SUSTENABILITY FROM THE MANKIND - NATURE ENTROPIC EXCHANGE PERSPECTIVE

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Abstract:
The paper refers to elements which are the arguments for a sustainable development of the economic process, a process that defines the economic system, which is closely linked with its environment.
The proposed objectives are:
- *Highlighting the need to address the economic system in an entropic perspective for understanding the impact of economic activities on the environment;*
- *Building an argument to support the approach of the economic system from the perspective of sustainable development.*

It is a qualitative research approach, a deductive one, whose starting point is the theories developed by Georgescu-Roegen.

Key Words: *economic process, entropy, entropic exchange, sustainability*

JEL classification: Q01, Q56

Introduction

Since the 70s, concerns for sustainability have come among researchers in economics, having as starting point the classical economic theory that considers the economic process as a closed system in which inputs are transformed into outputs, this process being creator of value. Georgescu-Roegen has assumed that it is not taken into account the environment in these approaches, from which are extracted sources considered inputs in the economic process. Applying to economics the principles of thermodynamics from physics, it results that the scarce resources of the planet will disappear, because sources with low entropy are consumed and transformed into high entropy, leading to the deterioration of the environment, and even total destruction on long-term. For people it is therefore necessary to find solutions that would stop this phenomenon and the idea of sustainability in human activity envisages precisely this goal.

Entropy is a term firstly used by the German scientist Rudolf Clausius (the 9th century), to describe the measurement of energy that can not be converted into mechanical work. However, the involved principle was identified by the physicist Sadi Carnot, in 1827, who studied how steam engines work. At any time when energy passes from a high to a lower level of concentration, less energy remains available for mechanical work. Clausius summarized the second law of thermodynamics as follows: in the world (in the universe), as in a closed system, the entropy (the unavailable energy quantity) always tends towards a maximum value. The concept was extended to all systems, including the economic one, due to its qualitative nature. Moreover, entropy became a process by which the economic process might be defined and distinguished from other types of processes.

I. Mankind-nature entropic exchange as subject that distinguishes the economic process by the non-economic one

I. 1. Human Action: economic and non-economic action

The literature presents different views on the possibility to clearly delineate the economic actions of the non-economic ones. The classic materialism supports this idea, while the modern economy, backer of subjective interpretation of value, requires the meaninglessness of this approach. From methodological considerations, but also epistemological ones, the second type of answer can not be satisfactory for the economists. The economy, like any other field of research, must have its domain well defined. That is why specialists with concerns in the field of fundamental research have already provided guidelines on the definition of economics and of the economic action.

Thus, *the economics*, which exists only through human action, involves simultaneously: the ontological (the existential), the selection, the order and the entropic exchange between man and nature (Dinga, 2009). Analyzing these elements we can easily notice that the first three also characterize other areas of social sciences domain, while adding the last condition it is reached the social identification of *species* from *the social genus*, the one of the *economics*.

Therefore, the mankind-nature entropic exchange defines the necessary condition that makes the distinction between *economic* and *non-economic*.

I.2. The concept of entropy in economy

The entropy, as a thermodynamic measure that describes any physical-chemical system, characterizes the energy degradation, thereby understanding all forms of energy conversion into heat, until it is reached the equalization of absolute temperatures of that system's bodies.

The observations from the thermodynamic field, based on the Carnot's conclusion (heat always moves itself from warmer bodies to cooler ones), have concluded that all known forms of energy moved spontaneously, in a one-way, from the higher potential to the lower one. It was therefore defined the law referring to the qualitative nature of phenomena, *the entropy law* or *the second principle of thermodynamics.*

The further reasoning was that the material universe was subject to a permanent qualitative degradation, leading to theory of the heat death of the universe (in which all energy was unavailable).

The concept of entropy was extended to all systems' levels, including the economic ones, because the law of entropy is the only law that describes the evolution, and the economic process is an evolutive one, which involves qualitative change. Thus, in economy, it is considered that the lower entropy, the more available energy a system has (free energy, which can be "accessed"). Developments with high scientific value on this subject, in economics, have been made by the great thinker Nicholas Georgescu-Roegen.

