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GLOBAL SCENARIO OF THE WORLD ECONOMIC DEVELOPMENT IN THE CONTEXT OF THE THEORY OF ENTROPY OSCILLATIONS

Abstract

The paper analyzes the main trends of evolution of the global economic system and its interaction with the natural system. It is stated that sci-tech progress breaks new grounds for replacement of non-regenerative natural resources by other types of sources, introducing new environmentally friendly technologies and thus avoiding the transition into the phase of entropic oscillating cycle.

Key words:

Global economic system, entropy oscillating cycle, vertical integration, destructive processes, the processes of self-organization.

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Problem Statement. The forecast aspect of the global economic system evolution is one of the most important as far as its study determines under which laws the global economy will evolve. Quasi-stationary linear or spiral -wise development, a cascade of bifurcation transformations, oscillation of steady and unsteady states of transformation, which are similar to phase transitions in physics, these are the modes enabling the evolution of the global economic system and civilization in future.

Analysis of recent research and publications. In recent decades the economic synergy or physical economy, the theoretical basis of which is based on the methodology and mathematical models of the exact and natural sciences, especially physics has been intensely developing as a separate field of economics. However, as Russian researchers D. Chernavskii, N. Starkov, and A. Shcherbakov rightly pointed, the «natural (physical) economics» as an integrated science has not yet been created. Nevertheless, through the efforts of the named above scientists and of some other foreign experts, mainly Russian, this direction of economic science is now rapidly developing. Among the Ukrainian specialists working in this line, it is worth noting the following: L. Lysko, W. Reshetylo, V Soloviov, O. Shevchuk, V Vahurin, V Derbentsev, S. Dorohuntsov, A. Ralchuk and others.

Selecting unsolved aspects of the problem. However, the majority of economists are still working at traditional approaches which make the basis of «orthodox economics» (terminology used by R. Nelson, S. Winter). In our opinion, this was not accidental. The ambiguity of the situation with the application of synergy in the study of economic processes and phenomena is in the fact that the vast majority of publications devoted to this problem, use the synergy formally and descriptive. In the worst case, the terms of synergy and other sciences are used as a tribute to fashion, without actually synergetic methodology to explain the essence of phenomena and processes occurring in socio-economic systems. And this often happens even in the case when applying of synergetic approach is incorrect.

The object of the paper is to study the global scenario of the world economic development in the context of the theory of entropy fluctuations

The main results of the study. In general, with respect to the global economy there arises a dual situation. National economies become more open, due to the globalization of the world economy. It is just the open systems that are enabling for self-organization, and that occurs mainly due or as a result of transition to a state of high entropy and further cooperative actions of agents, or due to the principle of self-assembly. However, both types of self-organization include the openness of the system. The processes of self-organization observed in some processes of the global economy and its components implying national economies corroborate the fact of their openness. Hence, the global economy is an economic system of the highest level. The question arises: is it open?

This is important because the open systems pertain the criteria that determine the sign of entropy change in the open system. They enable to define certain conditions whose implementation in the system will generate the processes of self-improvement and self-organization, and in case of failure will cause the processes of disorganization [1, 2]. This question is fundamental because it determines which mode of development (improvement or random sequence of states) will determine the further evolution of the global economic system. For a closed system the entropy is known as not enabling to decrease (the second principle of thermodynamics), which means that the system can evolve specifically in the mode of disarrangement (or at least using the degree of organization which does not increase). In other words, if the system is closed, then sooner or later it is inevitable to encounter the processes of disorganization.

If $S(X)$ is viewed as the entropy of equilibrium closed (isolated) system, its release meets the situation of creating additional conditions. Then $S(X \mid Y)$ entropy of a stationary state after release (the system is unlocked), which resulted in the changes described by additional variable of Y that occurred in the system. It is known that the entropy of the system after release can not exceed the entropy of the closed system [3]

$$S(X) > S(X \mid Y). \qquad (1)$$

We will consider how this is connected with the global economy. For this purpose we will introduce the notion of entrostat. The latter is implied as a larger system that interacts with the studied system in which the velocity rate of parameters change and characteristics of elements is much lower than the velocity rate of parameters change and characteristics of the studied system.

