THE NATURE OF ENTROPY IN SOCIO-ECONOMIC SYSTEMS

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Abstract

This report analyzes the relationship between thermodynamic and information entropy. It is shown that in the case of socio-economic impact of information systems on the organization of social and economic systems is ambiguous.

Key words: *Entropy, socio-economic systems, information entropy, thermodynamic systems.*

JEL Classification: *F20*

I. INTRODUCTION

Entropy is one of the most fundamental concepts, which define the behavior of the world. The concept of entropy was introduced into science by Rudolf Clausius in 1865, who tried to formalize the thermal processes running. So at the beginning entropy was an abstract term, which was designed to give possibility to describe thermal processes by means of mathematic equations.

Socio-economic systems of different scales (up to global economy) do not belong to the thermodynamic systems, but similarly to the former in a series of cases their macrostate can also be expressed through the quantity of microstates and the elements of the system, which can take definite places in the system structure.

The problem of the definition of the essence of entropy is in complexity of its formalization.

But the meaning of entropy for understanding what is going on in the world which surrounds us is much greater than the value, which reflects the degree of order or disintegration of the system.

Purpose of the article is to analyze the relationship between thermodynamic and information entropy in socio-economic system.

II. REVIEW OF THE LAST PUBLICATIONS

Entropy is one of the fundamental notions, which define the behavior of the world. According to the neat expression of one of the Russian researchers of current global tendencies and processes V. I. Shapovalov: "Even though a lot of people hardly ever thought of it, but a lot of events in our lives are connected with the so-called law of entropy increase" [17, p.1].

The notion of entropy was introduced in science by R. Clausius, who tried to formalize the course of thermal processes. That is why at first entropy was the abstract term, the main function of which was to provide the possibility to describe the thermal processes with the help of mathematic equations. L. Boltzmann determined that the notion of the entropy has much deeper essence and it is one of the fundamental values, which describe the course of natural processes. Ukrainian sociologist L.Bevzenko connects entropy with the vagueness in social behaviour.

Shennon's definition of the entropy is connected with the notion of thermodynamic entropy. One of the biggest descriptive examples of such connection is the imaginary experiment, known under the name " Maxwell's demon", which leads to some kind of paradox in thermodynamics.

III. THE MAIN MATERIAL

R.Clausius has defined the entropy change ΔS of thermodynamic system during the reversible process as ratio of the general heat quantity change ΔQ to the value of the absolute temperature *T* (i.e. the term "entropy" was introduced to explain the change of the heat quantity at stable temperature):

$$\Delta S = \frac{\Delta Q}{T} \qquad (1.1)$$

Equation (1.1) is used only for the entropy change and it doesn't define the entropy itself, it is only used for isothermal process which happens in case of stable temperature.

The example of such process is water freezing: at the temperature 0°C water can be in liquid state and in case of insignificant external action quickly transforms into ice, changing its internal energy. At the same time the temperature of the substance stays 0°C. So, the state of the substance changes and it is accompanied by the change of the inner energy as a result of the change of substance structure.

Generalization of the formula (1.1) in case of the arbitrary quasi-static process is written as follows:

$$dS = \frac{\delta Q}{T}, \qquad (1.2)$$

where dS - gain (differential) entropy; δQ - infinitely small gain of heat quantity.

Let's admit that quasi-static process consists of a continuous sequence of equilibrium states.

As entropy is a function of state, the left side of equation (1.2) contains its full differential. In contrast, the quantity of heat is a function of the process, which was given this heat, so δQ it should not be considered as a complete differential.

At the end of XIX century L. Boltzmann discovered the connection between entropy and logarithm of the number of microstate that generate the same macroscopic state of the system [7]:

$$H = k \ln W, \qquad (1.3)$$

where *H* – is the entropy of the system in some state (macrostate); *k* – constant (constant of Boltzmann); *W* – number of microstates which cause some macrostate of the system.

According to the expression (1.1) the entropy is proportional to logarithm of the number of variants of interaction of variants between each other. Let's admit, that here are considered only such variants of interaction which respond to the same state (macrostate of the system). Each of such states is called the "microstate" of the system. The importance of entropy for understanding the course of the processes is determined by its connection with order-chaos in the systems. Historically this connection was grounded for physical systems, some time later the notion of entropy and its understanding as the measure of orderliness (disorganization) also started to be used for social and economic systems more often.

