium projects" (CDEP), which role is to promote sobriety, preservation and reparation of human activities' consequences on the environment. This mechanism will be explained in section 12.

The second mechanism to contain this over-consumption is the articulation between the EXEC and the ENEC. If a phenomenon of overconsumption occurs and the environmental situation deteriorates, then the money supply created the following year will decrease. In a HE, it is therefore impossible to over-consume resources without tending towards generalised impoverishment, and conversely, under-consumption of resources leads to the monetary enrichment of the economic zone, improving its capacity to act and preserve the environment.

[53] Qu'est ce qu'une monnaie fondante ? Association pour le développement de monnaies locales dans le Puy-de-Dôme [FR]. http://adml63.org/faqs/quest-ce-quune-monnaie-fondante/

10.3 - Choice and behaviour of money melting

To understand why we chose this monetary operation over another, we need to understand the issues involved in a homeostatic economy with a debt-money system.

A HE defines a country's wealth based on its EXEC indicators, which directly influence the mechanism of money creation. However, with a non-melting currency, the system would not work because there would no longer be a mechanism of monetary destruction (currently this mechanism is carried out through the repayment of credits). Thus, the economic system would allow for constant inflation and faster economic growth than at present. This is contrary to the third principle of a HE (principle of self-sustainability and reversibility to a state of equilibrium). It was therefore necessary to look for a mechanism of monetary destruction consistent with what we were looking for. Starting from these constraints and after considering a multitude of avenues concerning monetary destruction, a destruction mechanism integrated into money seemed to be the most effective way to tackle this problem, in addition to bringing out a number of non-negligible advantages.

First, it allows monetary creation to be indexed to indicators external to the human economy, which is not possible in a debt-money framework. Second, as explained above, it allows the money supply to stagnate. This stagnation can be measured on a bank account according to the situation of its balance, its income and expenditure, and the rate of melting applied to it. For example, if an individual saves a large part of his or her income instead of spending it, there will be a stagnation in the balance held after x years. As the accumulated money increases, the monetary destruction of the balance also increases.

Stagnation occurs when income equals expenses plus the currency destroyed by melting. This operation applies equally to an economic zone, when the sum of dividends equals the money supply destroyed by melting.

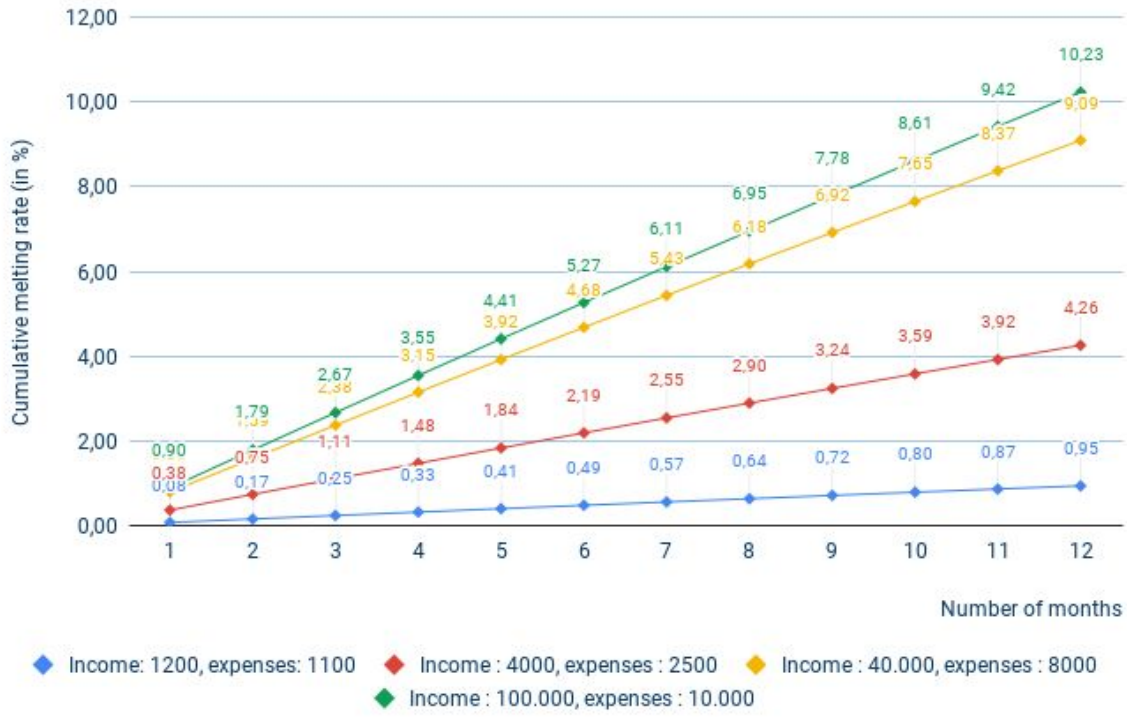

Figure 11. Calculation of melting rates accumulated over a year. The rates are based on different incomes and expenses.

As a result, this currency is fully in line with the search for a dynamic balance between the money supply of an economic area and the impact of individuals on their environment. To explain this in another way, it is not possible to become infinitely richer, except in the case of an infinite increase in the income of money in relation to expenditure, or an infinite decrease in expenditure. Since it is easier to decrease one's expenses than to increase one's income, sobriety seems to be the key to enrichment in such a system, and this is the result of money melting.

Moreover, the behaviour of money is intrinsically dependent on the way it is melted. Let us look at some examples regarding the consequences of savings melting. The results and the behaviour of the players in the economic area will be different depending on the time when melting is applied : if savings melt at the beginning of the month or at the end ; if they melt once a month, once a week, etc... For example, if the savings melt at the beginning of the month, the amount of money destroyed will be greater than if the melt occurs at the end of the month. *Conversely*, if it melts at the end of the month, it will have less impact on low wages. Another example, if the melting occurs every week, a greater quantity of money will be destroyed and it will impact all

the actors with melting in the first two weeks of the month greater than the melting in the last two weeks of the month. But this does not apply to people paid on the basis of weekly, bi-weekly or daily wages as is the case in some countries.