The main purpose of the economic activity is the self-preservation of the human species, and it can only be achieved through low entropy. Consuming low entropy from the environment, the economic system reduces its entropy, but this takes place along with the increase of the entropy in the system's environment. Moreover, a certain quantity of low entropy can be used only once, and by production (which involves the sorting activity, produced by man) the total entropy of the system increases with a higher quantity than the one which would result from the automatic, natural mixture, without any productive activity (Georgescu-Roegen, 2009; Dinga, 2009). Considering the fact that *the quantity of low entropy in the environment decreases continuously and irrevocably* and *the economic process consists of a continuous transformation of low entropy into high entropy, that is unrecoverable waste (pollution)*[1] (Georgescu-Roegen, 2009), it is clear for us the necessity of the link between the entropy and the economy, in general, and between the entropy and the bio-economy, in particular.

[1] In this regard, the example offered by Georgescu-Roegen (2009) is the one of a piece of coal that is converted through combustion into heat and ash. Or, the ash is an unrecoverable residue (we can not restore the piece of coal).

We have mentioned above, that the *mankind-nature entropic exchange* is the predicate to distinguish between economic action and other types of human actions. The development of the ideas of entropy allows us to specify what it is meant by this exchange. It's about exchanging substance, energy and / or information whose effect consists in transformation of the available energy into an unavailable one (by consuming the low entropy, it leads to the reverse of the entropy - decrease in the economic system, acceleration in the system's environment[2]).

Therefore, the relationship between entropy and economy (economic system / process) is revealed on two aspects: 1. by contributing to the definition of what the economic action means, 2. by the ability of the entropy law to explain the economic process and its effects, in a systemic perspective.

II. Entropic perspective on consequences of the economic process on ecosystem

According to the same thinker, *the production represents a deficit of entropy – it increases the total entropy with a higher quantity than the one which would result from an automatic mixing, without any productive activity. Only in the consumption itself a deficit of entropy does not exist in this respect.*

The action of sorting, specific to the economic system, implies, in turn, supplying with low entropy, in addition to what uses the system, to maintain the steady state. The effect? Producing more and more waste. Even in the recycling activity, the economic system must be "injected" with more low entropy, which speeds the increase of the environmental entropy.

In short, the law of entropy transmits the following consequences of the economic activity (Georgescu-Roegen, 2009; Zefferino, 2011):
- The matter is subject of irrevocable and irreversible degradation;
- From the entropic point of view, the cost for each activity is always higher than the result;
- Low entropy from the environment can be used only once;
- Low entropy of the Earth is a finite sum;
- Sorting contributes to the increase of the amount of waste.

Increasing the economic development leads to increased resource consumption. The standard economic representation of production highlights an ecological conflict, as to that matter is subject to an irrevocable dissipation. The production is similar to a continuous entropic degradation of natural and energetic resources, of nature and human capital (Abbas, 2011). Consequently, the irreversible exhaustion of usable resources and also the pollution that accompanies production compromise the ecosystem balance. Rationality based on optimality does not prove to be a solution, generating actually this situation in which the rhythm of exploitation of resources, much higher than the one of the population growth, has created the identified problems.

Moral implications apparition (fair distribution of resources – *inter-generational* and *intra-generational* equity, environmental protection) raises cognitive, methodological, technological problems, which can be solved by mankind throughout low entropy consumption.

III. Conceptual aspects of sustainable development

In a critical study on the law of entropy the following types of rationality are presented, beside the conclusion that the entropic model of the economic process suggests the sustainability paradigm (Dinga, 2009, pp. 422-424):

- *Local conservation rationality* (rationality of first degree) - involves stopping the growth of entropy of the stationary economic system, at the cost of consumption of low entropy from the system's environment;

[2] V. Dinga, 2009, pp. 422-423;

- *Total optimization rationality* (rationality of second degree) - involves the injection of additional low entropy from the system's environment, in comparison with maintaining a steady state situation, following the request of reaching the extreme of the objective-function, that leads to an accelerated growth of entropy that belongs to the system's environment;

- *Local sustainability rationality* (rationality of third degree) - has as principle "minimizing the total growth of entropy, i.e. minimizing the sum between the increase of entropy in dissipative structures and the increase of entropy in the environment of these dissipative structures" (ibid.).