The interconnection of entropy and orderliness in the equation (1.1) can be explained in such way. The order foresees presence of some quantity of limitations on the behaviour of the system elements, which defines the possible quantity of variants of interconnection between them. If the level of order is high, there are a lot of such limitations, so the quantity of interconnection variants is not big. In the boundary case there can be so many limitations that the elements of the system will interconnect in the only possible way. Then system has the only microstate and in the formula (1.1) we achieve lnl = 0. Entropy in such case acquire the minimum value, it equals zero. Such systems are called strictly determined. The other boundary case - is the complete absence of limitations. In such case entropy acquires maximum meaning and general dependence is as follows: the more microstates the system has, the bigger is the meaning of entropy, the more chaotic is the system. In other words "chaos" can be realized by the bigger quantity of microstates of the system, then "order". Such approach to the understanding of the essence of entropy was developed in the bounds of thermo-dynamics; it is mostly used for thermodynamic systems. Nevertheless it is worth to accent that in this order "chaos" doesn't foresee the absence of the structure in general. The possibility of staying in the same place of structure of the bigger amount of elements of the system (in case of entropy increase) is very important. As an example of thermo-dynamic system we can examine the set of molecules in a gravitational field. As we know from physics, in this case the most likely distribution is the distribution of molecules according to the barometric formula of Boltzmann. This condition can be realized in many ways: you can rearrange molecules, the entropy is maximal in such case, but it is not chaos in the mathematical sense (as a strong instability of non-linear systems) [12, pp.70-79]. The same situation occurs in the supercooled liquid, where crystallization begins. The formation of structures of "chaotic" fluid in it is parallel to the entropy increase.

As it is rightly noticed in the literature, problems with usage of the term "entropy" for definition of the level of disorder appears in such cases [22]:

- when different notions of disorder (in some cases chaos) and entropy becomes the measure on disorder in general;

- when the notion of entropy is used for the systems which are not thermo-dynamic.

In both cases the usage of the notion of thermodynamic entropy requires additional grounds [22]. Social and economic systems of different scales (up to global economy) doesn't belong to thermodynamic systems, but like the latter in some cases their makrostates can also be expressed in terms of microstate and system elements that can occupy certain places in the structure of the system. problem with determination of the essence of entropy in social and economic systems is the difficulty of its formalization. Despite big quantity of works of humanitarian orientation where the synergetic conceptual apparatus for the research of social and economic processes and events we didn't manage to find any job in which entropy is introduced as formalized value. What is more, even the essence of entropy as the measure of order or chaos is very rarely examined in works.

The most successfully, to our mind, entropy is explained in social and economic system "Ukrainian society at the beginning of the XXI century" Ukrainian sociologist L.Bovzenko who concretizes entropy in Ukrainian society before the famous events of 2004. The author connects entropy with uncertainty in social behaviour. The base of the L.Bevzenko's uncertainty chooses uncertainty of human qualities and the place which he ranks in the social system. In other words, the increase of entropy in society is adequate to the increase of the level of inconsistency of social status and personal qualities or professional skills. She aptly, at this stage, "it looked like any place could have been taken by anybody... Position of doctor became lesser connected with professionalism and more dependant on… possibility to pay for the position… No one will be too surprised if a judge is also a crime boss. Police could kill and rob or pull strings to those who killed or robbed. Such messages were in the press and other media and did not cause the scandal of the state level. As a subjective measure all these looked like the less certainty in a situation when you need to decide where to go for treatment, where children will go to learn, whom to confess, where to buy food and medicine without endangering human health (all licenses can be sold), where to go for help in case of violation of rights, where to call in case of robbery or beating. That was a situation where one element of the system is not different from the other (meaning a man who took the decision)" [5, pp.41-78].

The same way we can approach to the understanding of entropy as the measure of order/disorder in economic systems. For example, some group of people who know each other have bigger entropy then the enterprise with the same quantity of insiders and general amount of resources. In the last case the interaction between the group members are strictly limited. For example, owners interact with each other according to some rules, there are some rules between owners and managers of the enterprise, managers and workers of the enterprise etc. Both cases have equal quantity of the elements. However the state of the system "just a group of the people and their resources" can be realized with the much bigger quantity of microstates, then the state "enterprise". Accordingly, for the state "enterprise" the smaller value of the entropy and bigger level of order (orderliness) are typical.

