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Methodological and Ideological Options

Energy, growth, and evolution: Towards a naturalistic ontology of economics

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ABSTRACT

In recent years new approaches to the integration of economics and thermodynamics have been developed which build on the physics of open non-equilibrium systems, the so-called 'Maximum Entropy Production Principle'. I review these contributions in the light of the implications for economic ontology, i.e. the question what the fundamental constituents of real world economic phenomena are. I argue in favor of the 'naturalization' of economic ontology, using the phenomenon of economic growth as my workhorse, and I explore the implications for the cross-disciplinary foundations of ecological economics. The paper shows how economic growth can be conceived as a 'natural' process that is driven by fundamental physical forces. The argument proceeds in three steps. After a short review of recent research on the linkage between energy and growth, I establish the connection with bioeconomic theories about evolution that allow restating the role of Lotka's Maximum Power Principle (MPP) as a property of open non-equilibrium flow systems with sufficient degrees of freedom of structural adaptation. The MPP is then related to the recent literature on Maximum Entropy Production (MEP), especially as deployed in the Earth Sciences. Economic growth can be seen as resulting from evolutionary adaptations of flow gradients in economic systems that increase throughputs of exergy and generation of work, and which thereby enhance the capacity of the Earth System to maximize entropy production. This framework offers fresh perspectives on a number of issues in research and policy, which I discuss in the conclusion.

> (…) the influence of man, as the most successful species in the competitive struggle, seems to have been to accelerate the circulation of matter through the life cycle, both by "enlarging the wheel," and by causing it to "spin faster." The question was raised whether, in this, man has been unconsciously fulfilling a law of nature, according to which some physical quantity in the system tends toward a maximum.Lotka (1922a: 149)

1. Introduction: Ontology, Disciplinary Boundaries and Ecological Economics

The question whether energy and growth are causally related phenomena has always been one of the core topics in ecological economics. This paper reviews most recent pertinent contributions, concentrating on new insights gained from the growing literature on the 'Maximum Entropy Production' approach in geophysics (with the landmark volume Kleidon and Lorenz, 2005). In putting some hitherto disconnected pieces in this review together, I also propose a new hypothesis about the nature and causes of economic growth. My focus is on methodological and conceptual issues, especially in the context of how economics relates to the other sciences, in particular physics and biology. Thus, this paper is about economic ontology (Mäki, 2001): What are the constituent phenomena of real-world economic processes such as growth? How can they be subsumed under more general categories by which we classify and analyze reality? What do such ontological choices imply for drawing disciplinary boundaries? How does ontology shape our heuristics in finding solutions to real-world problems? I approach ontology in strictly 'naturalistic' terms (Papineau, 2009), thus asking what recent developments in the sciences imply for the ontology of economics and the human sciences (thus following the track laid by Bunge, 1977, 1979).

In ecological economics, ontological issues come to the fore when we consider the dividing lines between the theory of growth, environmental economics and ecological economics (Spash, 2012). Especially in demarcating 'ecological economics', it is important whether and how economics can be integrated with the sciences, in particular physics and biology. This question came up with the seminal contributions by Georgescu-Roegen (1971, 1976) who claimed that thermodynamics must be recognized as an essential element of economic theories of growth and the environment. Although his contributions received a lot of skeptical and critical responses, they also played an important role in triggering the rise of ecological economics as a field of research

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separate from environmental and resource economics. What is the main difference, as established in early syntheses such as Martinez-Alier (1987)?

- Environmental economics treats the environment as a constraint of economic processes and growth in particular, which can be overcome by technological innovation, especially in the sense that technology is a close to perfect substitute for natural resources, energy included. Further, and most importantly, the goal of economic activity is to increase human welfare in terms of economic goods, hence value creation.
- Ecological economics treats the human economy and the natural environment as one integrated system, such that laws and regularities of the natural sciences are included in economic analysis (for example, material flows). Many contributions to ecological economics also question the priority of human goals and instead introduce goals related to the overall sustainability of the ecological system, that is, life on Earth (such as in 'deep ecology' thinking).

If we look at current discussions in ecological economics, these borderlines appear to be blurring, as many empirical contributions tend to use standard tools of environmental economics. This observation points towards the necessity of ontological reflection (Spash, 2013). There is a serious methodological issue here, as is most evident in the recent debates about the economics of climate change. Disturbingly, the standard economic approaches are close to useless and meaningless for giving appropriate guidelines for the design of climate policies (for a corresponding 'mainstream insider' assessment, see Pyndick, 2013). The root of these troubles is the principled arbitrariness of the relationship between variables that catch the physical and biological system properties on the one hand, and variables that reflect economic decisions on the other hand, as far as these are based on the standard notions of utility, choice and value. For example, there is no universally applicable criterion of how to fix the interest rate that is used for discounting future costs and benefits of climate change; thus, estimations of current costs remain indeterminate and fully depend on close to arbitrary choices by the researcher. This dilemma shows that in dealing with climate change, a systematic conceptual integration of economics and the sciences is indispensable. Preparing the ground for this is the task of economic ontology. The core question is whether the parameters of the phenomena covered by the sciences merely define constraints of the economic process and hence only find expression in economic variables such as prices, or whether there are 'natural' causal determinants of the economic process proper which have to be explicitly included into economic theory.

