

Entropy Model Management of Organization

Irina Markina and Dmytro Dyachkov

Poltava National Technical Yurii Kondratyuk University

Abstract: The article deals with the evolution of "entropy". The economic aspect of this concept and its disorganizing effect as stochastic factors in the process of socio-economic system particularly its information component is defined. The features of entropic approach to the informational management needs of the organization within which entropy acts as a universal parameter determining the information capacity of the organization is discussed. On the basis of methodology of the system the analysis of extrapolation additive properties of entropy in different domains on the functioning of the socio-economic system is conducted. The construction of entropic model of management of the organization is done and held its formal description based on the definition of entropy subject management, facility management, external entropy (micro and macro) and internal environment of the organization, the entropy of an information system to determine the level of information and the possibility of it.

Key words: Entropy • Information • Organization • Negative entropy • Entropy model of socio-economic system • Resource • Information system • Information potential

INTRODUCTION

Problem Definition: The processes of creation and use of the information resources being a fundamental for functioning of an enterprise nowadays require specific approaches to their organization and development. Adequacy of incoming information content to users' objectives, its completeness, timeliness and a form of presentation are the basic criteria of profitability and efficiency of an enterprise's activity.

In the context of the market zone integration determination of information demand which is a decisive factor for an organization's resource potential formation becomes of great importance. Unavailability of information with a necessary volume and quality, which generates stochastic functioning of a socio-economic system, is characterized by a notion of information entropy [1].

Under the conditions of progressive informatization of the national economy growth of unstructured and weakly structured problems of an organization management is conditioned by a low level of information support of a management system and deepening influence of entropic effects. Reducing efficiency in use of the management system information support and growing entropy level give rise to growth of the information

demand at the organization, the management system, or a management object level [2].

In a general sense, the "information demand" should be understood as a need for information, which requires satisfaction of users' needs and is expressed as an information request [3]. Meaning content of the term of a management "information demand" and its peculiarity lies in the fact that each of the management levels is characterized by an own set of functions which can be solved by means of a definite quantitative and qualitative level of the information resources. Therefore, the management system information demands may be satisfied through reduction of the level of entropy within an information network of an organization.

The mentioned management approach is based on the principles of the classical information science theory, is focused at uncertainty and is expressed by entropy. Though description of uncertainty as a universal criterion of the information demand a new class of management models formed on the analogies with unforeseeable ever-changing natural phenomena can be distinguished.

Considering an organization as a complex probabilistic socio-economic system it is necessary not only to develop its entropic (information) model but also to determine the use pattern of the latter.

Analysis of the Latest Researches and Publications:

Due to the entropic approach to the management processes informatization and the level of uncertainty in an organization a problem of the information demand definition and determining entropic balance mechanisms becomes of urgent importance. The analyzed publications evidence that description of behavior of the complex systems, including socio-economic ones, in the context of entropy faced methodological difficulties.

The works of famous physicians Clausius R. and Boltzmann L. [4] are dedicated to problematics of the notion of “entropy” in definite research domains. Emergence of “information component” in the mentioned definition owes to engineer Hartley R. [5] and mathematician Shannon K. [6]. Brillouin L. who considered information entropy as a degree of information unavailability and information itself as a negative supplement of entropy, its negative value pointed out existence both of formal and semantic interrelation between information and physical entropy. He defined information as negative entropy [7].

In his works Zarakovsky G. mentioned about the principal possibility to use entropic characteristics along with other methods of analysis of economic processes [8]. Engineering psychology knows examples of efficient use of the entropic methods of research of the informational interaction processes between a man and a machine [9].

The following local scientists and well-known foreign theorists made an important contribution to the development of entropic approach to the organizational management: Prangishvili I., Osipov A., Uvarov A., Krianiev A., Matokhin V., Klimanov S., Prigozhin I., Ashby W. and other.