But the meaning of the entropy for the understanding of what is happening in the outward things is much bigger then the value which reflects the degree of order or disintegration of the system. It is connected with the dynamic of everything of which world consists of, including the socio-economic sphere, part of which is actually economy. In modern science, all the laws that are responsible for directing the processes, have one thing in common: their mathematical formulation are either inequality, or contain the symbol of extremum (maximum or minimum) [16, p.1]. These also include the law of entropy increasing. One of his formulations: in a completely closed system, all processes are accompanied by non-increase of the entropy. If a completely closed system is in equilibrium, its entropy is constant and equal to the maximum value for this system. This is the second law of thermodynamics beginning, which can be written mathematically as:

$$dS_i \geq 0 . \qquad (1.4)$$

In the expression (1.4) the index *i* denotes the so-called internal entropy corresponding to a closed system.

The effect of this law is manifested in the generation processes, which reduce the degree of organization of the system, i.e. increase their disorganization. Another equally important manifestation of this law is the appearance of processes that compensate the appearance of some kind of structural organization by increasing the level of chaos around it so that the total degree of organization of the system is still decreasing.

Thus, the example, suggested by V. Shapovalov, metal blank has a certain degree of organization (entropy). If turner fashions detail of it, then, at first glance, the entropy decreases as the degree of order in the detail is higher than in the workpiece. However, along the detail there is a lot of chip, the entropy of which is much higher than that of the workpiece. Therefore, the total entropy of the system "workpiece + chips" still becomes higher and degree of organization, consequently, becomes lower, despite the fact that there was a highly organized part of the system "detail".

However, the law of entropy increasing is valid for only completely closed systems. Absolute isolation means in physical systems the absence of exchange between energy and substance with the environment.

In the open system can be possible energy flows both out, and inside of it. In case of the flow of energy into the system comes (in case of a thermodynamic system) the amount of heat δQ_1 at the temperature T_1 and gives the environment quantity of heat δQ_2 at temperature T_2. The change in entropy connected with these flows of energy, equal to (entropy change according to the process of exchange):

$$dS_0 = \frac{\delta Q_1}{T_1} - \frac{\delta Q_2}{T_2}. \qquad (1.5)$$

If the system is stationary, the condition must be fulfilled $\delta Q_1 = \delta Q_2$ і $T_1 > T_2$, so that $dS_0 < 0$. As in such case change of entropy is negative, the expression "inflow of negentropy" is often used instead of entropy outflow from the system. Negentropy is defined as entropy with negative sign.

The general change of entropy of open system equals

$$dS = dS_i + dS_0. \qquad (1.6)$$

If all the time $dS > 0$ then internal entropy increase is not compensated by the inflows of foreign negentropy, the system moves to the nearest equilibrium state. If $dS = 0$, then we have a stationary process with a constant general entropy. In this case, some inner work is done in the system with generation of internal entropy, which makes, for example, the temperature T_1 of the external heat flow on the temperature T_2 of heat given by the system flow.

In the case of social and economic systems in the sharing process information exchange should be added. In the latter case we speak about the information entropy theory of which was developed by K. Shannon [19].

He suggested that the increase information equals the lost uncertainty and set the requirements for its measurement:

1) measure must be continuous, i.e. change of the value of the magnitude possibility at the small value must cause correspondingly small resulting function changes;

2) in the case when all options are equally possible, increasing the number of options must always increase the value of the function;

3) there must be a possibility to make a choice (in our example - letters) in two steps, in which the function of the final result should be the sum of functions of intermediate results.