For better understanding of the term of entrostat it is worth using the following considerations. Assume that the system 1 which is studied, interacts with the system 2, they both constitute a completely closed system. Under the law of entropy increase, the overall system remains in equilibrium if the change of entropy in the studied system ΔS_1 is equal to the entropy change of the second system ΔS_2 with the opposite sign.

This gives reason to get two *basic rules for controlling the order* in the system ([2]. These rules were called «the first method to control the laws of entropy»).

1. To increase the order of the system there should be increased the degree of its openness. Then the new value will meet a new, higher critical level of organization. As a result the processes of self-improvement will prevail in the system, increasing its organization to a new critical level.

2. To reduce the order of the system (reduction of organization) there should be reduced the degree of openness. This will decrease the critical level, resulting in the predominance of processes that disarrange the system to a new value of β.

Thus, in the professional literature the examples are provided where in the states where the border crossing regime is stiffening (the degree of openness decreases), the destructive processes occur in the economy, culture and other areas that are subject to restrictions as for the exchange with the external environment. Conversely, weakening the border crossing regime (increasing of openness) is accompanied by intensification of organization processes [5].

With the change in the degree of the system openness the latter leaves its previous stationary status and due to certain processes is evolving to new stages. However, with the achievement of a new steady state in the system there could arise entropy fluctuations

However, with the system achievement of a new steady state, the entropy fluctuations could occur in it . We use I.Pryhozhin theorem of minimum entropy production, according to which the increase of entropy of the system being close to its steady state occurs in accordance with the condition of [6]

$$\frac{\partial P}{\partial t} \le 0, \qquad (2)$$

where $P = \dfrac{\partial S}{\partial t}$ is the entropy production in the system; equal to zero corresponds to the steady state.

The condition reflects the fact that the processes taking place under increasing of entropy ($dS > 0$), the extremum of the function P corresponds to the minimum of entropy.

However, it is good to pay attention to an important fact: in the systems that interact with entrostat, the entropy production may be negative, i. e. the extremum of P function may correspond to maximum of entropy. Indeed, as it follows from the criteria the *entropy change in the open system (which interacts with entrostat*) the increase of the system openness rate transits it into a new steady state with lower entropy: $S_{\beta_1} < S_{\beta_0}$, if $\beta_1 > \beta_0$. .

Therefore, this transition is accompanied by a decrease in the entropy of the system ($\Delta S < 0$). In this case the entropy production P is negative and in the condition of the expression **(**2) the sign changes. Also, there could be the opposite situation: reducing the degree of openness leads to an increase in entropy of the new steady state: $S_{\beta_1} > S_{\beta_0}$, if $\beta_1 < \beta_0$, when $\Delta S > 0$, , P – positive value and in the condition of expression (2) the sign is preserved.

We will write the inequality (2) as an equation, adding certain functions of *F*(*P*, *S*):

$$\frac{\partial P}{\partial t} + F(P,S) = 0. \tag{3}$$

The same restrictions are applied to equation (3) as to Pryhozhin theorem. In particular, it is done in linear processes. The latter allows ignoring all but linear summands, in case of function *F* decomposition within the steady state. As a result, equation (3) takes the form of

$$\frac{\partial^2 S}{\partial t^2} + \alpha \frac{\partial S}{\partial t} + \mu S = \mu S_\beta, \tag{4}$$

where $\alpha = \left(\partial F / \partial P\right)_{P_\beta}$; $\mu = \left(\partial F / \partial S\right)_{S_\beta}$ partial derivatives of function *F* in a state characterized by some degree of openness of the system β.

If $\mu < 0$, the equation (4) has only unstable stationary solutions. If $0 < \mu < \frac{\alpha^2}{4}$, the solution of this equation is stable and aperiodic.

If $\mu > \frac{\alpha^2}{4}$, stationary solutions of this equation means the stable oscillations around S_β (or it is similar to ΔS_β).

