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Analysis

From Lotka's biophysics to Georgescu-Roegen's bioeconomics

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ABSTRACT

Alfred Lotka was one of the founders of modern ecology. This paper explores Lotka's contribution to biophysical economics resulting from the marriage of the three disciplines: biology, physics and economics. Lotka founded the concept of "exosomatic evolution" to characterise the economic activities in their biophysical environment as a continuation of biological processes. Like Vernadsky, he adopted a holistic perspective of planet-system — the biosphere.

Georgescu-Roegen was one of the founders of ecological economics. He explained the entropic nature of evolution and adopted Lotka's "exosomatic evolution" concept in his bioeconomic approach. Georgescu-Roegen had several warnings for economists about the irrevocability of the entropic degradation of matter–energy and the pressure on natural resources that goes hand in hand with economic processes in general.

This article aims at drawing a parallel between Lotka's contribution and Georgescu-Roegen's bioeconomics, by shedding light not only on their similarities, but also on the divergences that testify the novelty of Georgescu-Roegen's approach.

1. Introduction

The aim of this paper is an analytical comparison between the pioneering contributions of Alfred J. Lotka and Nicholas Georgescu-Roegen to ecological economics. I shall argue that the common starting point for these two authors is their interdisciplinary approach relating biology, physics, mathematics and social sciences. Eclecticism and cross-fertilisation between the findings of these various disciplines is a common feature of their respective works. Both authors stress the impossibility of separation or exclusion of these disciplines with respect to their relevance.

A parallel may be drawn between the two authors' biographies. By comparing the biographies of the two scientists, it becomes rapidly evident that even if there was a 26-year difference in their ages, they shared similar patterns. Both authors were naturalized US citizens coming from Eastern Europe: Lotka was born in Lwow, Austria–Hungary, formerly part of Poland, and Georgescu-Roegen came from Constantza, in Romania. They both benefited from an outstanding international education, in Europe and in the US, and shared sound scientific foundations and an interest for statistics. Many commentators have emphasized that perhaps the most salient aspect of their professional carrier is their eclecticism that led them to establish many connections between different fields, like biology, physics, social sciences, humanities, and also different approaches to a single field. They both innovatively combined different biological, mathematical, statistical, physical and economic theories.

Alfred Lotka is a scholar whose name is not very familiar to economists although Grinevald (1990) indicated that Lotka and Vernadsky, the prominent Russian scientist, founder of the biosphere concept (see Vernadsky, 1926), were the sources of Georgescu-Roegen's bioeconomics. According to Grinevald, Lotka and Vernadsky were in contact during the 1920s. They had a common interest in geochemistry and biogeochemical cycles. They both adopted a holistic view of the world, considering it a system — the biosphere. Grinevald stated that Lotka's book published in 1925 and called *Elements of Physical Biology* (reprinted in 1956 under the name of *Principles of Mathematical Biology*) was a scientific source for Georgescu-Roegen's bioeconomic approach. Being a faithful commentator of Georgescu-Roegen, Grinevald established Georgescu-Roegen's indebtedness to Lotka not only for the concept of technology as an *exosomatic instrument*, but also for the basic idea of the *biological foundations of the economy* (Lotka, 1925: 354). Georgescu-Roegen also used the concepts of exosomatic and endosomatic instruments to distinguish between human and social insect societies so as to illuminate the origins of social conflict among humans. Ant phenotypes correspond to their occupations (doorkeepers, soldiers, etc.) but there are no genetically determined castes or occupations for humans (see Gowdy and Mesner, 1998).

Kingsland (1994) later explores Lotka's influence and interest in economic theory, but Georgescu-Roegen is not mentioned in her work. Many commentators (Grinevald, 1990; Martinez-Alier, 1999; Mayumi and Gowdy, 1999; Cleveland, 1999; Bonaiuti, 2011; Missemer, 2013…) acknowledge Lotka's influence on Georgescu-Roegen. However, to my knowledge, all these comments lack any further specification or clarification regarding the content and meaning of the link between

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the two authors' contributions to the field of ecological economics. Georgescu-Roegen himself seems to understate it and his commentators follow suit. Whereas he thoroughly explained his indebtedness to Schumpeter, Georgescu-Roegen only briefly mentions Lotka's name when he presents the exosomatic and endosomatic concepts. Thus at first glance, it may appear that nothing more than an adoption of terms occurred. But what lies behind this legacy? What parts of Lotka's approach are similar to Georgescu-Roegen's bioeconomics? What are their divergences?

This paper attempts to fill this gap by identifying the different positions in Lotka's thinking and by outlining the manner in which they operate in the subsequent reflection of Georgescu-Roegen. I shall develop my argument based on the comparison of selected writings. Lotka's work was well known at Harvard University during the 1930s (see Weintraub, 1991) and Georgescu-Roegen studied with Schumpeter at Harvard from 1934 to 1937.

The paper's argumentation is elaborated on chronological grounds and thus views Georgescu-Roegen's ideas in light of Lotka's. It contributes to the mapping out of a history of ideas running from biophysics to bioeconomics and extending to biophysical economics or ecological economics. Little has been done to explain the role of the Lotka–Georgescu-Roegen connection on the overall development of ecological economics. This paper seeks to contribute to this domain by focusing on the economic consequences of taking into consideration the entropic nature of life, of production and consumption. In the bioeconomic approach, economics is part of a broader scientific perspective dealing with the fate of the human species.