But what we mean by sustainable development?

The sustainability term is very often confused with durability[3]. We are not interested here to make an inventory of different opinions and differences, but only to make a clarification under a theoretical aspect. That is why we focus on another study of the author cited above, that clarifies, rigorously and relevantly, in our opinion, this difference.

Thus, *durable development* means "that ethic-economic rationality which ensures preservation of existential conditions of human society, on an indefinite time horizon, at the level of the whole natural and social space, accessible or possibly accessible in the future" (Dinga, 2009, p. 42). *Sustainable development* is defined as "that characteristic of a process (a phenomenon, a system) that maintains it on the desirable path, on a preset or acceptable "band", on an indefinite time period and on a global accessibility space" (ibid., p. 46). For a better understanding of the conceptual distinction we further present the details of the author:

- Maintaining the desirable path should not be done by itself, but it involves decisions, actions in this scope;

- Maintaining in a preset "band" implies that this concept does not involve "stationarity", but increases / decreases in acceptable margins;

- It requires consideration of the environment in which the economic process is developed, due to the presented entropic reasons.

IV. The economic process and sustainable development

The economic process is closely linked to its environment. Ensuring the environmental sustainability where is developing the economic process leads to its sustainability. Does this verity simplify the finding and implementation of ensuring measures of the economic process' sustainability?

Which are the possible solutions? On this question, answers are often far from reality. Even the bio-economic program suggested by Roegen, who recommends the consumption's decrease of resources, matter and energy, by not producing weapons and luxury goods or population's decrease to a level at which food can be ensured only through organic farming, may be classified as utopian (Georgescu-Roegen, 2009; Lostun, 2011). However, solutions are suggested.

An important issue raised by the work of Georgescu-Roegen, for example, is related to technological innovation, namely the need to find new ways to reduce the proportion of waste in the economic process. A critical point of the matter is considered achieved when existing technologies must be adjusted to meet both the growing demand for energy in conditions of reducing the base of energy, and the solution of the problem caused by the increased environmental entropy. It should meet, therefore, the need for adaptation of existing technologies to the attempts which aim at developing innovative

[3] In economics, confusions also occur when reference is made to the social responsibility of organizations

technologies. In some metallurgical and steel industry in the U.S.A, 20% of the total investment would be spent on pollution control equipment.

One of the sources of low entropy is sunlight. Researchers have shown that it is possible to substitute the global entropy from commercial sources with solar energy that can be captured using modern technologies in the areas of desert; that would be converted into electricity with zero entropy, efficiency reaching 10%. A range of 500-500 km^2 in the Sahara Desert can therefore replace all the used energy, causing a small quantity of entropy (Kaberger and Mansson, 2011, p. 176). Transforming hydrogen and methanol into the energy required by the means of transport is also an alternative to environmental problems caused by the fuels currently used in this purpose. Other solutions are related to wind energy, recycling waste, hydropower and various solar technologies for heating.

As shown by some researchers, metals, traditionally extracted from mines in a higher concentration, could be extracted from soil, biomass or sea water. In this regard cadmium is an example, which can be obtained on Salix plantations from contaminated sites, using solar energy to extract that metal from the soil (Kaberger and Mansson, 2011, p. 176).

In agriculture, we can not valorise the solar energy reserve in our pace, at any time. The proposed solutions to this problem are reflected in the development of organic farming, but they are subject to intense debate. Georgescu-Roegen shows that in agriculture the situation is worse than in the industry, in terms of how the planet's resources are used, especially from the perspective of population growth, which requires more increased food sources, emphasizing the harmful effects of the pesticides on the soil's regeneration capacity. Reducing the harmful effects on agricultural lands and developing a sustainable agriculture must take into account, from the perspective of the entropy theory developed by Georgescu-Roegen, the use of solar energy sources for production of agricultural goods and of new fertilizers, un-polluting ones.