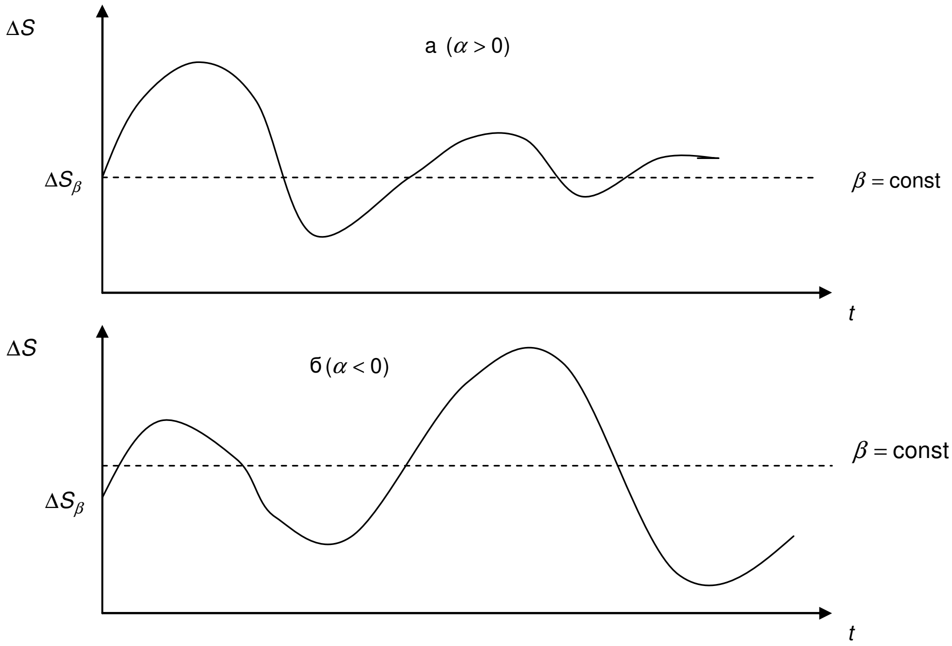
If $\alpha > 0$, the entropy fluctuations decay (Fig. 1a). When $\alpha < 0$, the amplitude of oscillation increases with time (Fig. 1b).

From the view of synergetics the cause for entropy oscillation onset is associated with the fundamental principle that the velocity of any interaction is finite. In this case, it is implied that the processes of self-organization and disorganization balance each other only at a critical level of the system. If the level of the system organization is lower or higher than the critical one, then it will “strive» to reach this level, that is, through various feedback mechanisms the processes of self-organization or disorganization will prevail. Having reached a critical level, the prevalence of processes of this or that kind will not be able to stop instantly.

Thus, the level of transparency and organization of the studied system is very important for the mode of its evolution. These characteristics are interrelated. Each system interacting with the external environment has a special level of organization, called critical.

Figure 2

Entropy oscillations within the steady state characterized by openness *β*



Source: developed by the author according to [4]

To characterize the degree of openness of the global economy (from the perspective of its relationship with natural environment) it is good to take advantage of the openness (influence) coefficient, which is defined as:

$$k = \frac{n_{us}}{N}, \quad (5)$$

where k – is a coefficient of the world economic relationship with natural environment; n_{us} – a number of elements of the environment, the global economic system interacts with; N – a number of elements of the environment, the global economy could potentially interact with.

For each element of natural environment, which interacts with the global economic system, we introduce the intensity of its use (impact)

$$I_m = \frac{V_m}{V_m^*}, \quad (6)$$

where I_m is – the intensity of the *m* natural environmental element use;

V_m – the volume of the *m*-natural environment element used in global economy;

V_m^* – the maximum possible volume of the *m*-natural environment element to be used in global economy

Then the degree of openness (influence) of the world economy on natural environment *P* is defined as bi-parametric dependence of $P(K,\{I_1,...I_{n_{us}}\})$. That is, the P index depends on the number of natural environment elements used in the world economic system, and on the intensity of their use.