This paper is organised as follows: Section 2 presents Lotka's work and strong interest in the social sciences. Section 3 focuses on selected writings of A.J. Lotka dealing with the energetics of evolution and his biophysical project. In Section 4 Georgescu-Roegen's bioeconomics (1972) and "minimal bioeconomic program" (1978) are described and discussed in light of the law of entropy and its economic consequences. The concluding remarks present our discoveries resulting from close examination of the relationship between these two visions. They also discuss the novelty of Georgescu-Roegen's ideas and the reasons that made him diverge from Lotka's optimistic predictions of the future.

2. A.J. Lotka: Ecology and Social Sciences

The 1920s and 1930s were the "Golden Age" of theoretical ecology (see Scudo, 1984). A.J. Lotka (1880–1949) was one of the five major theorists of ecology, along with Elton, Kostitzin, Teissier and Schmalhausen.

According to Scudo, two main features characterise this "Golden Age". The first was the coming together of scientists who had previously worked in isolation. Their views started to converge in 1926 and 1927. The second feature relates to the theoretical orientation of their common front. They abandoned the prevailing theories that were mostly physiological interpretations like "neo-lamarckism" or "neo-darwinism", thus calling for a reinterpretation of Darwin's theory.

Scudo acknowledged the relationship between the "Golden Age" theories of ecology and the social sciences. Lotka and Volterra were both inspired by Pareto's economic theory. Lotka became involved in economic theory very early (1914) and in this respect was the first to attempt the adoption of mathematical methods used in economics in ecology. His ambition was to develop a mathematically rigorous "economy of nature" (Lotka, 1925: 215 and 277) and thus paved the way to the "age of ecology" (see Worster, 1977). He was familiar with mathematical economics and in his works refer to Cournot, Jevons, Edgeworth, Pareto, and Fisher (Lotka, 1925).

Lotka was an eclectic scientist to say the least. He never held any academic position, and taught as an assistant professor for only a short time. His job as a statistician at the Metropolitan Life Insurance Company (1925) inspired him to become a demographer, and it is mostly in this field that he gained his reputation for his stable population theory. His contributions to ecology cover many areas: analysis of nutrient cycling, population growth, predator–prey interactions, anticipation of ecosystem analysis and the analysis of the evolution of the entire world system.

His interest in natural and social sciences resulted in an interdisciplinary work, a cross-fertilisation between these two research fields. After two decades of labour he published his analysis of biological systems in thermodynamic terms in a book called *Elements of Physical Biology* in 1925. It was an original and unique book, but also "too eclectic to become part of the canon of any field" (Kingsland, 1994: 232). But Kingsland asserts that it had strong repercussions, especially for those readers that were receptive to interdisciplinary thinking:

> "He made people think about things differently, he inspired them, and this stimulating effect created something like a cult following" [(Kingsland, 1994: 232).]

Lotka graduated from the University of Birmingham, where he studied physics under John Henry Poynting. He travelled to Leipzig and there he studied with Friedrich Wilhelm Ostwald, the founder of the energetics school of physical chemistry. When he moved from Europe to the US (in 1902), the influence of Poynting and Ostwald stimulated him to create a new discipline called "physical biology", analogous to physical chemistry:

> "In introducing the term *Physical Biology* the writer would suggest that the term *Biophysics* be employed (as hitherto) to denote that branch of science which treats the physics of individual life processes, as exhibited in the individual organism (e.g., conduction of an impulse along nerve or muscle); and that the term Physical Biology be reserved to denote the broader field of the application of physical principles in the study of life-bearing systems as a whole. Physical biology would, in this terminology, include biophysics as a subordinate province" [(Lotka, 1925: 49fn).]

He compared the world to a giant engine and wanted to demonstrate the unity of man and nature, to show how human activity influences the operation of the "world engine" (Lotka, 1925: 331). By espousing this holistic view of ecology and evolution, Lotka laid the groundwork for an economic theory embedded in the field of physical biology. The industrial system cannot be separated from nature or from the biological and physical principles that govern the whole world. This is not an approach based upon analogy, like the one between, say, the predator–prey model and certain theories of the firm. It is an integrated system of interactions that considers men and machines as biological entities with organs producing and consuming energy and matter. While explaining that biological processes are based upon the principles of thermodynamics, Lotka thought that physical methods are not directly transferable to biology and that biology is more than physics, thus refusing the reductionist view which maintains that physical laws explain all natural processes.

> Georgescu-Roegen shared the vision that biology is not reducible to physics, and states "the present laws of physics and chemistry do not explain life completely. (…) It is also because of the entropic indeterminateness that life does matter in the entropic process" [(Georgescu-Roegen, 1972: 64).]

Kingsland shed light on the influence of Lotka's work on economic theory but omitted Georgescu-Roegen. The economic profession was avid for metaphors and analogies from physics and biology at that time (see Mirowski, 1994). Kingsland discussed Lotka's influence on Henry Schultz, on Herbert Simon and Paul Samuelson. A neoclassical economist, teaching at the Chicago University, Henry Schultz was an admirer of Lotka's book on physical biology. He communicated his passion to his students: one of them was Herbert Simon, who read Lotka's book in 1936. Simon reviewed the 2nd edition of the book in 1959 and made it an inescapable reference for students of economics. He characterised