On the basis of these considerations, we are currently considering a 1% month-end meltdown on all accounts, as well as a 1% meltdown on all transactions. These melting modalities may evolve according to new models of the behaviour of monetary melting.

11 - Mechanisms of money creation

As we are accustomed to the debt-based money creation mechanism, it seems instinctive to us. Yet, it has little legitimacy in its current functioning. Indeed, this money creation is not based on any external prerequisite, apart from trust. This trust being that of the creditor towards the borrower, the position of the creditor is therefore relatively comfortable since it allows him to create a certain amount of money that is not based on any wealth that would allow him to exercise a conversion of his capacity for money creation. In other words, there is nothing to justify this mechanism of money creation other than the fact that it is legally authorized. From this observation, the monetary creation of a HE proposes an adequacy between the money created and the resource wealth potentially available.

Since it is not desirable to exploit all resources and it is on the contrary preferable to save them in the long term, this currency should therefore correspond to the extent of untapped resources and therefore seems to be a more sustainable indicator of value than that of production capacity. **This reversal of wealth creation could transform an economy that creates its wealth on the destruction of resources into an economy that creates its wealth on the preservation of its resources. In short, it is a monetary creation from nature "*ex naturae*" and not to the detriment of nature.**

Therefore, the monetary creation in a HE does not work on the basis of debt but on the basis of a grant or donation according to the EXEC indicators. The created money is given to and shared between State, citizens and companies. The amount of money created varies according to the average of the exo-economic indicators as explained in section 8.2.

Monetary destruction is carried out through the melting of money. Each month, a part of the money is destroyed on all accounts, following a defined percentage. Melting is also applied to every transaction. This melting mechanism stabilizes the overall money supply regardless of the amount of money injected into the economy. Moreover, dynamic equilibrium does not allow for exponential growth. It tends to make money creation stable over time and to stabilize the money supply in circulation in the economy. A second mechanism of money creation, coupled with the first and called "certified dynamic equilibrium projects" (CDEPs). It redirects investment in projects whose objectives are to increase biodiversity, to clean up or reduce sources of pollution, to reduce the ecological footprint and to reduce the consumption of non-renewable resources. It also makes it possible to temporarily avoid the melting effect. This second mechanism of monetary creation will be detailed in part 12.

The two money creation mechanisms (*ex naturae* and CDEP) are managed by an international central bank, called ICB. Its mission will be to issue money for countries wishing to join this economic system. The functioning and roles of the ICB will be explained in Annexe A1.4.

11.1 - Formulas for money creation

The formulas for money creation are different depending on the criteria taken into consideration but are all dependent on the EXEC indicators. Here are the three formulas that allow for the creation of money-giving to the government, companies and citizens.

State dividend (STAD)

$$STAD = DEI \times 22\,000 \times c$$

This is the average of the exo-economic indicators (DEI) multiplied by 22,000, (which corresponds to the average of the 10 European countries with the highest public expenditure per citizen, in euro equivalent[54]), multiplied by the number of citizens in the State (c). Thus, public expenditure per citizen is based on a quality of service that is not equivalent to the gross domestic product, but on the need for a State to be able to provide adequate services to its population. This is why our calculations are indexed to the euro currency, in particular in order

[54] Calculations have been made in Euro equivalent to have a reference system that allows us to better perceive inconsistencies and errors.

to assess the quantity of money needed for a high level of service per citizen (average of the 10 European countries with the highest public expenditure per citizen). STAD takes into account the number of citizens in the State, the more populated the State is, the greater the dividend given to the State.

Total State Citizen Dividend (TCITD)

$$TCITD = STAD$$

Citizen's Dividend (CITD)

$$CITD = STAD / c$$

The TCITD indicator is calculated on the basis of the State's indicator (STAD) and is then divided by the number of citizens (c). As a result, citizens receive a dividend that is strongly related to the country's EXEC indicators generating the enrichment or impoverishment of the entire population according to these indicators.

Total State Enterprise Dividend (TENTD)

$$TENTD = nENTD$$

Enterprises' Dividend (ENTD)

$$ENTD = DEI \times P + (e \times CITD / (r / e \times 10^4)$$

In this formula, DEI corresponds to the dynamic equilibrium index and has a strong influence on the final dividend given to a company. It is multiplied by *P*, the operating revenue used as an initial base (e.g. the average of the last three best years of operation of a firm). *P* has to be updated in the calculation of ENTD over a fixed period of several years (e.g. every three years). The updates of *P* take place out of the ENTD and book transfer. To this is added *e* which indicates the number of current employees, multiplied by CITD, which corresponds to the country's minimum income. Finally, *r* means the wage gap between the highest wage in the company and CITD, it is divided by the number of employees in the company, itself multiplied by 10^{55}. This formulation makes it possible to obtain a dividend that is relatively close to the

[55] The different formulas for money creation are currently at the proposal stage and may evolve in the future.

firm's operating income when DEI is equal to 1. It also incorporates wage differentials and thus ensure a better distribution of wealth within firms.

For the time being, ENTD is intended to be calculated individually, company by company[1]. The accumulated dividend of all companies is TENTD, which is the accumulation of all the ENTDs operating in a state.

Total dividend of an economic area (DEA xx)

$$DEA\ xx = STAD + TCITD + TENTD$$

The aggregate money supply of an economic area is the money supply created for a country, over one year, including the money supply created for the state, businesses and citizens. In order to differentiate between the DEAs of the different countries when writing the formula, the use of ISO 3166-1[56] is desirable, so the two letters representing the country replace "xx". For example, for France (thus including the French State, French companies and French citizens), the form would be DEA FR.

12 - Certified dynamic equilibrium projects (CDEP), the second mechanism of money creation

The second mechanism of monetary creation (CDEP) is carried out through the ICB (international central bank). It renders profitable the projects that are today at a loss and cannot be implemented in our economy. It is no more, no less, a mechanism to make the loss profitable, for example : projects that increase biodiversity or natural areas, projects that clean up or reduce the emission of pollutants into the environment, those that lead to a reduction in the use of non-renewable resources and those that tend to reduce the ecological footprint on a large scale. All actors in society (State, private companies, individuals, associations, communities) can create or participate in this type of project.

