Complementary Strategic Model for Managing Entropy of the Organization

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Abstract

The energy entropy of an organization reflects its state both from the point of view of the efficiency of energy turnover and from the point of view of information entropy, which reflects the state of the organization's external environment. As a result of experimental studies, it has been established that information entropy is the main influencing parameter. The logical chain is complementary: the state of the environment, information entropy, energy entropy allows you to explore and build forecasts of the state of an organization based on forecasts of changes in information entropy under the influence of many environmental factors. For this, an approach is proposed based on considering the process of changing information entropy as a semi-Markov process, the transitional matrix of probabilities of which depends on the received control actions - the "rebuff" of the organization to the challenges of the environment. The presented results are the basis for further study of the dynamics of energy entropy and for carrying out experimental calculations for specific organizations and specific scenarios of the external environment.

Keywords 1

Information entropy; complementary strategy; energy; semi-Markov process; external environment

1. Introduction

The entropy concept of management [1] is the result of integration processes in modern science, which are conditioned, on the one hand, by the intensive globalization of society and the availability of scientific results in various directions to specialists from various fields of knowledge; on the other hand, the need to adjust the existing theories in the field of organization management, which were developed for completely different conditions of the external environment. Thus, today the entropy concept allows us to study the dynamics of organizations and improve the efficiency of their management following the challenges of the modern business environment.

2. Literature review

The development of the general theory of systems and the theory of control systems in the 50-the 60s of the last century determined two key approaches "hard" and "soft" systems approach [2]. These definitions are used simultaneously in modeling methodology and system analysis methodology. The "rigid" methodology allows for a single interpretation of the system and is effective in modeling technical systems, technological subsystems, and certain aspects of the functioning of organizations.

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"Soft" - allows for a plurality of interpretations of reality, in which individual stakeholders, with their own goals, act largely independently. According to the methodology of "soft" modeling, the model of an organizational system is a set of explicit and implicit models for its management [2]. Thus, a soft systems approach deals with the undefined requirements of the future transformation of the system, important subjective factors, the free use of problem-solving tools at the discretion of the analyst. It follows from this that the value-oriented approach is based on a “soft” systemic approach.

Organizations, regardless of their type, act according to their organizational management strategies, which are based on an orientation towards development, sustainable prosperity, and customer satisfaction. In today's competitive environment, such complementary strategies are often designed to maintain or create a competitive advantage vis-à-vis other organizations or the competitive value of products. When carrying out activities, organizations must adapt their strategies to the uncertainty of the external environment and internal dynamics, as well as find ways of effectively investing management resources to timely achieve the planned strategic indicators.

The developed complementary strategies must be implemented taking into account the real state of affairs, but they do not always have the opportunity to be carried out as planned. It is necessary to constantly adapt the strategy, bringing it in line with the actual requirements of the uncertain environment and the actual position of the organization, even if initially it was developed taking into account all internal and external requirements.

Regardless of the criteria for the optimality of strategies, they are influenced by the goals of the organization, their structure, the capabilities of the organization, and its environment. Therefore, we can offer three mechanisms of implementation of the strategy.

The mechanism of the first type consists in the establishment of certain principles and/or the introduction of an appropriate structure for the effective implementation of day-to-day operations, the adoption of major and minor decisions to increase the level of professionalism and culture of the organization's employees. Such a mechanism is being designed to create a well-managed organization.

The mechanism of the second type is aimed at the development of new techniques and mechanisms for their implementation, which an organization can apply in work with both technological processes (equipment and technology) and managerial (business processes and business models).

The third mechanism defines the mechanism for the cyclical creation of new values, such as products and services that provide organizations with learning, which, in turn, determines the existing values of the organizations themselves.

To give the strategy a concrete and practical form, it is necessary to form an adequate and predictive strategy based on several project missions and create programs based on them. The program, therefore, will consist of separate projects, each of which is presented in the form of structures and descriptions of the implementation process, which together will be aimed at realizing the program's mission.