That’s why the function of entropy H must meet the following conditions:

1) $H(p_1, ..., p_n)$ determined and continuous for all $p_1, ..., p_n$, де $p_i \in [0, 1]$ for all $i = 1, ..., n$ та $p_1 + ... + p_n = 1$;

2) for integer positive n this inequality must be done:

$$H\Bigg(\underbrace{\frac{1}{n}, ..., \frac{1}{n}}_{n}\Bigg) < H\Bigg(\underbrace{\frac{1}{n+1}, ..., \frac{1}{n+1}}_{n+1}\Bigg);$$

3) for some positives b_i, де $b_1 + ... + b_n = n$, must be done the equality:

$$H\Bigg(\underbrace{\frac{1}{n}, ..., \frac{1}{n}}_{n}\Bigg) = H\left(\frac{b_1}{n}, ..., \frac{b_k}{n}\right) + \sum_{i=1}^{k} \frac{b_i}{n} H\Bigg(\underbrace{\frac{1}{b_i}, ..., \frac{1}{b_i}}_{b_i}\Bigg).$$

Shannon showed that the only function that satisfies these requirements looks like [19]

$$H = -K \sum_{i=1}^{n} p(i) \log_2 p(i), \qquad (1.7)$$

where K is the constant (required only to choose the units of measure).

Shannon's entropy measure expresses the uncertainty of a random variable realization. Thus, entropy is the difference between the information contained in the message, and that part of the information accurately known (or well-provided) in the message. An example of this is the redundancy of language, explicit statistical regularities in the appearance of the letters, pairs of consecutive letters, triplets, etc.

Information dual entropy for independent random events *x* with *n* possible states (from 1 to *n*) is counted by the formula

$$H(x) = -\sum_{i=1}^{n} p(i) \log_2 p(i). \qquad (1.8)$$

The value which is determined by the formula (1.8), is also called average entropy messages. The value $\log_2\left(\frac{1}{p_i}\right)$ is called partly entropy, which characterizes only i state.

Thus, the entropy of the event x is the sum with opposite sign of all products of relative frequency of the appearance of i event multiplied by their own double logarithms. This definition for discrete random events must be extended to the function of probability distribution.

It turned out that Shannon's definition of entropy is connected with the concept of thermodynamic entropy. One of the most illustrative examples of this relationship is the thought experiment known as "Maxwell's demon", which leads to a paradox in thermodynamics. The essence of the paradox was that two vessels were examined with different temperatures connected by a narrow tube with bars led by the so-called "demon". He could measure the speed of the separate molecules that fly and selectively pass faster molecules in a vessel with a high temperature, and slower - in a vessel with low temperature. Then all the faster molecules were concentrated in a vessel with a higher temperature, continuing to increase it, but slower - in the vessel with a lower temperature, continuing to reduce it. Indeed, the lower is the average speed of the molecules, the lower is the temperature. This conceptual experiment indicated that as a result of such heat exchange between the cold and hot body the hot is even more heated and cold – is even more cooled. As it is know, thermodynamics establishes the opposite direction of the flow of thermal processes. As a result, heat temperature of both bodies must be compared: a hotter must become cooler and cooler must become hotter.

The paradox can be resolved by the introduction of information to the process. To measure the speed of the molecules "demon" would get information about its speed. However, any information receiving is the physical process, which is accompanied by the increase of entropy. Quantitative calculations showed that the increase of entropy during the measurement exceeds the absolute value of the entropy decrease caused by the redistribution of molecules "demon" [8].

So there is a connection between thermodynamic and information entropy. For example, Maxwell's demon also opposes the thermodynamic entropy of information and receiving of certain amount of information equals entropy reduction.

It is also worth to define the entropy of a random variable by previously introducing the notion of distribution of the random variable *X*, which has a finite number of values

$$PX(x_i) = p_i, \quad p_i \ge 0, i = 1, 2, ..., n, \quad \sum_{i=1}^{n} p_i = 1 \qquad (1.9)$$

and its own information

$$I(X) = -\log\left(PX(X)\right). \qquad (1.10)$$

Then the entropy is defined as the mathematic expectation of its own information

$$H(X) = E\left(I(X)\right) = -\sum_{i=1}^{n} p(i)\log p(i). \qquad (1.11)$$

Entropy is the number of units of information, determined in the context of a probabilistic model for the data source. For example, a coin tossing has an entropy $-2\cdot 0.5\cdot\log_2\left(\frac{1}{2}\right) = 1$ bits per shot (on the assumption of its independence). If the source generates an infinite message consisting of only identical letters, its entropy will be equal $-\sum_{n=1}^{\infty}\log_2(1) = 0$.

Basic properties of entropy are summarized to the next.

