ENTROPY CONDITIONS OF SELF-ORGANIZATION OF THE BANKING SYSTEM

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Abstract: The conditions for market transformations are accompanied by a growing influence on the banks' activity by the flow of destructive disturbances that can cause chaotic behavior of the economic system as a whole and the banking system, in particular. The purpose of the study is to identify the preface of self-organization of the banking system, taking into account the information factor and the level of the entropy of the system. The theoretical questions of mutual influence and interconnection of entropy and information are considered in the paper, as well as their influence on the processes of self-organization in the banking system. From the point of view of the entropy approach the nature and conditions of self-organization in the banking system are disclosed. For the efficient functioning of the modern banking system, the search and analysis of the dependence between the entropy indicators, accumulated information and the synergistic effect, taking into account dualism of chaos and order, are of considerable interest. On the basis of the complex of these indicators, the results of the conducted research, which reveal the dynamic properties of self-organization of the banking system, are presented.
Keywords: banking system, synergetics, self-organization, level of orderliness, entropy, chaos.

1. Introduction

The growing changeability of the external environment of functioning of the banking system greatly enhances its disorder and instability which, in turn, leads to consolidation and transformation of banks. As a result, in a changing environment the banking system undergoes qualitative changes and restructuring: the fast and slow phases of development are shifted; system structures are created and disappear. Therefore, the knowledge and interpretation of the conditions of self-organization processes in the functioning of the banking system has not only theoretical but also practical value for designing the possible consequences of consolidation of banks and the formation of synergistic effects as a result of this.

Chaotization of the banking system violates the orderliness of its behavior, becoming very sensitive even to very weak disturbances that can give rise to a fundamentally different mode of behavior of the evolving system. In the context of synergetics, a chaotic system over time is subject to complex transformations with the acquisition of an ordered mode of functioning [1–3]. Therefore, we consider it necessary to interpret chaos and order, to identify the condition of self-organizing processes in the banking system and to explore possible options for influencing the level of saturation of information on the state of equilibrium and orderliness of the banking system.

2. Materials and methods

The object of the research is the banking system as an economic system of micro-level which has such features as: complexity, dynamism and ability to self-organization. During the study, methods of abstract and logical and system analysis were used in the theoretical substantiation of self-organization processes of the banking system, as well as special methods of thermodynamics, statistical physics, and methods of analogy, comparison, mathematical dependencies in particular. The theoretical basis of the obtained scientific results is well-known postulates of information theory, chaos theory, synergetics theory.

3. Results

The order in non-equilibrium systems is formed from chaos in the process of which, as a result of energy dissipation in the system, a dissipative structure arises which is associated with a significant decrease in energy of the system and an increase of the level of entropy [4]. In non-equilibrium environments, the energy loss is compensated by its inflow from the outside; just thanks to it the process of self-organization of the system takes place [5]. The basic condition for the process of self-organization of the banking system is the transfer of the system to a non-equilibrium state, which is only possible, if the system exchanges with its external environment material and energy, financial and information flows and is quite sensitive to external disturbances. It should be taken into account that under the condition of non-linearity of such processes, even very slight external disturbances due to their repeated reiteration and strengthening can generate large-scale structural changes in the system.

We consider it expedient to use the notion of relative entropy (degree of orderliness), proposed by a well-known researcher G. Forster, which makes it possible to find out the moment of occurrence of order or chaos in the system [6]. We can remind that entropy is rather difficult for understanding by the concepts of physics, because it differs significantly from other thermodynamic quantities (pressure, volume, internal energy). Understanding of its essence depends on how researchers consider a complex economic system; therefore, entropy is not purely a property of the system, because it depends on the subjective view of researchers. Consequently, taking into account the canons of information theory, the degree of orderliness of the banking system can be characterized as follows [7, 8]:

$$R=1-(H/H_m), \qquad (1)$$

where N is entropy of the source of information; H_m is the maximum possible entropy of the source of information;

R is the level of orderliness (relative entropy).

Analyzing the above formula 1, it is quite obvious, that the magnitude of the index of degree of orderliness (relative entropy) (R) is in the range from 0 to 1, therefore its boundary values (R=0) correspond to the missing order in the system and characterize the degree of entropy, or show a perfect order when R=1, and the entropy level is equal to 0 [9].

The essence of self-organization of the banking system is that the level of its orderliness increases substantially, and accordingly, the rate of change in the relative entropy (R) indicator should be positive. The growth (change) of any independent variable is identified with its differential, and then self-organization of the banking system will be possible subject to the following condition [10, 11]:

$$\frac{dR}{dt} > 0. \qquad (2)$$

Using formula 1, we will differentiate it and get inequality which will clearly indicate the preconditions for self-organization processes in the banking system:

$$\frac{dR}{dt} = -\frac{H_m \frac{dH}{dt} - H\frac{dH_m}{dt}}{H_m^2} > 0. \quad (3)$$

Taking into account that the denominator of fraction (3) will always be positive ($H_m^2 > 0$), we obtain the condition for implementation of inequality (2), that is, the condition for self-organization of the banking system [10, 11]:

$$H\frac{dH_m}{dt} > H_m \frac{dH}{dt}. \quad (4)$$

Consequently, the process of self-organization of the banking system will only be possible, if the level of entropy in the behavior of banks and the system in general concedes the growing order (relative entropy). Or. In other words: self-organization of the banking system foresees that the differential entropy (dH) must be less than the differential of maximum entropy (dH_m): $dH<dH_m$ which will mean a relative increase in orderliness in the system [10].

