Reconciling Schumpeter and Georgescu-Roegen
- Entropy in a Schumpeterian Model of Growth -

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Abstract

In this paper we try to incorporate Georgescu-Roegen's concept of bioeconomics into a Schumpeterian endogenous growth model. Georgescu-Roegen believes that the production process irrevocably degrades the terrestrial low-entropy resources (energy and matter). Its mode of operation translates as a deficit in entropic terms [Georgescu-Roegen, 1971, P. 279]. Economic activity therefore is by nature basically entropic. One of the fundamental conclusions that derive from the entropic nature of production is the rejection of growth on the basis that it does not comply with physical constraints (Miernyk, 1999). Taking up on this concept, the objective of our paper is to analyse whether the degradation of energy and matter ultimately must cease any growth process in the long run, or, whether it might be mitigated through Schumpetarian innovations in the direction of enhanced resource efficiency.

In his major work Georgescu-Roegen has provided a concept for introducing the entropy law into economic analysis as well as for uncovering the irreversible nature of the transformation of energy and matter (1971). In simplified terms, the process of production draws on high quality mineral and energy resources - with low entropy - and transforms them into products. But this movement occurs simultaneously with the disposal of valueless - high-entropy - wastes into the environment.

More specifically, two categories of elements contribute to production: funds and flows. These two concepts are fundamental. The role of funds is to transform flows that pass through the process. This category is made up of elements such as capital, land and labour. Such elements have a dual quality: they offer services that are limited in time and they are both inputs and outputs (expressed in physical units). Alongside these funds, flows enter and exit the process of production. These are elements whose quality can vary over time and which cannot be both inputs and outputs. Implicit in this approach is the complementarity between funds and flows.

Further, the concept of "irreversibility" is fundamental to the analysis of any economic process because it implies considering the qualitative change of elements that contribute to production. The act of production is therefore inherently dialectical. Thus, the qualitative change of any production process at one time can be measured by the entropy variable, which, from a physical perspective, can be assessed by the waste flow rejected into the environment.

To capture these ideas in a formal way, we use an endogenous growth model in which we incorporate the circulation of matter under the material balance constraint including a recycling option. Moreover, we assume that the transformation of natural resources must obey the entropy law in Georgescu-Roegen's sense. In particular, we consider an economy which is producing a general purpose good from capital, nonrenewable natural resources, and recycled intermediates. The material content of final production ends up as degraded wastes which subsequently may be recycled or simply dumped into the environment. Dumping of course is harmful to the environment. Recycled wastes then may be reused in production as secondary

material to substitute for natural resources just like renewable resources may substitute for nonrenewable ones. Material balance gets respected such that generated wastes must reflect that amount of natural resources which previously had been extracted from the environment. As well, the entropy law is met in the sense that degraded matter cannot be directly reused in production without undergoing a recycling process for which additional inputs like energy and natural resources are necessary.

The remaining part of the model primarily draws from the Schumpetarian Approach to Endogenous Growth which basically goes back to Aghion-Howitt (1992, 2009). What lies at the heart of the "Schumpeterian" conception of evolution is the notion of discontinuity and its materialization in the economy in the form of new combinations. Technical progress is eminently revolutionary. The emergence of new combinations at the instigation of the entrepreneur is crucial. These innovations, when applied to the sphere of production, drive economic evolution. In the Aghion-Howitt approach Schumpeter's idea of creative destruction is (maybe insufficiently) reflected in the obsoleteness of old designs which by a conditioned random walk are replaced by new ones. In our model technical progress specifically takes the form of "green" innovations.

As a main result, we find support of Georgescu-Roegen's hypothesis that growth cannot be sustained in the long run, if natural resources are considered essential to production and the dematerialization of production is not a preferred option. The reason simply is that recycling under the entropy law cannot overcome the finiteness of natural resource stocks which equally are the ultimate source of the recycling option. However, it can be shown that recycling of matter under material balance and physical constraints may nevertheless enhance the evolution of the economy by increasing the growth rates of production and consumption over time compared to a frame in which the recycling option is not available.

Literature

Aghion P., Howitt P. (1992), *A Model of Growth through Creative Destruction*, Econometrica, 60, p. 323-351.

Aghion P., Howitt P. (2009), *The Economics of Growth*, Cambridge (Mass.), MIT Press.

Georgescu-Roegen N. (1971),*The entropy law and the economic process*. Cambridge, Mass., Harvard University Press.

Alcouffe, A., Ferrari, S., Hanusch, H. (2004), *"Marx, Schumpeter and Georgescu Roegen: three conceptions of evolution of economic systems?"* Note Lirhe, 385 (04-1).

Alcouffe, A., Kuhn, T (2004), *Schumpeterian endogenous growth theory and evolutionary economics*, in: Journal of Evolutionary Economics, 14 (2), 223-236.

Mierynyk, W. H. (1999*), 'Economic growth theory and the Georgescu-Roegen paradigm'*, in K. Mayumi and J. Gowdy (eds*), Bioeconomics and Sustainability: Essays in Honor of Nicholas Georgescu-Roegen*, Cheltenham: Edward Elgar, 69–81.

Schumpeter, J. A. (1912), (1934): *The Theory of Economic Development*, Oxford, Galaxy Books.

Setterfield, M. (ed.), (2010), *Handbook of Alternative Theories of Economic Growth*, Cheltenham, Edward Elgar