Also, the methods for defining the mission can take various regulated and ad hoc forms that are not tied to specific deadlines. The program team turns the mission into scenarios through mission detailing and builds a program based on an acceptable scenario alternative as a group of projects using program architecture control. It is important from the very beginning to determine the procedures that would regulate at what stage the mission of the program from a variety of alternatives will turn into a certain scenario, when and how the group of projects that make up the program is determined, who makes and who approves the necessary changes. To achieve this, it is necessary to make the life cycle of the program manageable and regulate the procedures for examining alternatives and making decisions within the life cycle of this program in an uncertain environment.

The life cycle of a program, which is formed "from top to bottom", is defined at the stage of execution as the union of the life cycles of projects that make up the program. In a bottom-up program, in which the life cycles of individual projects are built from the bottom up, they are often difficult to adapt to the mission requirements of the value creation program, and also to be tied to the program's time and resource constraints. Therefore, the life cycle of each project must be developed in conjunction with the life cycle of the program.

Contextual analysis is a methodology for understanding and presenting a holistic picture of a program. This analysis is used to interpret the mission mainly in cases where the interacting multiple values of the program are expressed in abstract terms. Uncertainty of this type has caused and is causing numerous losses and additional costs. Misunderstandings arise from the fact that the context of the mission cannot be fully disclosed due to the lack of development of the corresponding methods. Therefore, to describe the mission, it is necessary to develop basic rules for its interpretation.

In context analysis, the rules that form the system, or the corresponding methodology for shaping the overall context, should be presented visually, and the requirements of the customer or the planner (the so-called "program planner") should be implemented as much as possible.

The first step in the universalization of entropy was the use of information entropy (Shannon's entropy) as a precautionary measure and uncertainty in the organization as a whole, and for a specific project in particular. Further development of the idea of applying entropy to organizations was associated with the justification of the universalization of the second law of thermodynamics - the law of conservation of energy, and in particular, its validity for systems of any nature, including organizations.

However, despite some attempts to use entropy as a measure of energy dissipation for organizations, it can be stated that there is a practical lack of sound concept, theory, and appropriate methods of applying entropy in the management of organizations. Also, different types of entropies of organizations are in a certain relationship, which requires an integrated consideration of their behavior and dynamics, which in principle is absent in modern research.

The need to use the entropy concept in the management of organizations is because the format of the existing theoretical basis, which is based on such categories as "efficiency", "value", "success", "sustainability" does not allow, on the one hand, in many situations to explain success or efficiency, on the other hand, to justify the necessary measures to ensure success and resilience in today's turbulent environment, where anomalies prevail over the generally accepted in the theory of management organizations.

This study aims to form a new methodology that develops the ideas of a value-based approach in the management of project-oriented organizations, which is based on a system of some order with energy and information flows, which leads to different types of interrelated entropies that affect project sustainability and success. - oriented organizations. Thus, "entropy" characterizes the state of the organization, "sustainability" determines its viability, "value" acts as a goal and result, and the project methodology forms the basis for managing the activities of companies, enterprises, and organizations.

The entropy concept of managing organizations transforms the classical concept of "sustainability" as applied to organizations, "transferring" the classical corridor of sustainability to the plane "time - entropy" [2].

Within the framework of this concept, entropy acts as a universal and integral indicator of the state of the organization [3], developing the ideas of using entropy as an indicator of the state of the project, which was expressed in [4-8]. At the same time, if earlier in works (for example, [4]) informational (Shannon's) entropy was used, then in the entropy concept [1, 3, 9] the tendency “informational entropy - energy entropy” is considered. Thus, energy entropy is the main indicator of the state of both an individual project and a project-oriented organization as a whole, which is based on information entropy - a fundamental indicator of the efficiency of business processes from the standpoint of order in the organization and the impact of the organization on the external environment. Information entropy is a measure of uncertainty in which decisions are made and the business processes of the organization.

Structural entropy characterizes the orderliness of the organization as a system, so the "coherence" of business processes of the organization and management procedures, adequate allocation of resources, etc. determine the degree of the orderliness of the organization, characterized by structural entropy.

