

# Innovative abilities of entrepreneurial structures of the agro-industrial complex in the parameters of economic security: entropy approach

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**Abstract.** Digital platforms are acquiring the status of a new trend in the process of innovative infrastructure automation for business structures of the agro-industrial complex (hereinafter referred to as AIC). Innovative changes lead to an increase in the entropy of the system and a decrease in its stability. The purpose of the work is to develop methodological aspects of the innovative abilities of entrepreneurial structures in the agro-industrial complex in the context of economic security by removing information uncertainty. In the course of the study, the methods of systemic and comparative analysis, entropy analysis, network theory and innovations were used. Based on the study of the development trend "digital agriculture" and the information security of agro-industrial complex business structures as the main component of economic security, it has been established that there is a growing information uncertainty. The result of the study is a developed flowchart for the development of innovative processes and changes in entropy associated with the integration of resources into the system of innovative infrastructure of business structures of the agro-industrial complex.

## 1 Introduction

Among the strategic threats to national security, it should be especially noted: the existing vulnerability of various types of information; isolation of significant segments of the domestic economy from international trade and its lack of competitiveness; export and raw material orientation; lagging behind in the development of innovative products and the promotion of promising technologies. Under these conditions, the adequacy and promptness of response to the rapidly changing challenges of time and the exogenous environment increases significantly, requiring timely action, including in the innovation

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sphere. In turn, issues related to the internal abilities to implement innovative activities at all hierarchical levels acquire increased importance.

In the theory and practice of strategic management, the term "innovative abilities" began to be used, which characterizes the feasibility of entrepreneurial structures to organize and implement an innovative process that is focused on the formation of scientific and professional competencies, technological reserves and creative potential in the field of innovative management. Therefore, knowledge of innovative abilities in management will allow the introduction of new ideas, which may favorably affect the change in the position of an economic entity in the industry.

It should be noted that Russia in the Global Innovation Index - 2022 took 47th place out of 132 countries compared to the previous year, it increased by 3 points. According to the GII-2022, the country's innovative potential is used by 61% [1].

Despite the fact that the level of innovative activity of organizations in agriculture in 2021 amounted to 8.1% [2], one of the sectors of the economy most prone to technological innovation has recently been precisely the agricultural sector. This circumstance is confirmed by the adopted normative legal acts that determine the sectoral scientific, technical and innovation policy. Moreover, the question of the possibility of an innovative breakthrough is transferred from the level of industries to the level of economic integration of a group of enterprises.

Currently, one of the main trend vectors for the development of agricultural enterprises, positioned as a breakthrough innovation, has shifted towards high technologies and new business models. According to the concept of the Scientific and Technological Development of Digital Agriculture "Digital Agriculture" in Russia, a breakthrough innovation should be understood as "an integrated information system that provides multilateral user interactions for the exchange of information and values, leading to a reduction in overall transaction costs, optimization of business processes, and an increase in the efficiency of the chain of supplies of goods and services" [3].

"Smart agriculture" in Russia currently has seven areas that reflect the digital transformation of agriculture in the context of scientific and technological progress. At least six projects of a full innovative complex scientific and technical cycle are envisaged to be involved in agricultural production. These projects include end-to-end digital systems of the classes "Digital technologies in the management of the agro-industrial complex", "Digital land use", "Smart field", "Smart garden", "Smart greenhouse", "Smart farm", based on modern competitive domestic technologies, methods, algorithms" [4]. Exceptionally innovative abilities are responsible for the ability of agricultural enterprises to implement such digital agricultural solutions based on the available innovative resources.

Innovative formations of entrepreneurial structures in the agro-industrial complex, based on the automation of most agricultural processes and the use of digital tools and using the online exchange of basic data between subjects of the information sphere, are aimed at monitoring the full cycle of agricultural production, ensuring the safety of activities. With their help, real-time processing and transmission of data on the state of each object and its environment, the collection of which is carried out using equipment and sensors for monitoring the state of cultivated crops, animals, soil parameters and microclimate indicators, the presence of pests, etc. Innovative abilities are largely determined by the effective activity of the entrepreneurial structures of the agro-industrial complex and the level of their technological development. The direction of innovative development makes it possible to form new priorities for the agricultural sector of the economy, which can give the agro-industrial complex a high-tech look. At the same time, the innovative development of entrepreneurial structures in the agro-industrial complex is presented as a phenomenon consisting of a set of information transformation processes determined by the implementation of innovations in a real chronotope.

## 2 Materials and methods

For business structures of the agro-industrial complex, in the context of ensuring economic security, innovations initiate and carry threats to the innovation process that are significant for economic security. The main task of the economic security management system is to anticipate and prevent all kinds of threats. At the same time, one should take into account their complex nature in the dualism variant due to the presence of threats of an exogenous nature (changes in technology, institutional factors, turbulence in the external environment, breakthroughs in the innovation activities of competitors) and endogenous nature, due to the presence of serious problems, as a rule, in the organization of innovation management.