The research developed by Georgescu-Roegen has aroused earnest disputes in the economic environment, many theorists arguing or its apocalyptic position, one of the main exponents being the ecological economist Daily, or showing that physical laws can not be applied in economy or they have been interpreted erroneously (Krysiak, 2006).

Conclusions

Georgescu Roegen criticises the classic economic theory, which presents the economic process as a circular and closed one, which does not consider explicitly the matter-energy flow and the physical environment from which materials are taken as inputs and the effects it has on the environment. As a result, he explains, from the physical point of view, the economic process converts valuable natural resources (with low entropy) into waste (high entropy). The qualitative difference between the inputs in the economic process and the outputs confirms that nature plays, at its turn, an important role in the economic process and in creating value (Georgescu-Roegen, in Hussen, 2004, p 256). Because production increases the entropy and the energy is limited, measures are necessary to be taken in order to reduce the environmental impacts, the proposals in this respect regarding innovation (creating technologies to decrease residues) and stopping population growth; all that will limit the changes that lead to the depletion of the environmental resources.

The research developed by Georgescu-Roegen has aroused earnest disputes in the economic environment, many theorists arguing or its apocalyptic position, one of the main exponents being the ecological economist Daily, or showing that physical laws can not be applied in economy or they have been interpreted erroneously. Krysiak shows that, in a static sense, these laws of physics imply that the economic activity depends on natural resources and the environment's ability to absorb generated emissions. In the dynamic sense, the production with zero entropy is possible only with a higher consumption of resources. According to the developed model, "even with the possibility of human or physical capital accumulation, a larger production of a product with marginal entropy that does not lead to energy loss must always use more resources" (Krysiak, 2006, p 190) .

Kaberger and Mansson bring arguments explaining that not all changes resulting from the economic process are likely to increase entropy, and the limits of Georgescu-Roegen's theory are conceivable, especially because of the period when it had been developed, the 70's, when some technologies had just loomed. But in present, technology has evolved, being able to undertake the pressure that people exert on the level of energy from the environment: using sunlight for producing energy, using hydrogen and methanol needed to transportation, extracting minerals from soil, organic farming. All these are viable alternatives that will contribute to a sustainable economic growth, so that future generations can access the resources of the planet.

Acknowledges

This work was supported by the project "Post-Doctoral Studies in Economics: training program for elite researchers - SPODE" co-funded from the European Social Fund through the Development of Human Resources Operational Programme 2007-2013, contract no. POSDRU/89/1.5/S/61755.

BIBLIOGRAPHY

1. Abbas, M. (2011), *Le politique économique du changement climatique*, http://halshs.archives-ouvertes.fr/docs/00/60/17/01/PDF/MA_RI89_2011.pdf, accessed in March 2012;
2. Dinga, E. (2009), *Studii de economie. Contribuţii de analiză logică, epistemologică şi metodologică*, Editura Economică, Bucureşti;
3. Georgescu-Roegen, N. (2009), *Legea entropiei și procesul economic*, Editura Expert, București;
4. Hussen, A. (2004), *Principels of Environmental Economics, Second Edition*, Taylor & Francis Group, New York;
5. Kaberger, T., Mansson, B. (2011), *Analysis Entropy and economic processes — physics perspectives,* în *Ecological Economics* 36 (2001), pp. 165-179, Editura Elsevier, http://elmu.umm.ac.id/file.php/1/jurnal/E/Ecological%20Economics/Vol36.Issue1.Jan 2001/1146.pdf, accessed in March 2012;
6. Krysiak, F. C. (2006), *Entropy, limits to growth, and the prospects for weak sustainability, in* Ecological Economics 58, pp.182–191, Editura Elsevier, http://www.econbiz.de/archiv1/2009/99949_entropy_growth_sustainability.pdf, accessed in March 2012;
7. Lostun, A.M., 2011, *An entropic perspective on economic crises*, MPRA Paper No. 33584, http://mpra.ub.uni-muenchen.de/33584/1/MPRA _paper_33584.pdf;
8. Zefferino, L., *Economia e entropia*, http://www.alvec.it/TemplatesV2/articolo. asp?IDArticolo=412, accessed in February 2012