[56] The ISO 3166-1 standard defines alphanumeric codes (two to three letters and one of three digits) for every country in the world. https://www.iban.com/country-codes

12.1 - Procedure for setting up a CDEP

- A project file is proposed to the ICB body that deals with the processing of CDEPs. This file includes the idea of the project, its development, objectives, implementation period, cost and financing.

- If the project is accepted, it receives a "certification" from the certifying authority linked to the ICB. If the project is rejected, it cannot be funded.

- Once the project is certified, it can receive funding (if the group initiating the project does not have the necessary funds) or finance it itself.

- The project must be set up and checks may be carried out (by the certification body) to verify that the project is taking place.

- Once the project has been completed, the monitoring body ensures that the project is finalized by verifying on site that it has been carried out properly. If nothing is done, the certification is withdrawn.

- If the project is validated by the control body, then the project financiers are fully reimbursed and receive a capital gain (variable depending on the category of the project and the general melting rate of the economic zone). If the project has not been carried out as specified in the specifications, the certification can be lifted. A project partially completed but not finalized for budgetary or technical reasons may be reimbursed up to the amount of the work carried out, without any added value.

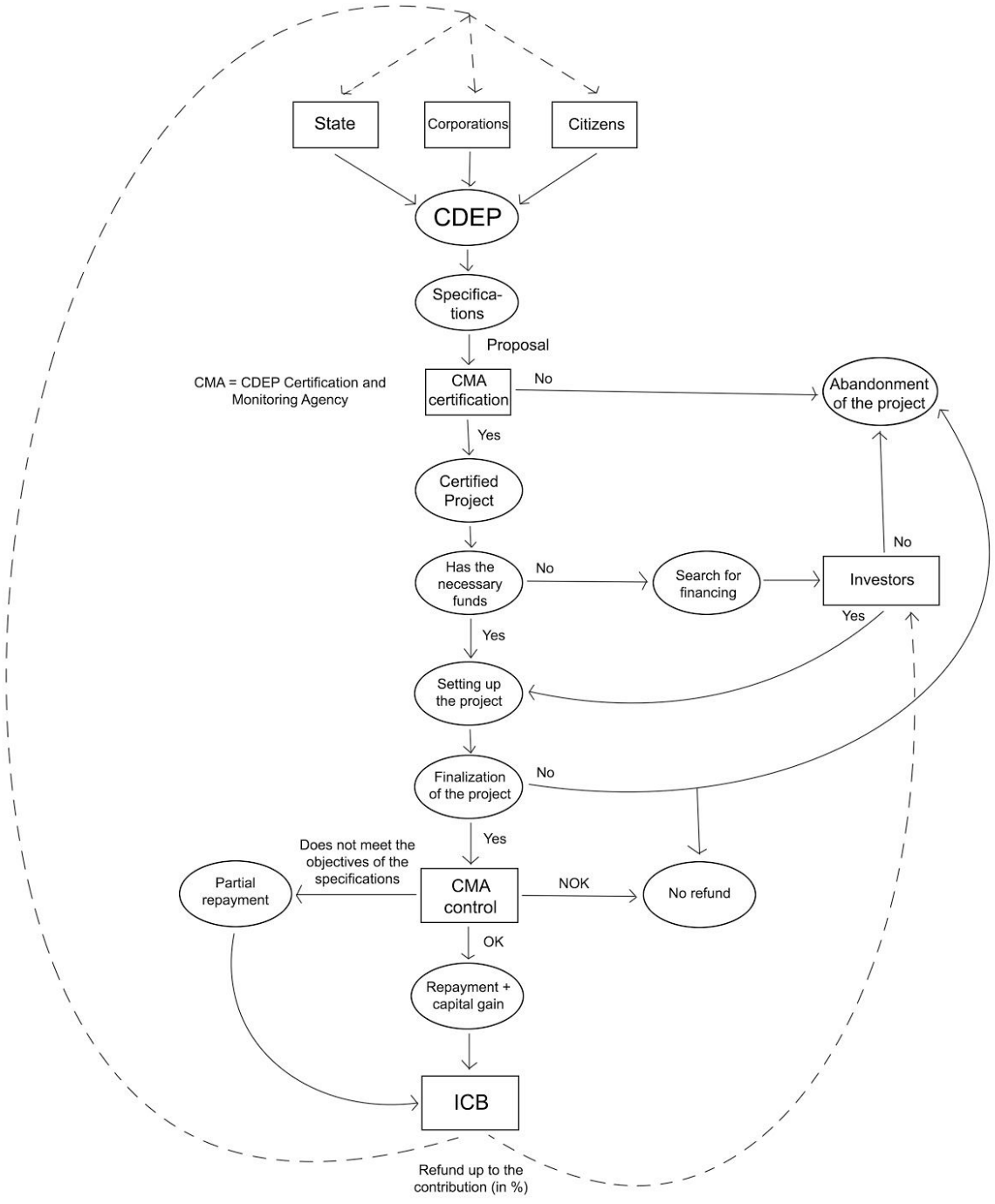

Figure 12. Certified Dynamic Equilibrium Project (CDEP) Implementation Process.

CDEPs are exclusively non-profit projects and no subsequent profits can be made from their direct achievement. They are one-time, one-off projects and not regular projects with a periodic focus. They are financed exclusively through a melting currency.

Financing CDEPs becomes advantageous in an economy operating on a melting currency and **allows for a return on the loss**. As money is destroyed at the end of each month, it becomes more interesting for large capital to invest massively in CDEPs in order to avoid money melting. The CDEPs also make it possible to improve the EXEC indicators and thus to enrich the country monetarily while reducing its ecological impact, to repair environmental pollution and to reduce the excessive use of non-renewable resources. It is therefore the second central element of HE, which, together with the EXEC indicators, makes it possible to maintain a stable economy over long periods.