1. *Positivity*: $H(X) \ge 0$.
2. *Limitation*: $H(X) \le \log_2|X|$. Equality holds if the probability of all elements of the multitude X is the same.
3. If X, Y are independent, then $H(X\cdot Y) = H(X) + H(Y)$.
4. Entropy is a function of the distribution of elements' probability.
5. If X, Y have the same distribution of elements' probability, then $H(X) = H(Y)$.

Information and entropy were tied together also by N. Wiener, who introduced the concept of negative entropy [23]. In his approach, the loss (non-receipt) of information by the system leads to its disorganization's increase, while the flow of information to the system promotes the improving of organization in it. Therefore, these two notions are interrelated: with the increase of the flow of information the entropy decreases, and vice versa, with the loss of information the entropy grows. However in the case of socio-economic systems the information's impact on the organization of socio-economic systems is too ambiguous [10, pp.1215-1230].

The problem of the relationship of the chaos and the information in socio-economic systems is linked to the fact that in such systems the behavior of elements, which are sensitive to the information (sensitivity is meant as ability to change the order of interaction with other elements of the system), changes not only because of the information's volume, but also because of its semantic meaning. In the case of semantic incoherence of simultaneous flows of information, the behavior of such elements becomes more chaotic. Some aspects of the influence of information on the processes of self-organization let us consider a bit further. Let us note that for closed socio-economic systems the law of entropy's increase has the same effect as for physical systems. However, this law's action is not universal, not always socio-economic systems and processes are in equilibrium or in the state close to it.

Let us find out if there exists any analogue of the state of thermodynamic equilibrium in the socio-economic systems and processes, meaning such a state that corresponds to the maximum of the entropy. This requires the socio-economic system to be in a state of equilibrium, and "active elements" of this system (the agents) to be independent.

If we consider the nature of the most economic theories, the principle of balance is key into them. It was formulated by the founder of the classical theory Adam Smith in the "An Inquiry into the Nature and Causes of the Wealth of Nations". His famous metaphor of the "invisible hand" of the market is nothing more than a second principle of thermodynamics. And the "invisible hand" of thermodynamics determines the direction of the processes – in the first case, in the economy, in the second case – in inanimate nature. This principle of equilibrium A. Smith obtained as a consequence of imaginary experiments with the ideal market model with ideal participants' competition. The principle of the "invisible hand" has a clear expression of the price in the mechanism of the market balancing of the demand and supply of Walrasian model. V.M. Sergeyev reasonably notes that behind the difference of views about the nature of market equilibrium of both the neoclassical and classical approaches, in the basis of their conceptions is metaphorical identification of the market as certain stable mechanical system such as weights, so that system's deviations from the equilibrium state cause the emergence of the forces seeking to return the system to equilibrium state [15, p.17]. This state is characterized by the equilibrium price, and all the processes in the market take place in such a direction to establish the equilibrium market price.

However, we should be aware that the state of market equilibrium is a metaphysical supposition, the principle of balance in social and economic processes is adopted a priori. As D. Egorov confirms, in the whole (in economic systems and processes – our comment) also the situations of stationary nonequilibrium can be realized (and actually are realized) [6, p.7].

It may seem that with the development of the mathematical model of general economic equilibrium [3], the principle of equilibrium moved from ontological postulate to the category of strictly proven positions. However, the proof of the existence of equilibrium in the models like Arrow – Debreu assumes the validity of another axiomatic principle that is accepted without proof, meaning the principle of the utility function's maximization. Let us note that the utility function is actually acting as an analogue of the dynamical system's potential. However, unlike the Lagrangian function, the economists usually don't know about the utility function in numerical form. Furthermore, as a rule, the existence of equilibrium automatically implies the compliance of the principles of information's completeness and economic agents' independence.

As for information's completeness, given the quality attributes of information, George Akerlof [1, pp.485-500], Michael Spence [20, p. 355–374] and Joseph Stiglitz [21, pp.407-430], who were awarded the Nobel Prize in 2001, laid the basis of market theory of information, which is based on its asymmetry and therefore incompleteness for various economic agents.

G. Akerlof confirmed that asymmetric information may lead to a reverse selection in the market. For example, because the sellers have more complete information about the cars they sell than buyers and renters, in the market for second-hand cars ("lemons") begin to dominate buyers with poor solvency and offer shifts towards low-quality cars [1, pp.485-500]. M. Spence proved that such information asymmetry leads to a certain shift of the equilibrium in the labor market [20, p. 355–374], according to J. Stiglitz, in the market of bank loans [21, pp.407-430].