Parts of a Common Problem Which Were Not Settled

Previously: Existence of a wide variety of issues dedicated to peculiarities of the entropic approach to management of the technical, mechanical, biological and socio-economic systems, insufficient level of substantiation of use of its additive properties in respect of management of an organization as a socio-economic system were a background for determining the research objective.

Problem Definition: The article is aimed at determination of the principal characteristics of information and thermodynamic entropy and designing of an entropy model of an organization management.

Summary of Essentials: Due to universal properties of entropy its use goes beyond the scope of thermodynamics. One of the challenging directions of modeling complex stochastic socio-economic systems behavior is based on use of additive property of entropy especially for determining level and quality of available information necessary for an organization and for satisfying information demands of management entities.

In order to understand the entropic approach to development of new theoretical and methodical fundamentals of the economic processes management it is advisable to start with comprehension of the essence and interpretation of the notion of entropy.

Entropy, from Greek - turn, transformation. In physics entropy is a degree of probability of actualization of any macroscopic state. Entropy is a physical value from the section of thermodynamics, which characterizes repeatability of a process or impossibility of its repetition. Natural sciences determine entropy as a degree of disorder in a system. The information theory states that entropy is a grade of incompleteness, uncertainty of knowledge. The notion of social entropy reflects a nature of chaos in human life; of chaos, which can undergo modifications at different levels of destruction of an individualized human life, which is the world of culture. The historical aspect of entropy is used for explication of the phenomenon of alternate version of history (historic process invariance and variance). From the point of view of cybernetics entropy is a degree of information randomness, uncertainty of occurrence of any symbol of a primary alphabet.

By using a system analysis methodology and taking into consideration multivariability and semantic peculiarities of the concept of entropy, in general sense it can be determined as loss of the regularity principles, disappearance of structure due to chaotic character of elements, as a grade of system inner irregularity.

Any open system has so called critical organization level. If a system’s regularity is lower than this level then the order-increasing processes prevail in it, however if higher the processes which generate disorganization (chaos) are prevalent. The mentioned processes during their run create equilibrium and the system state becomes stable.

Any kind of system can be considered as a set of trivial system elements or subsystems. Nevertheless this set includes elements which go beyond the scope of structure and act as a source of dissipative factor which in its turn is the principal source of information necessary for a system functioning.

The concepts of information and entropy appeared to be very useful for characterization of the properties of deterministic chaos. In this context, information is in charge of a system order and entropy – of a system disorder that prevails in it.

Entropy is a fundamental property of any of the systems with ambiguous or probabilistic behavior [10]. The notion of entropy is versatile and allows for well-defined interpretation with use of terms of the applicable subdiscipline. Use of this category progressively grows in the modern science for description of structural organization and disorganization, a grade of destruction of relations between a system elements. Therefore, entropy may play a role of a universal parameter and suits ideally for solving the analyzed problems relating to behavior of the complex stochastic systems.

Thus, extrapolation of entropy phenomena incidental to the thermodynamic systems to functioning of the socio-economic systems will allow determining specific nature of regularities of interrelationships between information and entropy.

First of all, it is necessary to mention that in the thermodynamic systems entropy is a parameter describing the equilibrium state of a thermodynamic system (the more the system is “balanced” the higher is entropy). In the socio-economic systems entropy is a parameter, which determines a level of degree of internal disorder (chaotic state).

The second peculiarity is that entropy in the thermodynamic discrete systems is a function of energy, volume and amount of substance. In a socio-economic system, entropy is connected with a level of growth of the information demand, a level of informational uncertainty.

Thirdly, additive nature of entropy is limited to the fact that a system “macro state” depends on a number of probable “micro states” (microscopic states), which are in agreement with their properties. This gives rise to a quasi-equation, which determines that a sum of entropy of system elements is equal to entropy of the system as a whole.

The fourth, in the thermodynamic systems the “Maxwell's demon” paradigm may be subject only to abstractive analysis meanwhile in a socio-economic system and an information subsystem it is possible to mark off various information resources in practice and express entropy in terms of quantity.