CDEPs are divided into four main categories (A, B, C, D) that have different rates of return on investment. These rates are measured according to the overall melting rate of the economic zone (the country's economic zone). They cannot be higher than this rate at the risk of allowing a greater amount of money to be created than initially destroyed by melting.

CDEP category A: corresponds to projects with the objective of increasing biodiversity. The rate of return on investment is 80% the overall melting rate.
CDEP category B: corresponds to projects whose objective is to clean up or reduce the emission of pollutants into the environment. The rate of return on investment is 60% the overall melting rate.
CDEP category C: corresponds to projects whose objective is to reduce the ecological footprint. The rate of return on investment is 40% the overall melting rate.
CDEP category D: corresponds to projects whose objective is to reduce the consumption of non-renewable resources. The rate of return on investment is 20% the overall melting rate.

	Category A	Category B	Category C	Category D
Total melting: 5%.	4%	3%	2%	1%
Gain with 1 million invested	40 000	30 000	20 000	10 000

Table 2 - Example of gains on CDEP according to their categories

In Table 2, we see the gains of CDEPs based on an overall melt rate of 5% on a $1 million investment. The rate of return on investment is therefore correlated to the overall melting rate of an economic zone. The lower the melting rate, the less profitable the CDEPs are, the higher the melting rate, the more profitable the CDEPs are.

13 - Mechanisms of credit and savings

The logic behind the mechanism of credit is different in a HE, since it does not allow for direct money creation. However, it remains quite similar in operation to the one currently in existence. The biggest difference is that the amount of money needed to pay the credit comes from the dividend created and given each month, according to the EXEC indicators and the additional contributions available. When a loan is taken out, the entire dividend is no longer paid into the borrower's account, but into the lender's account. In practice, credit still works through the banks, but they will no longer be able to create the money needed for it, they will have to call on private or public lenders, who wish to make use of their bank surpluses before the money melts. The banks will provide private and public actors with accounts reserved for loans. These accounts will allow lenders to avoid money melting if the money is lent quickly. Indeed, if there are not enough requests for loans, the loan accounts will undergo melting (the rate is the same on all bank accounts). Once the loan is made, the lender receives an annuity (the repayment of the credit) on his account, which is equivalent to the dividend normally received by the borrower plus, if the borrower is able to do so, the additional contribution of the latter. Repayment time is directly subject to the EXEC indicators. The better the EXEC indicators, the faster the loans can be repaid. The more they deteriorate, the longer the loans need to be repaid (reminder: the dividend evolves according to the EXEC indicators). Banks, on the other hand, can finance themselves through an interest rate on the loan that will be deducted monthly from the borrower's dividend. Through this mechanism, credit no longer allows for direct money creation and allows individuals, businesses and institutions with a monetary surplus to finance the economy while possibly reducing the meltdown of their balances.

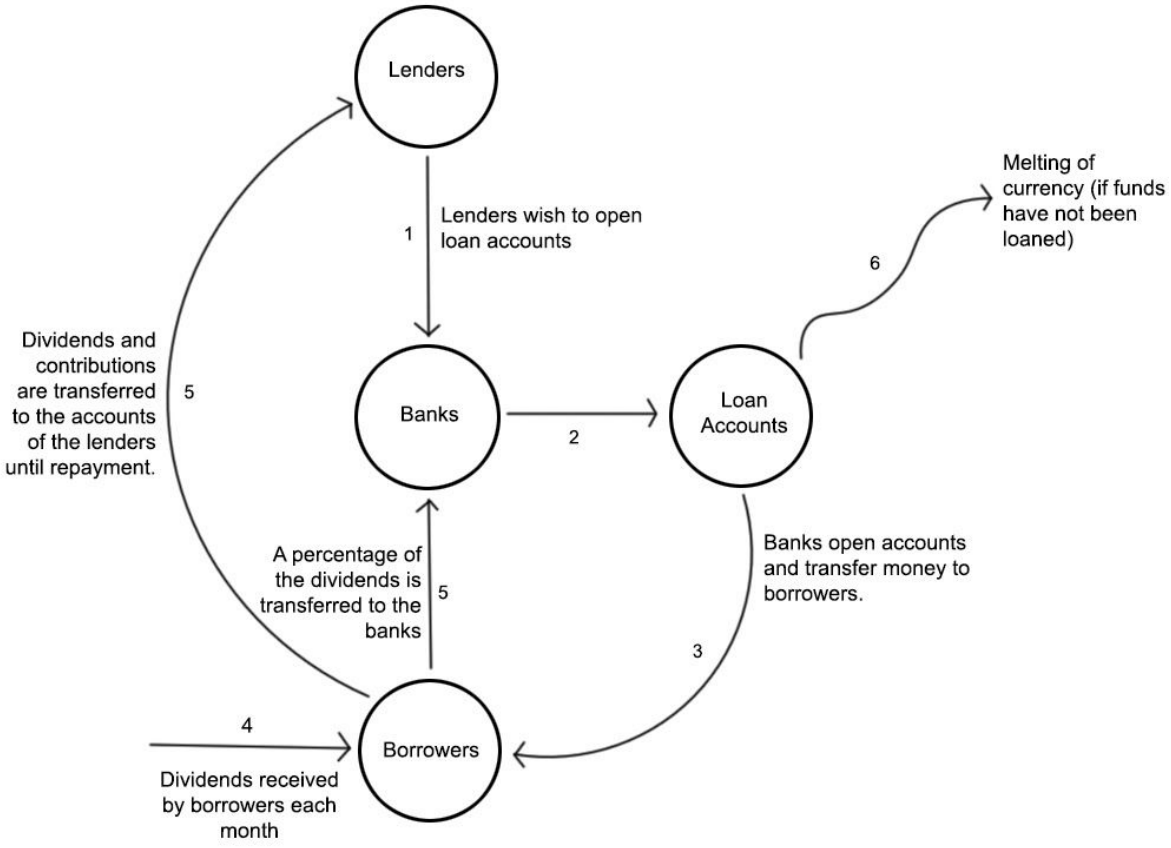

Figure 13. Mechanism of credit in a homeostatic economy.