As defined Nobel Laureate of 2001 year J. Stiglitz, any market is characterized by asymmetric information, which is greater when the market is less developed [21, pp.407-430]. The essence of this asymmetry is that some market agents have at their disposal more information about these or other market objects than others.

Because the nature and essence of markets are the same, similar phenomena exist in the investment market [9, pp.21-26]. Information asymmetries form and provide the stability of regional model of investment distribution worldwide. Moreover, this model can also be stable in a state that does not match the state of stable equilibrium.

As for the economic agents' independence, in a range of cases it is more an abstraction than actually realized scenarios of economic agents' behavior. In some cases, the actions of economic agents are closely correlated with each other. In this paper [10, pp.1215-1230] we have shown that, in particular, the actions of investors are not independent, they are interrelated through information. Briefly, such a relationship can be described as follows.

Let us assume that the investor invested in an object in which no one invested before. The probability that his such an action will end with a failure (losses) is high. Let us suppose that this exactly happened. The information about it is distributed among other agents of innovation and investment process (investors) and establishes more the rules that forbid investing in such objects. So, the rest of the investors' abstention from investing in such an object is caused by the action of the considered investor (in this case by the negative consequences of his investment). This is a classic implementation of the mechanism of negative feedback, which returns the system to equilibrium in the case of deviations. The deviation is the single investment in the object, which is seen as unattractive.

However, (although with less probability) it is possible also the opposite result. In fact informal investment rules are derived from historical experience and everyday situations can vary, and investments, which in the past inevitably ended in failure, today can be successful. Then the information, that an investor's investment in "unattractive" by the perspective of most investors object was successful, is distributed among investors. Therefore, if the first investment in such a object was made by the most risky investor, then further investments may be realized by less risky investors. This encourages more other investors to such investment, sets to invest in such objects (these can be individual enterprises, branches of the country, etc.). And in this case the actions of the investors as economic agents are interdependent. This means the deviation's fixing by positive feedback.

From the above mentioned it follows logically that on the global investment and financial markets the actions of the economic agents are not independent.

However, the principle of equilibrium is defined within the axiomatic system (the axiom on maximum of utility function, information's completeness and independence of the behavior of economic agents). Therefore, it corresponds to the real economy as much as a set of axioms of neoclassical models corresponds to the last. It is worth to recognize that in many cases the models of general economic equilibrium in a given stage (often in too considerable) are adequate to real processes occurring in the national economies and at global scale. However, this does not always happen.

By violation of the principle of information's completeness and independence of economic agents in such fields as global stock and financial markets, monetary circulation and credit, in terms of globalization the economic systems are in the states far from equilibrium for a long time. Such a situation also is possible in other areas: production of industrial goods, mining, etc. It is worth to assume that the underproduction of food at the world scale, which is emphasized the last several years, is such a deviation too, and the "hand of the market" in this case does not work, as evidenced by the rise in food prices globally, and not their fluctuations around an abstract "equilibrium" level .

Awareness of non-compliance of real agents of economic relations to axiomatic idealizations of the model of general economic equilibrium has stimulated the creation of economic concepts on a fundamentally different ontological basis. Violation of the principle of information's completeness is accepted by the representatives of Austrian School of Economics (from K. Menger to F. Hayek), institutionalism and evolutionary approach to economic theory (A. Alhiyan [2, pp. 211-221], D. Nort [11, pp.69-91], etc.). In this respect, D. Egorov notes that "Pareto optimum, of course, is a state too attractive for the economy, but the real market participants, as opposed to the ideal, may not ever reach it; in this case the development of the economy more adequately is described in the categories of evolutional development [6]. V.M. Sergeev also indicates that, although representatives of the Austrian School had a skeptical regard to the use of mathematical tools in economics, their ideas are necessary to be expressed through the unit of statistical thermodynamics or theory of information [15, p.3]. The principle of utility function's maximization should be considered not only as an analogue of Hamilton's principle in mechanics, but also of maximization of entropy in thermodynamics. "With some very abstract point of view, any "equilibrium theory" with all the differences between mechanical and thermodynamic approaches should be the *theory of critical points of reflections*, meaning a chapter of differential topology"[15, p.87]. Thermodynamic metaphor is, however, more acceptable, as it can be used also considering the participants' incompleteness of knowledge about the system: "Equilibrium, unlike mechanical metaphor, in thermodynamic metaphor does not mean the existence of a special point of the system of differential equations or extremum of potential function, but Pfaff equation's movement through integrated surface (surface of equation of states)" [15, p.33]. It is important that in these terms exists the opportunity to build a mathematical theory of economic equilibrium without relying on the concept of utility [15, p.146].