Energy entropy in its classical sense is a kind of "shadow" of the organization and is associated with energy dissipation (

The prerequisites for the formalization of energy entropy were the works [11-18], in which the legitimacy of using the second law of thermodynamics to systems of a different nature, including organizations, was substantiated. But the energy entropy of organizations was formalized in [3], where the following regularity is proposed for its assessment:

$$S = \frac{(U - E^{in}) \cdot U \cdot \eta^{et} \cdot H}{U + E^{in} - E^{ex}}, \tag{1}$$

where S - energy entropy, H - information entropy, U - total energy (capital) of the organization; E^{in} - energy inflow, E^{ex} - energy outflow (free energy directed to work), η^{et} - an indicator of the reference energy efficiency of the organization.

Note that (1) is formed from the second law of thermodynamics, the temperature is taken:

$$T = \frac{\mu}{H} = \frac{\mu}{-\sum_{k=1}^{K} p(A_k) \cdot \ln(p(A_k))}, \tag{2}$$

where

$$\mu = \frac{\eta}{\eta^{et}}, \eta = \frac{U + (E^{in} - E^{ex})}{U}. \tag{3}$$

The interrelation and unity of information entropy and energy entropy, on the one hand, determines the task of studying this interrelation under various conditions. On the other hand, there is a need for research and development of tools for targeted impact on information entropy to form the required level of energy entropy from the standpoint of the organization's sustainability. Note that in most works devoted to the use of information entropy in project evaluation (for example, [5-8]), as a structural unit of project-oriented organizations, the focus is on the essence of evaluation and the evaluation method. But there are practically no studies related to the formalization of the dynamics of information entropy, which is necessary in connection with its influence on the indicator of the state of the organization - energy entropy. Thus, the formulated ideas and provisions of the entropy concept of managing organizations require their development in the indicated direction. The foregoing determined the purpose and objectives of this study.

3. Study of the behavior of energy entropy

Based on (1), we investigate the behavior of the organization's energy entropy at various levels of the main influencing parameters. Figure 1 shows the dependence of energy entropy S on information entropy H and total energy U for different values E^{in}.

The figure clearly illustrates that with an increase in the total energy U, the energy entropy increases significantly if the level of incoming energy E^{in} is relatively low. In this case, the energy entropy becomes negative at a significant level E^{in}, which is many times higher E^{ex} and turns out to be even higher than it could be with “ideal” energy efficiency η^{et}.