14 - Importations and exportations

Importing and exporting work differently in a HE because they must necessarily be accounted for in EXEC indicators while being affected by the exchange rate of the currencies. There are therefore several scenarii depending on the economic system of the importing and exporting country.

14.1 - Importing

In order to avoid the circumvention of the EFI and NRRI indicators by importing products that have generated pollution during production, it is essential to integrate importations in the EFI and NRRI indicators. Thus, importations can no longer become a solution for externalizing the

pollution generated by the country's consumption. This mechanism negatively affects countries that massively import products with high environmental impacts. Consequently, the deported pollution is included in the EXEC indicators, without going through the legislative or taxation system, and in no case prohibits the import of environmentally harmful products. Also, since EXEC does not respect the principle of economic growth, the debate of free trade versus protectionism may well become obsolete.

While at first glance imports appear to be more restrictive for the importing country (because they influence the indicators), they are in reality just as restrictive as in a capitalist system, because they have a negative effect on the trade balance. In the case of an import of products from a country also operating in a HE, only the energy cost of the imported products' journey can be counted and not the cost of their production, as the latter has already been counted in the exporting country. Imports are therefore more advantageous when the imported products come from another country that also has a HE.

14.2 - Exporting

Exports, on the other hand, cannot have an impact on the EXEC indicators. Indeed, the country's production is already accounted for in the indicators. Including their impact on the export indicators would be tantamount to double counting these productions on the EXEC indicators.

There are, however, two different export scenarii, the first of which concerns exports to another country in a HE. In this case, the export takes place at no additional cost to the exporter (which already pays for the production of the exported products in its indicators). The second case being the export to a country not having a HE. In this framework, the melting of the currency has to take place on the products at the time of the exchange between the two currencies. In addition, waste exports are accounted for in the EXEC indicators.

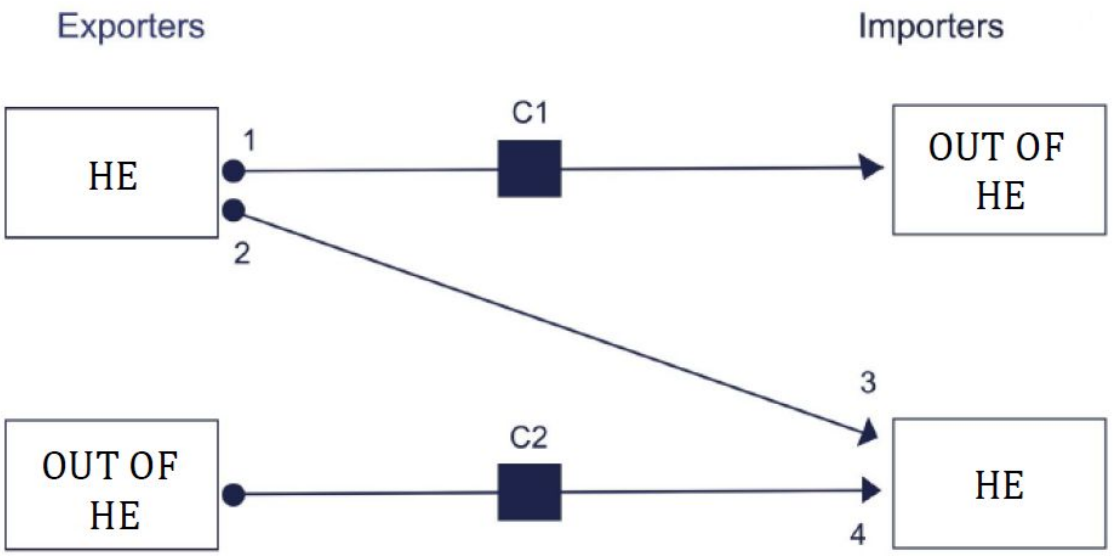

Figure 14. Import-export mechanism, effect on EXEC and currency exchange indicators.

1 - HE exports to non HE. Exchange rate applies (C1), melting applies at time of exchange. EXEC indicators are not impacted, except in the case of waste exports.

2 - HE exports to HE. No exchange rate, melting applies to the exchange. No effect on EXEC indicators (as they are already accounted for at the time of production).

3 - HE imports from HE. No exchange rate, melting applies to the exchange. Only the cost of transport is counted in the EXEC indicators of the importing country.

4 - HE imports from non HE. Exchange rate applies (C2), melting applies at the time of exchange. Effects on EXEC indicators.

15 - Exchange rates

The exchange rate mechanism is not yet clearly established, although the idea of indexing the exchange rate of the new currency to a basket of currencies to be defined seems interesting. This point remains to be developed.

16 - Electronic money

The constraint of melting money prevents the use of fiat money. While it is still technically possible to make payments using banknotes adapted to a melting currency, such as the physiocratic mark[57], digital technologies currently allow us to greatly simplify the system. Indeed, the collection and destruction of melting currency could be a time-consuming exercise on a large scale and would multiply the possibilities for counterfeiting. It could also limit the possibilities of a HE, especially on calculations related to the average melting rate of an economic zone. Therefore, it seems coherent to favour a fully digital currency, which would simplify trade and reduce the risks of counterfeiting. Yet, digital tools are not "dematerialized" , we should thus optimize resources and energy use within the framework of this electronic money.

17 - Common property

In a homeostatic economy, the notion of common goods, of resources, which are rival and non-exclusive, is quite different from our current view of them. Indeed, common goods are now considered from the point of view of management, through two parameters: governance and ownership. According to the work of Elinor Ostrom[58], the commons are organized around the notion of self-management and appropriation, e.g. the people who "manage" these commons are those who use them. The problem is that, at present, private companies or citizens can just as easily exploit common goods without respecting their renewal rates or the populations that use them. Thus common goods need to be regulated by law.

The homeostatic economy, because of the way it works, allows a different arrangement of the management of common goods. Indeed, they are no longer dependent on the notion of ownership or governance. In a HE, the State, businesses and citizens have a common interest in taking care of common goods, since they have a direct impact on them through the dividend

[57]Wära was a local melting currency in circulation in 1931 in Schwanenkirchen, Bavaria. These were banknotes whose reverse side showed its value in the months following its issue.