Interaction means the use of certain elements of the environment in economic activity. In this sense, the more these elements are used, the more dependent on the environment becomes the world economy. After all, in case of these items shortage either their transition to a new state, the «normal» development of the global economy is impossible. On the other hand, using the elements of nature is nothing else but the influence of the global economic system on the environment. Added to this is the impact produced on the environment as a natural media to human existence. If we consider the historical aspect of the interaction of economy and natural environment, the major trends of increasing influence on the latter produced by the world economy started from the period of manufacturing and industry development In those times there was a rapid increase in the scale of natural resources exploitation, mainly due to mineral raw materials and fuel. Alongside with that, the utilization of land, water, and forest resources also increased. V. Vernadskiy said that humanity up to the twentieth century used nineteen chemical elements in the production, while in early twentieth century the number of chemical elements used in the production was 59 [7]. Over the last century the dynamics of this process significantly speeded up. Thus, in the twenty first century, all chemical elements of the Mendelieiev periodic table are used in the world economy. So, we approximately estimate that

$$\frac{k_{1900}}{k_{2000}} \approx 3-4 \text{ times}, \quad (7)$$

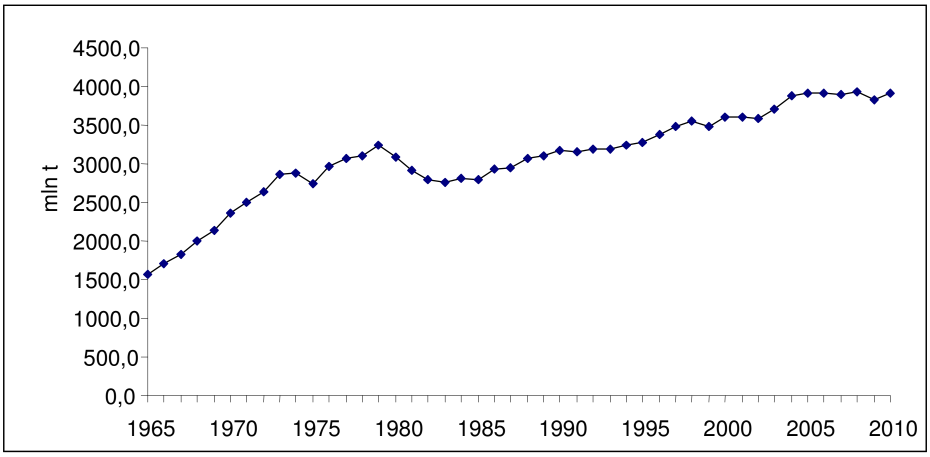
where k_{1900}, k_{2000} are the coefficients of influence produced by the global economy on natural environment, respectively at the beginning of the twentieth and twenty first centuries.

So, the coefficient of the effect produced by the global economy on the environment is impossible to be estimated accurately. Nevertheless, it can safely be stated that the tendency is observed to its significant (3-4 times per century) growth

In addition, the coefficients of intense use of the natural environment elements also grow. For example, in the last 45 years, oil production grew more than twofold (Fig. 2).

Figure 2

The dynamics of world oil production



Source: constructed by the author according to [8]

If in 1965 the world oil production was 1567.3 billion tons, in 2010 it made 3913.7mln. tons. And though in that time there happened to be decreasing oil productions, the global consumption of natural resources is tending to grow

The similar trend refers to coal production (Fig. 3).

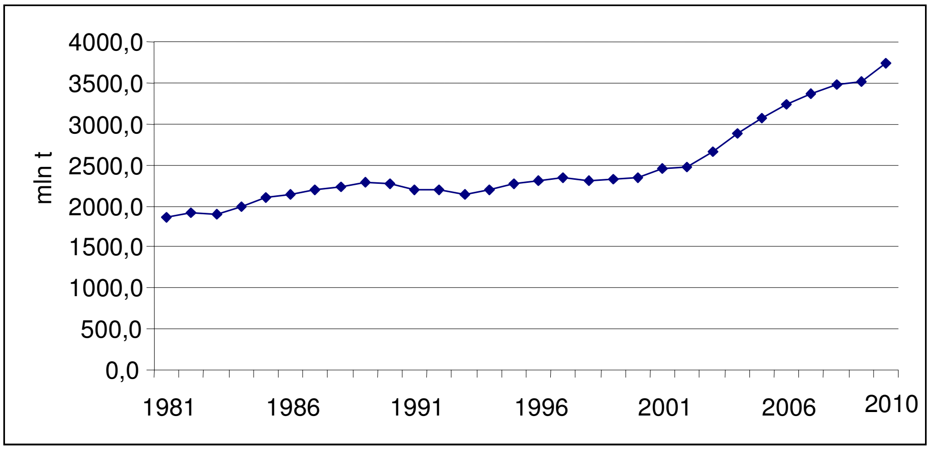
In 1981 the world production of coal amounted to 1852.7 million tons. For three decades, it has doubled, and in 2010 reached 3731.4 million tons Thus, proceeding from the named figures of oil and coal production we can conclude that in global scale the respective coefficients of the influence intensity (excluding changes in explored reserves, which slightly increased) make:

for oil: $\frac{I_{oil\_2010}}{I_{oil\_1965}} \approx 2{,}5$ times;

for coal: $\frac{I_{coad\_2010}}{I_{coad\_1981}} \approx 2$ times.

Figure 3

Dynamics of world coal production in 1981–2010



Source: constructed by the author according to [8]

As we see, the intensity of influence (use) coefficients of the above elements of nature in the world economy grew too fast.

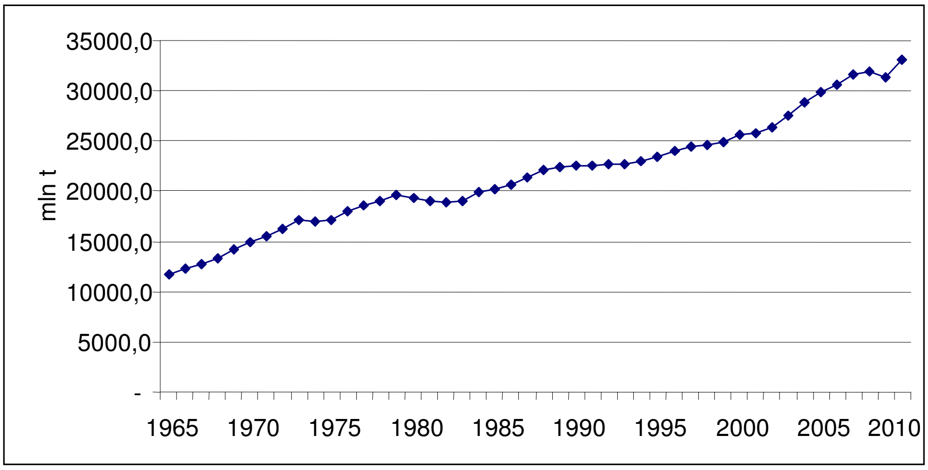
Annually about 35–40 billion tons of various materials and products are excavated. Last century forests were extensively destroyed for industry and agricultural lands were intensely expanded. At the beginning of the 21st century out of the entire land area, almost 45 million square kms, or about 1/3, is used for arable and pasture lands, orchards and plantations. Forests cover more than 40 million square kms. of the land, a great part of it is being intensely developed (annual timber harvest makes more than 2 billion cubic meters).

Every year fuel combustion utilizes about 15–20 billion tons of free oxygen in atmospheric air, and the amount of water, which is taken annually from sources is estimated more than 560 billion tons (which is partly irreversibly lost, partly discharged as waste water).

The reverse process is the generation of large quantities of carbon dioxide, which is emitted into the environment (Fig. 4).

Figure 4

Dynamics of carbon dioxide emission in the atmosphere resulted by the functioning of the global economy



Source: constructed by the author according to source [8].

If in 1965 the total emissions of carbon dioxide in the world amounted to 11744.7 million tons, then in 2010 it was 33 158.4 mln. tons. For the period of less than half a century, the intensity of environmental impact through that channel almost tripled.

The above indicates that the impact of the global economic system on the surrounding natural system is fairly great. We can not prove correctly, either the openness of world economy with respect to natural system has reached a critical level, but at least we believe that it is surely approaching that level. In its turn, this means that the scale of the global economy dependence on that element of nature increases.

It should further be noted that the needs of the world economy in natural resources are rapidly increasing. According to the estimates, in the long term, to reach the consumption of primary materials and products by the population at the Earth's present level of consumption in most developed countries the total volume of their output should be tripled, and concerning the most important mineral resources (fuel, metals) their production should increase by more than 10 times.