The fifth peculiarity is that the communication theory states that any additional information increases negative entropy of a system. For the socio-economic systems

growth of information volume as such will not always facilitate decrease of entropy. A system negative entropy will surely be increased only due to information of stipulated quality and its incoming in a certain moment.

Entropy increases irreversibly only in closed systems that have no interaction with other systems and external environment. But in open systems behavior of entropy may vary: increase, remain constant or even decrease. The reason of such different behavior of entropy can be explained by the fact that contrary to the closed systems having only own constantly-increasing entropy the open systems have several types of entropy:

- Own entropy which like in the closed systems tends to constant increase;
- Entropy which is brought into an open system from external environment (imported entropy);
- Entropy which is brought into external environment from an open system (exported entropy).

Besides in the general case it is necessary to take into account free negative entropy which counterbalances increase of the own entropy and in its influence on a system is equivalent to “export” of entropy.

Socio-economic formations are open systems in which growth rate of entropy depends on quantity and complexity of interrelations with external environment. That's why the higher the number of influencing factors the faster transformation of low-entropy objects into high-entropy ones.

In order to determine a principle of this mechanism it is necessary to analyze it just in common interaction between a system and a supersystem in the terms of “internal environment” and “external environment” of an organization.

It is rational to consider an entropy model of an organization management in the context of its main components: internal environment, external environment (macro- and microenvironment), a management entity (a decision maker) and an information system of an organization.

Taking into account influence of direct and indirect external environment factors on functioning of a socio-economic system an information system of an organization forms an external environment model at the level of available external environment data. Given that a management entity does not have an opportunity to determine the necessary information concerning influencing factors in a particular situation to the full

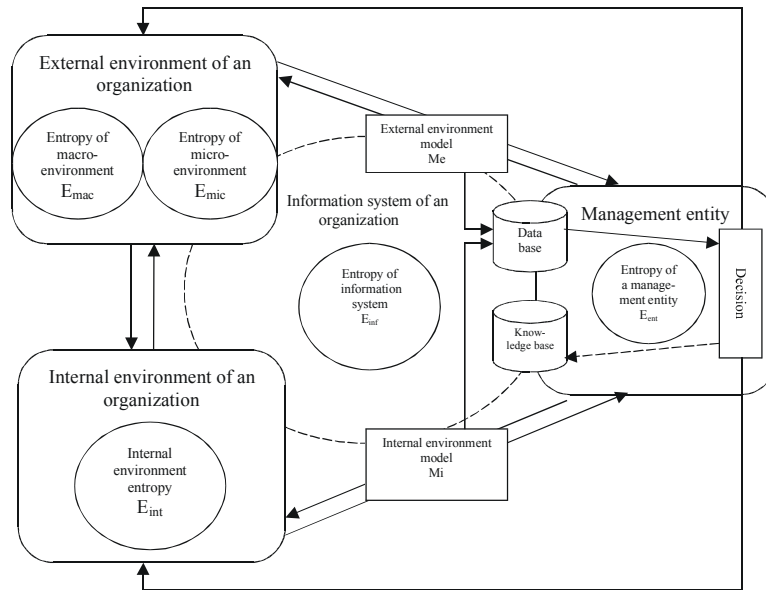


Fig. 1: Entropy model of organization management [designed by authors]

extent, in order to minimize the choice of the most effective management solutions occurs an information demand expressed in increase of the microenvironment entropy and the macroenvironment entropy of an organization.

In a similar way increase of an organization internal environment entropy is being conditioned and a model of internal environment is being formed. Data necessary for taking managerial decisions are formed through involving an organization information system and on the basis of the external and internal environment models; the mentioned data are represented by a database functioning as an information resource and a part of information potential for a management entity (a decision-maker). In this case, it should be taken into account that the information system itself is an open system and also has a definite level of uncertainty, i.e. entropy of the organization information system (Fig. 1).