[58] Elinor Ostrom, *Governing the commons: The evolution of collective action*, 1990.

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they receive each month. Thus, without the need for special governance, legislation or ownership, the preservation of common goods becomes in this framework a *sine qua non* condition for the economic health of all actors. This mechanism of interdependence between the different actors and the common goods allows the emergence of individual and collective co-responsibility for the common goods and those, without legislation, without the need for appropriation, without governance of the common goods.

18 - International Organization (IO)

The optimal functioning of a HE depends on the indicators and their correspondence with the data collected. It is easy to rig the indicators when the country that decides to set up a HE is both the organiser and the controller of its own indicators. For a total reliability of the collected data, it is therefore necessary to consider the establishment of a HE and its monitoring by an independent body outside the State. Since the HE is applicable at the level of a nation, it is preferable to opt for an international organization (IO) that will have the function of enabling the establishment of HE in different countries. In detail, the mission of this organization will be : to set up the infrastructure and the development of skills essential for starting a HE in a country; to collect data for each indicator; to establish scientific standards on the constitution of indicators and the different methodologies for collecting information; to carry out analyses on the reliability of the methods and information collected; and to improve the formulas of the indicators according to new scientific knowledge. The organization will also have a body that will be responsible for certifying and delivering certified dynamic equilibrium projects (CDEPs), monitoring them and validating them once they have been implemented.

The role of an international central bank (ICB) will be to create the currency of each economic zone according to the EXEC indicators and also to create the currency resulting from the second mechanism of monetary creation: the realization of certified dynamic equilibrium projects (CDEP). As a result, States will have to give up their power of monetary creation by joining a HE. **However, the IO will not be able to influence the policy of the Member States**. Thus, each adhering State will keep its regalian powers, apart from that of monetary sovereignty. It is therefore an international organization whose sole objective is to ensure the proper functioning of an economy with a dynamic equilibrium. The establishment of this IO will necessarily have to come from the States interested in this economic system and will require the adhesion of a

certain number of States for the implementation of a HE. These first States interested in this economic system will have to set up the IO by financing the establishment of this organization.

The IO shall be composed of several bodies, some of which are detailed in Annexe 1. However, at the present stage of reflection on the subject, the structuring of the international organization will need to be further developed.

19 - Effects of the homeostatic economy

19.1 - Effects on geopolitics

The homeostatic economy allows us to move away from an economy of exclusive competition towards a model of cooperation between states and competition/cooperation between companies. The fact that the wealth of countries depends entirely on the EXEC indicators and therefore on the management of energy, industrial, agricultural, environmental, and such policies provides the countries with the ability to focus on their own improvements and no longer on the comparison of wealth produced between States. Thanks to this mechanism, competition between States no longer makes sense resulting in an appeased geopolitical climate. Moreover, the IO Charter should encourage mutual assistance among States, so as to make it attractive to small States. In the long run, the more countries join the HE, the more peace in the world could spread.

19.2 - Effects on States

The role of the HE's member states will not change**, apart from the power of money creation** reserved for the ICB. The States will therefore remain free to exercise the political doctrines they wish to undertake, the additional constraints will be those brought about by the indicators and the maintenance of their "good health". In addition, the donation based currency will enable the States to repay their current debts, but also to avoid the vagaries of financial markets and economic crises and to simplify administration. The money-debt system obliges states to levy taxes in order to repay loans. In a HE, a State could, if it wished, put **an end to the systems of taxation,** which would no longer make much sense in a homeostatic economy. This could have

the effect of simplifying the exercise of power in domestic politics by making states emerge without taxes, in other words, what we currently call tax havens. Moreover, the very notion of "tax haven" would no longer make sense in a HE, since there would be little reason to flee a system that does not tax its citizens. **Moreover, no longer constrained by the problem of competition, the States could develop more serenely by focusing on their internal problems and their projects.** So there are multiple advantages for states to adopt the HE, even if there are disadvantages, which remain, as far as we know, relatively minor compared to the advantages. The disadvantages will be described in section 21.2.

19.3 - Effects on businesses

While the changes to be made within companies may seem substantial, they could still be quite advantageous. CDEPs could make it possible to finance projects that today cannot be carried out because they are not profitable. Business research and development could be greatly modified, because CDEPs could support research projects aimed at improving indicators, which would enable companies operating in a HE to make profitable research projects with a positive consequence on exo-economic indicators. This mechanism could also make these **companies more competitive** regarding countries that are not in a HE. Indeed, in the context of fixed-term industrial operations, it would be possible to repair the damage linked to the activity through certified dynamic equilibrium projects (CDEPs) and to derive benefits from them, which is currently impossible. CDEPs could therefore be a significant advantage for invitation to tender in non-HE countries.

The melting of money seems to be a major constraint for companies. However, it is compensated by the absence or reduction of taxes and levies, which actually perform the same role. As products and services may no longer be taxed, businesses could benefit significantly. The effects on large firms could be felt in many ways, for example, financing via the primary market could be achieved via the credit mechanism and via the corporate dividend (ENTD). However, the impact of a HE on large enterprises needs to be further investigated.

19.4 - Effects on private banks

Private banks would no longer have the privilege of issuing currency in HE countries, which implies a major change in their systemic role and internal functioning. However, banks still have control over the credit mechanism (see section 13). They could also play a role in the investment carried out for CDEPs.

Given the melting nature of money, it will not be available for use in financial markets, which could have significant, but not currently measured, consequences for banks. This is an area where further assessment is needed.

19.5 - Effects on investors

The investment will necessarily change in form and nature. Notably, through the impact of melting money on investment strategies, but also through CDEPs that provide a low-risk investment solution by adding value to funds otherwise subject to melting money, in addition to allowing the avoidance of melting money. Loan accounts also make it possible to transform a stock of money into a flow of money (in the form of a monthly annuity), which undergoes less melting over time, thus minimizing the loss caused by melting.

19.6 - Effects on financial markets

The financial markets are certainly the biggest conundrum in the whole picture. In a HE, they are no longer useful. They were created to accelerate the flow of money and allow for greater economic responsiveness. In a homeostatic economy, the acceleration of money flow is one of the advantages of using a melting currency.