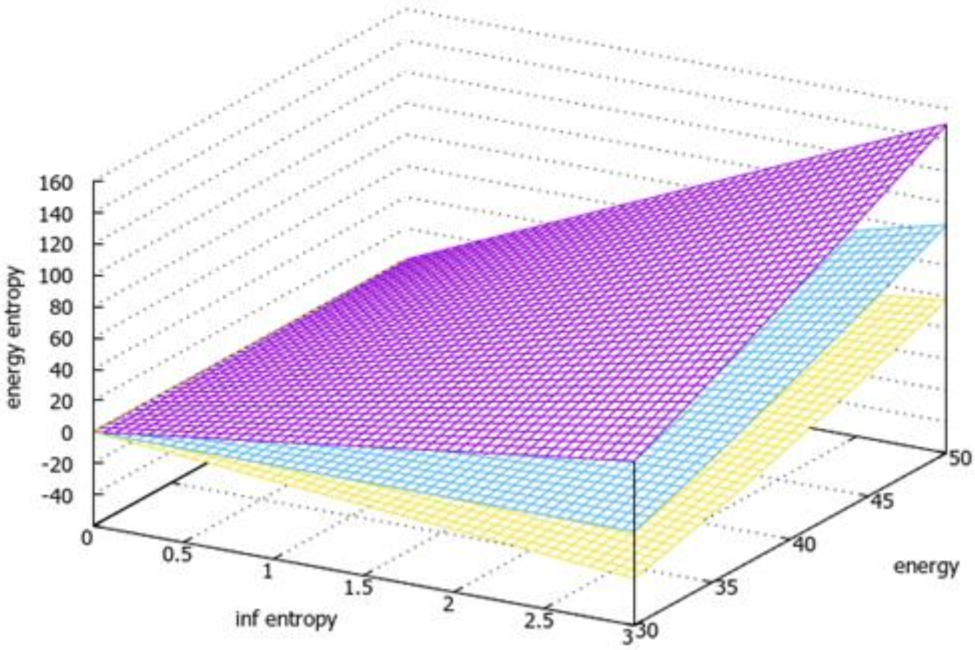

Figure 1: Graphical representation of the dependence of energy entropy on information entropy H and total energy U for different values E^{in}.

Such a situation is quite the case for mega-successful (at a certain time interval) organizations - when, for example, their product is so in demand that it is sold at a multiply inflated price, bringing super-profit to the organization. This is consistent with Schrödinger's thesis that negative entropy is what a living organism feeds on. These considerations are also true for organizations whose success and vital activity depends on their ability to “absorb” negative entropy (negentropy).

The dependence of energy entropy on the level of input energy E^{in} for different values E^{ex} is shown in Fig. 2, where it is seen how significantly the energy entropy increases at $E^{in} \to 0$ a higher level E^{ex}. The two-dimensional image in Fig. 3 shows more clearly the dynamics of energy entropy during growth E^{in}.

As a result of the research, the following conclusions can be drawn:

- the higher the level of incoming energy E^{in} (and, accordingly, the level of energy efficiency), the lower the energy entropy as a characteristic of the measure of "uselessness" of the organization's outgoing energy;
- a lower level of outgoing energy E^{ex} (free energy) at the same level of incoming energy E^{in} provides higher energy efficiency and, as a consequence η, a lower level of energy entropy;
- the higher the level of total energy U at the same levels of incoming-outgoing flows, the higher the energy entropy; the organization in such a situation use a smaller part as free energy than at a lower level of total energy.

Another conclusion on the behavior of energy entropy, which can be made based on analysis (1): an increase in energy U with a decrease in the degree of disorder (information entropy) H and with an increase in free E^{ex} and incoming energy E^{in} will ensure not only the maintenance of a certain level of energy entropy but also its decrease. Conversely, an increase in total energy without maintaining or increasing the share of free energy leads to an increase in energy entropy.

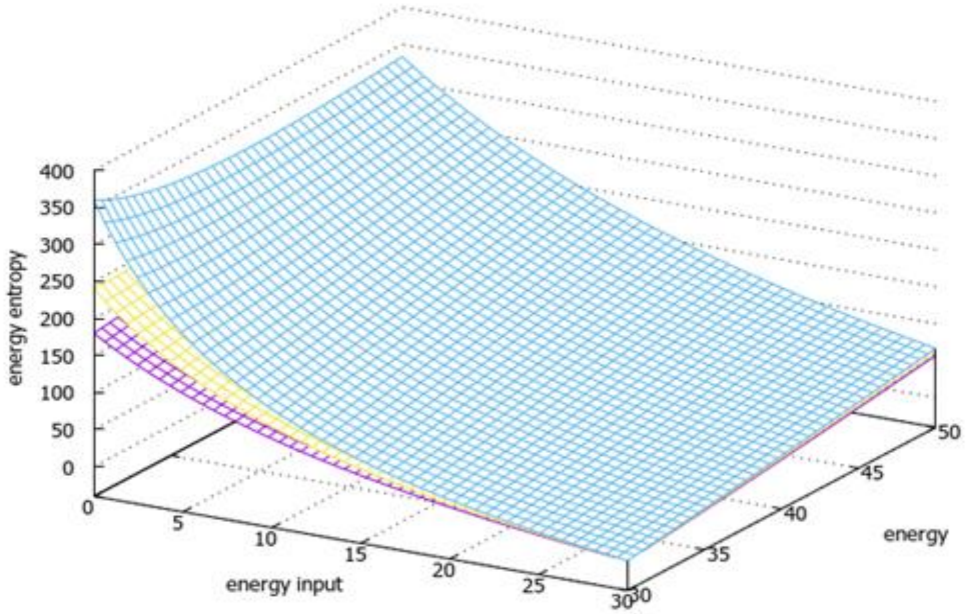

Figure 2: Graphical representation of the dependence of energy entropy on incoming energy E^{in} and total energy U for various values E^{ex}.