Change of an entity's entropy comes along due to the received information. In the ideal case it brings about decrease of its entropy which influences on the grade of satisfaction of the information demand and, as a result, on decrease of a range of alternative managerial decisions.

Therefore it is possible to establish a quasi-inequality according to which entropy of a management entity is less or equal to sums of entropy of external and internal environment of an organization:

$$E_{ent} \leq E_{int} + (E_{mac} + E_{mic}), \quad (1)$$

where,

E_{ent} – Entropy of a management entity;

E_{int} – Entropy of an organization internal environment;

E_{mac} – Entropy of macroenvironment of an organization external environment;

E_{mic} – Entropy of microenvironment of an organization external environment.

Negative entropy characteristic of information potential relatively to management objects is expressed in its ability to filter incoming information flows and transform the same into information resources represented by collected, processed, sorted, accumulated and generated information about a certain object and its features (state of the object).

Entropy of a management entity is determined by the level of its theoretical and practical knowledge, its competence.

In the course of taking a managerial decision a management entity performs definite actions aimed at decrease of uncertainty in relation to the state of a specific object or an organization as a whole. In this case, an equation describing interrelation between entropy, information, competences, skills and efforts (work) of a management entity will be as follows:

$$\Delta E_{ent} = f\{\Delta I\} + \{\Delta P\}, \quad (2)$$

where,

ΔI – Information flows in an organization;
 ΔP – Competences, skills and efforts (work) of a management entity.

The equation shows that decrease of entropy of an entity is due to increase of volume of information mastered by the entity, its competence and skills to use information.

Entropy of an information system is a function from a set of range of entropy values of a management entity, entropy of external environment and entropy of internal environment.

$$E_{inf} = f(\{W(E_{ent})\}, \{W(E_{int})\}, \{W(E_{mac})\}, \{W(E_{mic})\}), \quad (3)$$

where,

E_{inf} – Entropy of an organization information system.

Constant growth of the information demand causes necessity in accumulation and effective use of information resources, generation of information potential of organizational entities, which acts as a main precondition for information entropy decrease.

The open systems by getting energy, substances, information from external environment decrease their own entropy and increase order and level of their structural organization mainly due to growth of entropy in external environment.

If any change of an organization as a socio-economic system takes place change of external environment entropy (ΔE_{env}) may be expressed by the following equation:

$$\Delta E_{env} = \Delta E_1 + \Delta E_2, \quad (4)$$

where,

ΔE_1 – Change of a system entropy due to exchange (getting) of information from external environment by the system;

ΔE_2 – Change of entropy as a result of processes happening inside the system itself without influence on the part of external environment.

If ΔE_1 change due to influence of external environment through information tends to disequilibrium decrease, creation of new opportunities, ΔE_2 change unwittingly and constantly tends to disequilibrium growth, getting of balance.

A management entity should decrease uncertainties in regard of a system as a whole, generate variety of the system possible states and in the ideal case bring the full range of the system possible states determined by environment influence or action of internal factors to an intended state.

Behavior of resulting entropy depends on change rate of its constituents. That's why resulting entropy may act in whatsoever manner: to grow, to decrease or to remain constant.

Entropy of an organization as a management system is indicative of the grade of structuredness and orderliness of information about an economic entity. Proceeding from the statements made by Shannon K. and Boltzmann L. and being guided by the Law of requisite variety in the management systems in the works of Ashby W. [11], general entropy of a socio-economic system may be determined as absence (chaotic, disordered, disorganized nature) of information about the range of its states and their properties.

$$E = -I\{S\}, \quad (5)$$

where,

E - General entropy of an organization;

I - Information contained in the organization;

S - State of the organization.

Conclusions and recommendations for further research in this area. The idea of inseparable unity of management processes, information and entropy, synergy and optimization of information management, aimed at achieving of a qualitatively new state and development of an organization account for formation and growth of information potential, which can be defined as a major factor in the "struggle" against uncertainty, disorganization and disorder of elements of a socio-economic system.

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