Analyzing the obtained inequality (4) and using the proof of G. Fester, we will consider possible cases of entropy and its impact on the ability of the banking system to self-organization, for the results we will formulate the appropriate conclusions.

1. We will assume that the maximum entropy of the banking system is unchanged, that is, H_m=const, then the derivative of the left-hand part of the inequality (4) will be zero $\left(\frac{dH_m}{dt} = 0\right)$, consequently we will get such an inequality: $\frac{dH}{dt} < 0$. In this case, the most convenient and expected result is when a fixed value of maximum entropy self-organization of the banking system is accompanied by a decrease in entropy in its internal environment, that is, the system's order is growing. Thanks to it during the course of self-organization in the banking system, the phenomenon of coherence (conformity) of its elements (banks) is revealed due to saturation of their actions and the interaction between them by effective management information. Just this forces out entropy (chaos) from the banking system.

2. Let us consider the case when entropy (the amount of accumulated in the management information system) of the banking system is constant, that is, H=const, then the derivative of the right-hand part of the inequality (4) will be zero $\left(\frac{dH}{dt} = 0\right)$, and the condition of the positive rate of change of the derivative will be: $H_m \frac{dH}{dt} > 0$. Consequently, the conclusion arises that is reasonably expected for self-organizing systems: despite of the potentially possible increase in the maximum value of the H_m entropy of the system, it restrains the current value of entropy (H) at the previous level.

Just in this the stabilizing influence of the regulatory function in the banking system is manifested, because in spite of the growth of market fluctuations and disturbances that are trying to increase chaos, the banking system retains its entropy and order at a constantly-necessary level. It should also be noted, that with the expansion of the banking system due to the creation of its new elements (banks), there may be a weakening of the management function of the system's regulation, so the issue of introducing additional measures for improvement of functioning of the banking system, that is, maintaining of its constant level of entropy, remains a matter of urgency.

3. The general case where it is possible to change both types of entropy: H and H_m in inequality (4) entails special interest. So, let's talk about the formalization of the universal property of a system that is capable of self-organization. First, it is evident that inequality (4) does not require the presence of threshold values of entropy, but at the same time, obliges to adhere to the main correlation: the product of the value of entropy in the banking system (H) and the rate of increase of maximum entropy in it (H_m), which is represented in the left-hand part of the inequality must exceed the product of its magnitude and the rate of change in the entropy of the system $\left(\frac{dH}{dt}\right)$ which is given in the right-hand part of the inequality [12]. At the same time, in the dynamics of functioning of the banking system, the reduction of some indicators can be compensated by the growth of other indicators, provided that the inequality is maintained (4).

Secondly, the agreed change of indicators is not excluded. Thus, for the left-hand part of the inequality (4) we will mark: if the current value of entropy H is sufficiently large, the rate of growth of maximum entropy $\left(\frac{dH_m}{dt}\right)$ can be reduced to the extent that such a dynamics will satisfy the requirement of the condition of the inequality (4). This conclusion is fully explained by the conceptual look at the achievement of self-organization in the system: if the value of the entropy H is too large, then the requirements for increasing the potentially maximum entropy H_m are mitigated and, on the contrary, when the rate of change in the maximum entropy of a system increases, the value of entropy H can "not hurry" behind it. For example, when the system's behavior becomes disorderly and threatens its integrity, the desire to curb and suspend the further entropy of functioning of the banking system by increasing the influence of the governing bodies through the use of their regulatory and managerial information is quite natural and obvious. Just in this the synergistic principle of I. Prigozhyna finds its reflection, when from the chaos in the system the order is formed, and evolving system undergoes restructuring and goes into a qualitatively new state [4, 9].

Similar considerations are given for the right-hand part of the inequality (4). To ensure the process of self-organization of the banking system, a situation where the maximum possible entropy H_m aims at increase and the rate of growth of entropy $\left(\frac{dH}{dt}\right)$ also remains moderate will be favorable. Also, according to synergistic postulates, a decrease in the rate of change in the maximum possible entropy of the system helps to curb the spread of potential chaotic processes and increases order in the system. At the same time, if there is a decrease in at least one of the multipliers, the other can grow within the condition of inequality (4). Therefore, in a rather chaotic functioning of the banking system, it is expedient to reduce the current entropy in the system with the help of introducing management information into the system from the controlling structures, which will result in an orderly increase in its behavior.

4. Discussion

The results, obtained by us, give the right to note that the non-linear dynamics makes it possible to reveal the essence of the process of self-organization of the banking system as a chain of separate phases of order and chaos, which consistently change their functioning during its operation. The main basis of such a process is the principle of I. Prigozhyna – "development through instability" [4].

Self-organization of the banking system involves rather complex types of its behavior: there are continuous system transitions from equilibrium to non-equilibrium states, which are known as "non-equilibrium phase transitions" in synergetic methodology [13, 14]. The main precondition for self-organization processes in the banking system is its entropy nature, which involves dynamic changes in order and chaos. In the study of the economic nature and characteristic features of self-organization of banks, it reveals itself an entropy dependence of the state of development of the banking system on the amount of management information, introduced to it.

Similar phenomena of a banking system that is capable of self-organization form the direction of further research – deepening the analysis of the effect of its functioning from the indicator of orderliness of the behavior of the system, as well as computer simulation of the loss scenarios and restoring the stability of the banking system in an unstable environment.

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