Going back to Georgescu-Roegen, there is one topic that allows developing a coherent ontological argument. This is the question of how energy relates to growth, and whether it is possible to approach growth as a 'natural' phenomenon. Is energy just a constraint of the economic process, or is energy a causal force or even a 'prime mover' in the economic process? Looking at recent contributions, there is a new argument unfolding that I will overview in this paper. The first step (Section 2) is to recognize the central role of energy in driving economic growth. This is by no means a new insight, but remains a disputed issue until today, although there is plenty of empirical evidence in favor of this idea. I will briefly summarize the state of the art, and then will simply take position: Let us assume that the empirical hypothesis is warranted stating that growth of energy throughputs and economic growth are two sides of one coin. What would that imply for economic ontology? This leads to the next step: Why does energy throughput grow? In principle, there are two responses to this question. One is that markets or, capitalism, create an endogenous dynamics by which the demand for energy throughputs is continuously increasing. This was mainly the response of Georgescu-Roegen and, for example, more recently, Binswanger (2013). This would imply that by means of an appropriate intervention into the market mechanisms one could possibly loosen the interdependence between energy and growth. This view still remains in the 'energy as constraint' paradigm; however, it adds the idea that certain economic systems generate the incentives exploiting energy intensively and overcoming the energy constraint by means of technological progress.

I will argue in favor of a much more radical view (following earlier programmatic statements such as Hall et al., 2001). This is that the energy–growth link reflects basic principles of evolution as a biological phenomenon (Section 3). Thus, energy would appear to be an essential causal element in an evolutionary approach to ecological economics. I think that in spite of the seminal contribution by Ayres (1994), energy theorists (and even Ayres himself) have later side-lined the necessity to ground their analysis on evolutionary theory as the necessary link between the economics and the physics of energy. For example, in Kümmel's (2013) magistral synthesis evolution and evolutionary theory are entirely blanked out, and hence biology as a disciplinary bridge between physics and economics; Ayres has concentrated his work on developing the industrial metabolism and material flows framework (Ayres and Ayres, 2002), and in his recent synthesis biology does not play a systematic role (Ayres and Warr, 2009). In contrast, my argument builds on the general ontological supposition that the human economy is a living system, hence an ecological system or integral part of a larger ecosystem, with the special feature of including technological artifacts and their evolution as 'extended phenotype' (Dawkins, 1982).

The idea that growth of energy throughputs is a generic property of evolution was first proposed by Lotka (1922a,b, 1945) in stating what was later labeled as his 'maximum power principle' (building on the earlier contributions of the German energy theorists, in particular Ostwald, for a survey see Martinez-Alier, 1987 and shorter Smil, 2008: 8ff). Although Georgescu-Roegen (1971: 307ff.) received Lotka's concept of 'exosomatic instruments' in interpreting human technology as an adaptive means (which easily fits with Dawkin's notion of 'extended phenotype'), he did not systematically refer to Lotka's theory of biological evolution. I think that this is a major reason why the field of energy and economics is still fragmented into diverse methodological approaches, and why we face troubles in interpreting what is still incomplete empirical evidence. There are certain recent developments in physics, biology and the ecological sciences which allow for restating Lotka's theorem as a principle in economics, too (and which go beyond what has been discussed in the earlier, already rich literature on the subject, surveyed by Buenstorf, 2000). I will briefly sketch the basic reasoning. This requires a creative synthesis, because the debate often manifests deep internal divisions among different schools of thought (such as between 'empower' theorists also claiming Lotka, Odum, 2008, and physicists such as Kümmel). I claim that these divisions can partly be overcome in the more general ontological analysis.

Once this step is done, I can proceed to the final argument (Section 4). If we treat energy as a part of economic ontology and hence as a causal factor, we can view economic growth as a direct manifestation of thermodynamic laws. In his original 'energy as constraint' approach, Georgescu-Roegen applied equilibrium thermodynamics in his argument. Today, we have new concepts for non-equilibrium thermodynamics. These new concepts directly tie up with Lotka's maximum power principle and have been introduced in the climate and Earth sciences recently (Kleidon, 2009). This more general framework is established by the Maximum Entropy Production (MEP) Principle. Then, evolution in general and economic evolution in particular can be approached as phenomena that directly express these more fundamental physical principles. In this view, economic growth is a direct manifestation of the more fundamental thermodynamic causalities. As a result, we achieve an ontological unification of physics, biology and economics.

In a nutshell, economic growth is not just operating under the constraint of the Second Law, but is the manifestation of the Second Law. This change of perspective has many important implications for policy issues of which I discuss a few in concluding the paper (Section 5).