IV. CONCLUSIONS

However, in our opinion, the approach to socio-economic processes based on thermodynamic equilibrium with all potential fertility has fundamental limitations that figuratively speaking, are "embedded" in its ontology. We consider (without claiming to originality of our thought) that economic theories based on the principle of equilibrium (in *any* of its form – mechanical or thermodynamic) are inadequate in try to describe *economic processes of self-organization*, and that just when the self-organization of economic systems occurs, particularly at the global level, both neoclassical and classical theories are powerless both to predict and to describe the changes that occur.

In fact, most of the processes observed in the nature and in society, at first glance, contradict the law of entropy increase. The formation of stars, planets from nebulae of gas and dust is not an increase, but a decrease in entropy and increase of the degree of order. In a state of entropy maximum the Earth (even in the form of the planet) would be a gas balloon. However, we know that it is not. Our planet has an internal structure, there exist the core, mantle and crust. On the surface there are relatively stable structures: the continents. A large number of molecules are incorporated into the bodies of certain form of animate and inanimate nature.

For example, human society also is not homogeneous global human mass, but has a rather complex structure: there are states, there are its own public associations in the states, there are also associations at the global level: alliances, multilateral agreements. In recent decades, there also have appeared highly organized suprastate structures of a new type: transnational corporations (TNCs). Economic activity is also highly organized, there exist enterprises, resource sharing rules and others. Does the above mentioned mean that the law of entropy increase does not function in all of the above mentioned and many other examples? Of course not. This law is truly one of the fundamental in modern science, but its application has certain limitations. The fact is that nebulae of gas and dust from which our planet was formed, animate and inanimate nature, human society are open systems that exchange energy, matter, information with the environment. Sharing is held for one, two or even all three elements presented above. In such systems are possible the processes which flow in the directions opposite to a given law of entropy increase. They are not always self-organization processes in synergetic sense, as it is often mistakenly noted in the literature primarily devoted to the study of social and economic processes [18], but these are processes of increase in the order or processes that lead to an increase in entropy.

The most convincing signs of antientropic processes on the physical and chemical levels, studied not only experimentally but also theoretically justified, was the discovery of self-organization of macrosystems as dissipative structures by I. Prigozhin [13], the discovery of concentration autowaves in periodic reactions by B.L. Belousov [4, pp.648-656] and A.M. Zhabotinskii [24] and the discovery of self-development of self-organization of elementary open catalytic systems in evolutionary catalysis by A.P. Rudenko [14], which gave the opportunity to consider and decide on a quantitative level not only the problem of self-organization, but also of a progressive chemical evolution and the origin of life.

These works and concepts developed in connection with them put the final point in the debate over the universality or ununiversality of second law and its contradictions with real phenomena in favor of the existence of two physical principles, according to which there are processes that have a different focus: to and opposite to equilibrium. As it is showed by A.P. Rudenko [14] on the basis of an example of elementary open catalytic systems, there exist interconnected and interdependent material objects of equilibrium and nonequilibrium structural organization of matter. Some of them are formed during the process, which is directed to equilibrium and is accompanied by the release of energy. Others are accompanied by the absorption of energy. The first type of processes is called entropic process (the process of equilibrium self-organization), the second is called antientropic process (the process of nonequilibrium self-organization). Because these principles are valid for all levels of development of matter, nowadays the science just experiences the becoming of new paradigm of natural sciences and social sciences that recognizes the division of the world into objects (systems) with equilibrium and nonequilibrium organization. Concordantly chaos ordering is possible as a result of two fundamental processes: one, which is trying for equilibrium, and the other, which is trying for nonequilibrium. In these conditions the classic science must abandon ideas about the existence of any universal laws of nature, divorced from concrete objects and at the same time mandatory for absolutely all the objects.

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