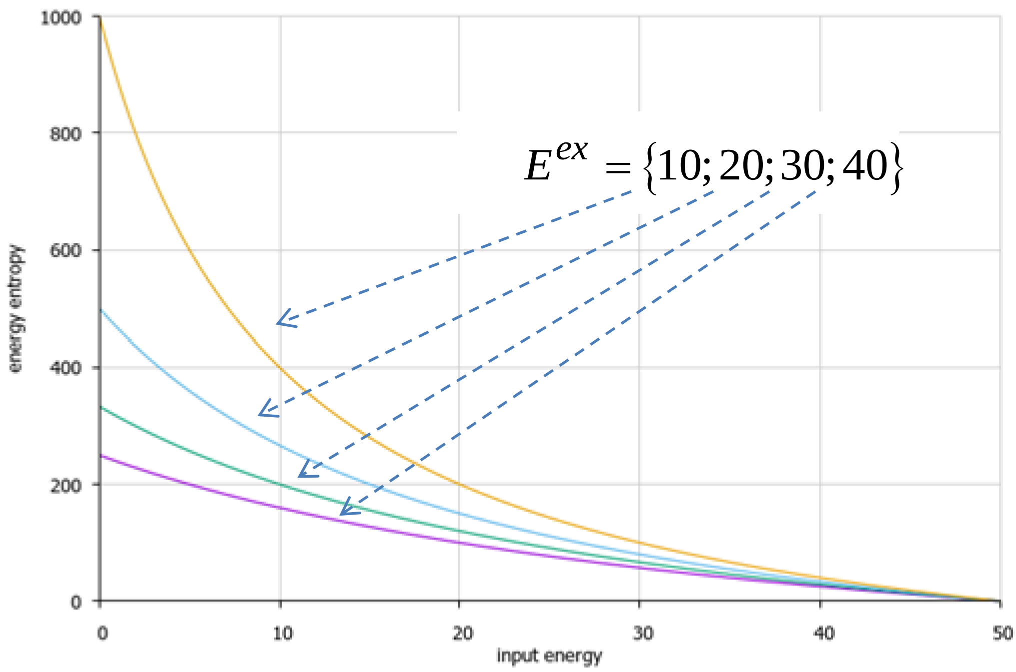

Figure 3: Graphical representation of the dependence of energy entropy on incoming energy E^{in} for various values E^{ex}

Note that the construction of graphical dependencies based on (1) allows us to investigate the critical values of the main energy parameters of organizations when setting a certain (critical) level of energy entropy (Fig. 4).