Since melting would prevent the accumulation of savings and since companies could finance themselves through the various means offered by the HE, the financial markets would no longer have sufficient reason to exist. Moreover, a problem related to the melting of the currency, generates the fact that it is not desirable to be able to put this currency on these markets. Indeed, if it was possible, this currency would most certainly be massively put on the secondary market in order to avoid its melting, which would be damaging for the CDEPs and the credit

mechanism, which, in turn, would not be able to function properly. This problem necessarily implies imposing a legal or functional impossibility to use this currency on the financial markets.

However, in a HE, the advantages of the melting money renders the mainspring of the primary and secondary markets obsolete. Nevertheless, it is highly likely that the foreign exchange market will still be used in a HE, in its present form or in some other form.

19.7 - Effects on citizens

Citizens benefit in a HE from a dividend depending on the health of the EXEC indicators. This dividend is comparable to an universal income with the difference that it is entirely dependent on the country's indicators. In practice, it would have the same effects as a universal income in addition to providing qualitative information of public interest. Indeed, since this dividend is directly indexed to the EXEC indicators, it allows citizens to know the country's overall situation regarding the environmental status, ecological footprint and consumption of non-renewable resources of the country. When the dividend declines, all citizens can infer that the situation has worsened and can therefore act accordingly without being subject to behavioural incentives. Conversely, if the dividend increases, all citizens of the country know that the overall situation has improved. It is therefore a mechanism that makes it possible to respect the second principle of HE (must allow the exchange and distribution of matter, energy **and information**) because it allows all citizens to obtain the most important information: the general state of the country's indicators.

Moreover, the absence of taxes and levies would allow a significant tax and psychological relief on citizens, the melting of the currency causing a decrease in wealth gaps as well as the disappearance of extreme poverty (thanks to the citizen's dividend CITD), this could contribute to a significant appeasement of social tensions, automatically facilitating the exercise of power at the same time. These first elements, consequences of HE show us that such a system would be relatively advantageous for citizens.

20 - Economic psychology

It is undeniable that the behaviour and economic conduct of the various actors in society are likely to be relatively different from those currently in action. In view of this observation, it would seem relevant to consider further study of this issue through psycho-sociological studies. This is therefore a part to be developed.

21 - Advantages and disadvantages of a homeostatic economy

21.1 - Benefits of a HE

- Allows to build an economy based on quantifiable, real and vital bases for any economy, here called the exo-economy (EXEC).

- Allows a large part of the ecological problems to be solved in a short period of time, through massive investment in profitable Certified Dynamic Equilibrium Projects (CDEP).

- Allows wealth to be built on the basis of the preservation and management of resources and no longer on their exploitation alone.

- Helps to maintain a viable human society in the long term, allows its sustainability and resilience.

- Allows for the abandonment of inter-State competition. As ENEC focuses on the domestic resources of the latter, their wealth is no longer dependent on other economic areas. This consequence could be a tool for pacifying relations between States.

- Allows for a significant reduction or even elimination of taxes in the HE countries.

- Solves the problem of extreme poverty through the monthly dividend given to citizens.

- Reduces the wealth gap between the richest and poorest in society.

- Promotes responsible entrepreneurship. In particular towards projects with an "ecological" focus, via the CDEPs in particular.

- Promotes R&D that reduces our ecological impact and our consumption of resources. Encourages the clean-up or increase of biodiversity by making its operations profitable through the principles of CDEP.

- Allows the relocation of the country's activities. Because imports are attributable to EXEC indicators in the case of trade with non-HE countries.

- Allows all stakeholders to have an overview of the country's ecological situation through the dividend. Indeed, if the dividend increases the following year, it means that the situation has improved overall. If it decreases, it means that the ecological situation of the country is deteriorating.

- States can repay their debts (via part of the State dividend STAD). All other players could also pay off their debts more quickly, via their dividends.

- Firms operating in HE may be more competitive than those operating in non-HE States. The CDEPs would make it possible to set up projects that would not be feasible in a capitalist economy. Moreover, some polluting companies could repair the pollution generated by their activities via the CDEPs.

21.2 - Disadvantages of a HE

- Model with little or no local applicability for testing system operation. HE therefore requires econometric modelling.
- Requires States to give up their monetary sovereignty.
- Requires a restructuring of the banking system.
- Money cannot be put on the financial markets (primary and secondary market).
- Requires infrastructure to collect data for the indicators.
- Low, but not negligible risk of overconsumption. This disadvantage is corrected by the EXEC and CDEP indicators.
- Risk of massive purchases of raw material stocks, artificially raising their prices. Melting on transactions limits the interest of this type of practice. This point can nevertheless be regulated by State legislation.
- Possibility of a race to buy real estate. The font on the transactions limits the interest of this type of practice. This point can be regulated by state legislation.
- Possibility of fiscal expatriation, to non HE countries, to avoid melting. However, the system tends on the other hand to become a "tax haven".
- May pose certain geopolitical problems, particularly with regard to certain non-renewable resources (between countries under HE and countries under capitalist economies).
- May create sudden changes in wealth levels in some countries. In the short time it takes to set up a HE, poor countries would become richer or vice versa in a very short time. After this period of change, the inertia of EXEC indicators will limit abrupt changes,

but could allow for greater economic stability.

22 - Conclusion

Taking into account the historical challenges that humanity must overcome in order to envisage its long-term survival - be it climate change, the massive disappearance of animal species, the over-consumption of resources, the major degradation of our environment or more generally the problems linked to human development - the singular approach proposed by the homeostatic economy proposes an applicable and viable long-term solution to tackle all these challenges.

Therefore, what we must retain from this synthesis lies in the fundamental difference between a capitalist economy, which allows enrichment on the basis of consumption of natural resources, and a HE, which allows enrichment on the basis of preservation of these natural resources. This is a total reversal of our economic precepts. This change of perspective is necessarily anchored on rethinking the system of monetary creation, on taking into account the exo-economy and on the mechanism that allows the profitability of the loss (CDEP).