Taking into account the growth of population and subsequent increase in unit costs of primary materials and products per capita, total demand for natural resources will be much heavier.

This means that the intensity coefficients of natural system elements use by the world economy will grow about 10 times.

Now we can regard to be clearly proven that the impact of the global economy on the environment is growing.

This has a direct relationship with the regime of the global economic system development. After all, it means that the natural system can no longer be considered as entrostat, since the change of entropy can not be neglected.

And the correlation between the «global economy» and «natural environment» moves to the so-called entropy oscillations. The essence of this regime is that with the exceeding of the critical level of one system's influence produced on the other one (which means the growth of organization level in natural environment) the probability grows of events causing the increase in entropy. That is, the events associated with the increase of entropy are occurring more often. The system goes into a state of the entropy oscillations.

The question arises: why the entropy oscillations are viewed as a synergistic effect? The answer is quite simple. In this case, there are all signs of typical synergy effect. The system gets farther from the state of equilibrium. As a result of cooperative actions (of various processes), the system acquires new properties (the mode changes). We emphasize that this change is a probability. So if the prevalence of organization processes is changed into the prevailing processes of disorganization, it is precisely in terms of probability: the probability of the development of disruption processes is higher than the probability of self-organization processes.

Conclusions. It is worth stating that the world economic system approaches the critical level of organization. And as a result of its increasing influence on the natural system the latter approaches to the similar (but its own) level. Consequently, the changes occur in the evolution of two interrelated systems. So, we argue, that as a result of these changes the synergistic regularities come to the fore, and they actually began to form the basic tendencies of the global economic system evolution and its interaction with the natural system.

We emphasize that natural disasters (floods, earthquakes, hurricanes), technological disasters (environmental crises, accidents, fires, etc.), financial turmoil, social and political tensions are of common property, that is, by their nature they are destructive processes that increase the environment entropy. However, the change of entropy is regulated by fundamental laws of nature Therefore, we believe that in the global economy and in natural system there is observed the development of some dangerous trends of prevailing destruction.

The conclusions of Forrester [10] and his followers drew attention of the worldwide and scientific community to global issues. The solution of these issues requires a revision of the paradigm of the development of world economy and society, especially of natural resources.

The current state of things leads to a dead end: according to Forrester – because of exhausting of natural resources; according to the theory of entropy fluctuations – because of ever growing amount of resources needed to oppose the destructive processes.

There prospective is a different mode of evolution of the global economic system and civilization in general. From the view of synergetic approach that way means a higher degree of openness of the economy with respect to natural environment. In fact, that is a high degree of integration of the economy into natural environment. In terms of classical science, the idea of «sustainable development» pretends to take the role of that new paradigm (from the English. «sustainable development» that is literally translated as agreed, mutually supported development). For the first time that idea was put forward in December 1986 by Gro Harlem Brundtland in her report «Our Common Future». From that time on the term “sustainable development” is being used in mass media, implying the model of development, under which vital needs of the present generation are met without reducing the similar possibility for future generations. If we consider this thesis in the context of entropy fluctuations, it provides for the preservation of the environment in a state that would be relatively the same respectively the critical level of the organization. The concept of sustainable development was supported in 1992 at the UN conference in Rio de Janeiro, where a Declaration on Environment and Development was adopted , i. e. the Declaration of appropriate measures for implementation of the strategy of sustainable development.

Termination of the tendency to reach a critical level of the global economy influence on natural environment and to prevent its transition to the «containment of the processes that increase entropy» in the twenty-first century provides for a shift of emphasis on the rational use of natural resources. This aspect shows another channel of influence of scientific and technical progress on the dynamics of global economic development. After all, it is just the technological progress that breaks new grounds for replacing non-regenerative natural resources with other types of sources, including various kinds of synthetic materials. Also the hi-tech introduces new environmentally friendly technologies that will reduce the effect of the global economy on the natural system, and thereby avoid the transition to the oscillatory entropic cycle, that is characterized by a greater probability of destructive processes against the process of self-organization.

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