Introduction to ecological econophysics for degrowth

1 Introduction

This paper synthesizes and updates the ideas given in detail in ref. [1]. As the global environmental limits are becoming apparent, there is increasing interest in radical transformations to move from a growth-dependent economy to a form of *degrowth* that enhances well-being [2]. However, such transformations will encounter formidable difficulties, including vested interests, cultural barriers and technical problems. The paper aims to contribute to a new macroeconomic theory that can address the technical problems posed by degrowth. I argue that, in addition to the insights from ecological economics, this theory will need insights from complexity science, especially from the recently-developed discipline known as *econophysics* [3, 4]. Therefore, it can be labeled as *ecological econophysics*.

2 Why econophysics

Radical alternatives often emphasize rules of interaction between economic agents that are fair in themselves, but there is no guarantee that these rules, when applied simultaneously by a very large number of agents, will give desirable results. Complex systems often display *emergent properties* [5], i.e. macroscopic features that cannot be deduced trivially from microscopic dynamics. Emergent properties are not always predictable, but partial predictions are possible with the help of complexity science. Therefore, this discipline is to become a basic tool for pragmatic utopian thinking.

One of the foremost complexity-based approaches to economic theory is econophysics [3, 4], which can be defined as the application of concepts and tools of statistical physics to economics. However, like mainstream economics, the econophysical literature ignores environmental constraints and is not addressed to changing the economic system. This points to a scientific gap needing an enormous research effort if we are to tackle the major problems of our planet successfully.

Notably, we need sound recipes to avoid these three obstacles to degrowth:

- Removing parts of an economy can trigger uncontrolled recessions.
- Decreasing access to natural resources can cause competition between luxury consumption and basic needs (e.g. biofuel vs. food).

- Any deep rearrangement of a complex system risks causing loss of resilience.

Some reasons why mainstream growth models will not help us are that: (1) by being equilibrium models, they exclude nonequilibrium phenomena such as endogenous recessions, and (2) by focusing on a representative agent, they cannot address distributive issues and exclude emergent properties.

Being based on statistical physics, an econophysical approach is ideal for our goals because economic fluctuations and distribution of resources among agents are best described by statistical distributions, and the job of statistical physics is to link statistical distributions to their underlying mechanisms. Less evidently, it can also contribute a lot to the issue of resilience.

3 Addressing the three obstacles

3.1 Degrowth without major recessions

Economies could respond to resource scarcity, environmental pressures and contractive policies in different ways. Both equilibrium models predicting smooth responses and Meadows-type models predicting collapse ignore granularity and modularity, which imply that the economy could fall part-by-part [1]. Economies regularly lose fragments, in the form of recessions. Recession sizes display a statistical distribution known as *power law* [6], similarly to catastrophic events in many other complex systems, e.g. wildland fires [7]. Forests respond to environmental stress with changes in the parameters of their power-law fire-size distribution [7], and this would be the most parsimonious response in economies too. However, full collapse is also imaginable as a result of certain policies [1].

While, probably, some crises are unavoidable, these could be partially bypassed by giving the economy other mechanisms to rearrange itself toward a configuration and scale that matches the new environmental reality (see some tentative policy measures in ref. [1]).

3.2 Degrowth without exclusion

A decreasing resource availability will have a stronger impact on lower income strata (especially over people affected also by other dimensions of inequality, such as gender inequality within households), which can go as far as to represent deprivation of the minimum needed for life. This can only be avoided if shrinking resources come hand in hand with increasing equality [8].

In this context, again, we find a power law distribution: this function describes part of the income distribution [9]. Power laws emerge frequently in complex systems, which does not mean that they should be universal and unavoidable. Ref. [1] shows how an econophysical model could be used to forecast the income distribution resulting from different policies. This model is not fully realistic, so more research is needed along these lines. Ideally, this could lead us to recipes to obtain equality as an emergent property rather than forcing it by controlling every detail of an economy.

Inequality also has a spatial projection, at multiple scales. It is likely to display a type of pattern known as multifractal [10], which suggests a path towards tentative forecasts of inequality patterns at all spatial scales in scenarios of declining economic output, declining transportation and changing policies.

3.3 Degrowth without loss of resilience

Sections 3.1-3.2 mention power laws and other scale-invariant patterns in key economic variables. These are characteristic of systems *between order and chaos* (BOC) [11]. Complexity science suggests that long-lasting complex systems are necessarily BOC [5]. BOC would be needed for complex information processing and resilience.

This is crucial for the transformations that we are envisaging, seeking to alter, precisely, distributions (of recessions, of income) whose current shape is indicative of BOC. If this is done naively, we risk building a system that, because of its structure, is damned to collapse or to degenerate. For example, it is tempting to think that the Soviet system had a systemic problem of excess order. Fortunately, it might be possible to move from a BOC economic system to a system that is completely different but is also viable and is also BOC, with some previous symptoms of BOC vanishing while other more benign symptoms emerge [1].

There are reasons to think that democracy is itself a BOC mechanism, which increases the hope that we can move from the market-controlled governments of the globalization era to a democratically-controlled economy striving for global sustainability [1].

4 Research strategy

Applying complexity science to economies does not imply that we have to rely on very complex models. We need to apply complex agent-based models to simulate alternative degrowing economies, but they cannot constitute our core strategy.

Statistical physics also has other tools. Most often, only a small fraction of the microscopic information is relevant on macroscopic scales (this is the basis of the well-established concept of *universality classes* [12], and of the new *idiosyncratic theory* [13]). By trying to identify the relevant information, we can perform tentative forecasts without need of complex simulations.

The author is convinced that further theoretical and empirical study along the lines of ecological econophysics is essential to develop sound alternatives for a sustainable, egalitarian, democratic and pleasant society, and invites other scientists to join this research line.

The message of this paper is not, by any means, that alternative policies should mainly be based on hard science. However, hard science has a role to play. Let us hope that it no longer stays behind.

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