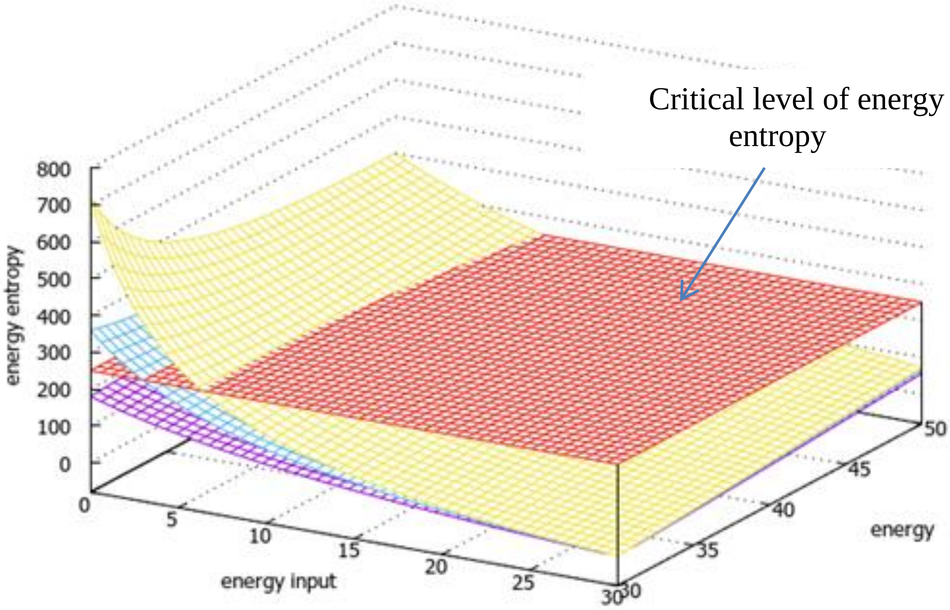

Figure 4: Illustration of determining the critical values of the energy parameters of the organization

This approach can be used in the processes of managing organizations to control their conditions and establish measures to reduce energy entropy.

4. Model of the dynamics of information entropy of the organization

As noted in [3], the informational entropy of an organization reflects the ability to "organize" and "control" (to a certain extent) the external environment. To assess the information entropy of an organization from the standpoint of the entropy concept, random events $A_i, i=\overline{1,n},$ are used, the essence of which is that the main parameters of the organization's energy exchange with the external environment [1] E^{ex}, E^{in} have taken certain values, therefore:

$$P(A_i)=P(E^{ex}=E_i^{ex} \wedge E^{in}=E_i^{in}), i=\overline{1,n}. \tag{4}$$

Thus, the information entropy of the organization:

$$H=-\sum_{i=1}^{n} P(A_i)\cdot\ln(P(A_i)). \tag{5}$$

The information entropy of the organization (5), on the one hand, changes under the influence of the targeted impact of the organization. On the other hand, a significant number of environmental factors have an almost unpredictable effect on the conditions in which the organization operates. This is especially true for the current situation.

So, the possible results of the organization's activities (energy exchange with the external environment) can be presented as a process of changing states (chain of states) from the point of view of information entropy; the principal view of this process in the form of a graph is shown in Fig. 5.

Each state $S_k, k = \overline{1, K}$ is a certain level of informational entropy of the organization. Thus, each state S_k is described by a set:

$$S_k : \left\langle H_k; A_i, P(A_i), i = \overline{1, n} \right\rangle, \tag{6}$$

where H_k is determined by (5). The list of possible states of the organization from the standpoint of information entropy can be compiled as a result of analyzes and generalization of experience, as well as scenarios for the development of the external environment and the organization itself. This takes into account those actions that the organization has already taken or is taking to influence the external environment.

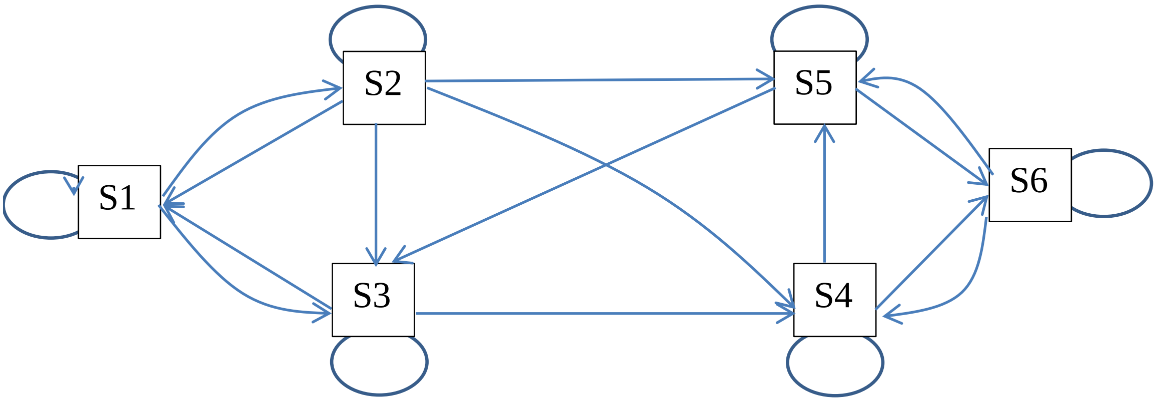

Figure 5: An example of a process for changing the information entropy of an organization