The homeostatic economy proves to be a complex system, like any economic system, the increasing complexity of our modern societies cannot allow for a simplification of our economies. Moreover, this complexity cannot be thought of by a small group of individuals, as the fields referring to it require a multidisciplinary analysis.

The homeostatic economy shows clear qualities with regard to what we practice today. The ambition of this economic proposal extends to the possibility of a profound societal change that requires reflection, adhesion and appropriation by everyone.

For these reasons and because we believe that pooling the skills and knowledge of each individual could only be beneficial, if not the *sine qua non* condition for success. We hope that other people, more qualified than we are in their fields, will take part in its development.

Some parts are incomplete for the moment and others have simply not been thought through, such as: the integration of international waters, the effects on dues systems, the management of States budgets and many other topics. The idea is to formalize one or more working research

and development groups on the feasibility of such a system. The credibility of the project therefore lies in highlighting and resolving its problems.

Although the question of political feasibility was not raised, it is nevertheless a question for many people, as we have been able to see during our various presentations and interviews. This question deserves an in-depth and strategic analysis that could not be done at the moment, preferring instead to ensure the relevance and solidity of the model. We are therefore proceeding step by step.

Finally, we believe that it is highly unlikely that a capitalist system can achieve a state of equilibrium between human society and its environment. Its exponential growth is in opposition to the physical constraints of planetary resources and biospheric balances. This situation will necessarily create a brake on the continuation of this economic model. However, there are few theoretically viable alternatives for economic systems. Let us then try, as best we can, to build a real alternative.

We thank you for reading it and for your feedback.

Annexes

Annexe 1

A1. Draft of the International Organisation's functioning

A1.1 - Charter of the International Organization (IO)

The charter[59] establishes the roles, functioning, financing, and rules inherent to the IO in order to ensure the smooth functioning of a homeostatic economy (HE) in the countries adhering to this organization. It must allow the protection of the States by the mutual assistance between the signatory countries, the impossibility to attack militarily or economically other adherent countries, the opening of its borders to the organization so that it can collect the data to constitute the indicators and all the information inherent to the good functioning of the IO and the HE.

A1.2 - Steering Committee

The steering committee is a body of the IO whose mission is: to evaluate the setting up of a HE in a territory; to assess whether the country's infrastructure, the quality and quantity of skills needed for its successful implementation are available. It is responsible for setting up a HE on the territory.

A1.3 - Shared Governance

The governance of the IO will be in charge of taking decisions in case of a proposal to modify the charter, a proposal to modify the methods of calculation of the indicators and any other

[59] The charter may not be the best tool for the IO because the countries ratifying it will necessarily have to give up their monetary sovereignty. For some states this will require a change in their constitution. It is very likely that a constitution for the IO will be mandatory. To be discussed with specialists in international and constitutional law.

decision to be taken, necessary for the good functioning and the improvement of the IO and a HE. This governance is shared between the member countries (one country: 1 vote) and the staff working within the IO, up to 50% for the member countries and 50% for the staff[60]. This provision avoids the situation of a blockage by the member countries if the proposals or suggestions from the scientists working within the scientific bodies of the IO go in a direction contrary to the interests of the member countries (data or methods that may overestimate certain phenomena or, on the contrary, underestimate others and give an advantage to the indicators of the member countries to the detriment of the latter's real situation).

Decisions within the governing body shall be made on the basis of voting with acceptance of the new proposal when more than 50% of the assembly agrees with the proposal. To save time on certain deliberations, consensus can be used, it works on the request of opposition to the new proposal, if there is no opposition, the text is adopted. If there is only one opposition, a vote must be taken. Proposals are at the initiative of scientists and States.

A1.4 - International Central Bank (ICB)

The International Central Bank (ICB) is the only banking institution that can issue currency for states adhering to the IO Charter and its monetary policy. The ICB is fully independent, like all IO entities, and must be fully transparent, following the second principle of HE.

The HE therefore requires the adhesion of States wishing to subscribe to this economic model and the abandonment of their monetary sovereignty, and requires the adherent States to abandon their monetary sovereignty The activity of the ICB is exclusively reserved for money creation based on information issued by the data collection and compilation body of each country. It also issues currency from the CDEPs that have been certified and validated by the body dedicated to this mission. Its role is therefore to issue the currency according to the EXEC indicators of each economic zone and to issue the currency created by the certified and completed CDEPs.

[60] Scientists could be drawn by lot to avoid their corruption.

A1.5 - Scientific committee on methodology and observation of indicators

The Scientific Committee on Methodology and Observation of Indicators is working on the analysis and improvement of the indicators according to new scientific data on the different parameters interacting with the EXEC indicators. Firstly, the members of this committee analyse the data collected by the collecting and observation bodies in order to verify the relevance of the information collected in relation to the primary role of the indicators. The second part of their missions consists in establishing a standardization of measurement tools and methods so that all the information collected in different countries follows a similar protocol. This is in order to avoid methodological bias and to guarantee the reliability of the data collected.

A1.6 - Data Collection Departments

The data collection departments, collect data on the spot and directly in each HE member country. Their role is to provide reliable data on the real situation of the countries in order to obtain high precision in the calculation of the indicators. They are composed of several branches to measure: the biodiversity index, the ecological footprint and non-renewable resources. A final branch collects all the data to perform calculations for the indicators. The delay between two data evaluations must be a maximum of one year to obtain a change in the DEI (dynamic equilibrium index) every year and thus an annual revaluation of monetary donations.

A1.7 - CDEP Certification and Monitoring Agency

As certified dynamic equilibrium projects are projects that allow participation in monetary creation, their certification criteria and controls must be managed by a specific body of the IO. This body is in charge of dealing with proposed projects by refusing or accepting their certification. Without certification, a project cannot be labelled "CDEP" and therefore cannot benefit from the reimbursement and capital gains attributed to certified projects. The other mission of this body is to ensure the consistency of investments in relation to the implementation of projects, the auditing of accounts and, finally, the monitoring of the implementation of CDEPs. This body is the only one that can withdraw certifications in the event of fraud.