Thus, we have a chain of possible states of the organization, which are formed under the influence of a turbulent environment. The transition from one state to another at each moment does not fundamentally depend on the history of events but depends solely on the current state of the organization and the impact on the environment. Some states may be returnable, some may not. This is determined by the specifics of the situation under consideration and the states themselves. At the same time, finding itself in any state, the organization, of course, will take any actions, each of which affects the process under consideration. Thus, we can assert that the considered process of changing the state of the organization from the standpoint of information entropy (in fact, the external environment of the organization) is a semi-Markov process, which, unlike the Markov process, has a certain effect applied by the organization in each state, which changes the probabilities of the transition of information entropy from one state to another. *We are talking about changes in the probability distribution of the results of the organization's energy exchange with certain probabilities.* Thus, the probabilities of the states under consideration at a time $t = 0$ can be established $P_k(0), k = \overline{1, K}$. Besides, transition probabilities $0 \leq q_{kj} \leq 1, k, j = \overline{1, K}$ can be established: which characterize the probabilities of transition from one state to another and form a transition matrix $\left[q_{kj} \right]$. According to the theory of Markov processes

$$\sum_{j=1}^{K} q_{kj} = 1, k = \overline{1, K}. \quad (7)$$

Let the time be discrete, thus, at each moment $t = 1, 2, 3...$, the information entropy with a certain probability either remains the same or passes into another state.

Based on the Kolmogorov-Chapman equation [12], the probabilities of the considered states at each moment can be determined.

$$P_j(t) = \sum_{k=1}^{K} P_k(t-1) \cdot q_{kj}, \; j = \overline{1, K} \quad (8)$$

Let a set of control actions be established for each state of the organization's information entropy $M(S_k), k = \overline{1, K}.$ Then the implementation of one or another control action leads to a change in the transition probabilities, thus, in fact, the matrix of transition probabilities has the form $\left[q_{kj}(M_z) \right], M_z \in M(S_k).$

So, the process of changing the information entropy of an organization can be identified as semi-Markov. The change in information entropy affects the energy entropy of the organization.

Thus, the study of the model of the process of changing information entropy will make it possible to predict not only the state of information entropy but also energy entropy, as an integral indicator of the state of the organization.

Conclusion

The energy entropy of an organization reflects its state both from the point of view of the efficiency of energy turnover and from the point of view of information entropy, which reflects the state of the organization's external environment. According to the entropy concept, the nature of the change in energy entropy under the influence of the main parameters that determine it was investigated. For this, appropriate experimental studies were carried out, which made it possible to conclude that information entropy is the main influencing parameter. "Invisible" entropy also forms a barrier in the form of a level at which the organization "collapses". For information entropy, the barrier is the level of uncertainty, after which the organization is in principle unable to make adequate decisions and operates in complete chaos and uncontrollability of the external environment. As entropy increases, the temperature of the organization decreases, i.e. the level of "heating" of the controlled part of the environment decreases, which leads to activity in conditions of complete uncertainty. In this case, there may be high energy efficiency of the organization - that is, the organization does not control anything in the external environment, but due to favorable conditions for a specific time it becomes possible, for example, to sell goods at inflated prices, which leads to increased energy efficiency. Thus, the logical chain: the state of the environment, information entropy, energy entropy allows you to explore and build forecasts of the state of an organization based on forecasts of changes in information entropy under the influence of many environmental factors. For this, an approach is proposed based on considering the process of changing information entropy as a semi-Markov process, the transitional matrix of probabilities of which depends on the received control actions - that is, the organization's "rebuff" to the challenges of the environment. The presented results are the basis for further study of the dynamics of energy entropy and for carrying out experimental calculations for specific organizations and specific scenarios of the external environment.

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