Therefore, the issues of managing innovative abilities and economic security seem to be relevant.

The task of management is to build, promote and develop the innovative abilities of entrepreneurial structures as a special functional area of business. The subject of innovative management of an organization is represented by a set of functional components, without which, in fact, it is not possible to initiate an innovative process and manage it. In turn, these components are included in innovative abilities in the form of the following key components (resources): information (digital), personnel, financial, technical, technological, material, organizational. At the same time, the information (digital) component also changes the position of the agro-industrial complex in the structure of national economies. In particular, the information (“digital”) component of innovative abilities, which allows to measure the ability of agro-industrial complex business structures to master digital technologies and platform solutions and further generate a stream of new ideas, is a necessary prerequisite for achieving high results of innovative activity.

In this regard, the use of information entropy in solving problems in the field of the information (“digital”) component of the system for managing the innovative abilities of agro-industrial business structures is aimed at reducing risks and increasing profits. The term "information entropy" was first introduced in 1948 by Claude Shannon [5], who linked together the main tools of information theory - the amount of information and the measure of information uncertainty. Entropy is a quantity calculated according to the formula described by K. Shannon:

$$H = I_{cp} = - \sum_{i=1}^n p_i \log p_i \tag{1}$$

where:  $H$  – entropy;

$I_{cp}$  – average amount of information;

$p_i$  – probabilities of individual events;

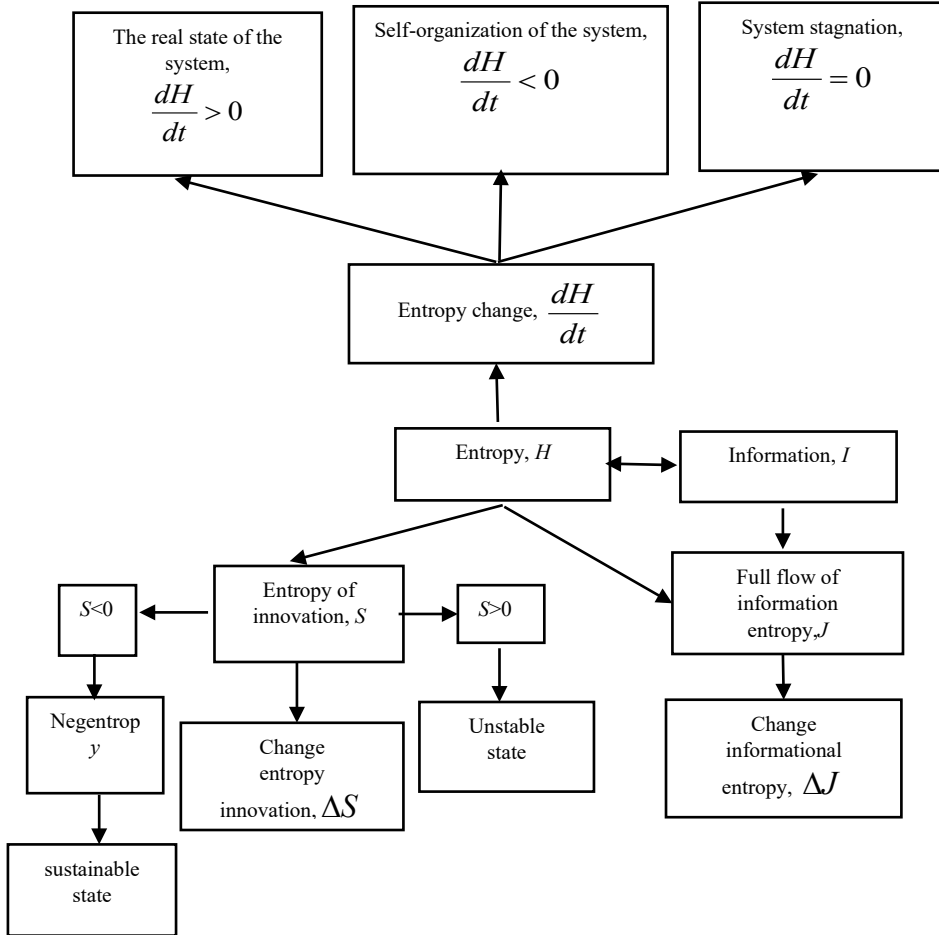
$n$  – the number of possible events.

This quantity is also called the average message entropy. Studies show [6] that an increase in the value of information entropy leads to a greater number of exogenous factors that affect the process described by the time series.

The American physicist Leon Brillouin in 1953 introduced the term “negentropy” into information theory, thereby reducing the concept of “negative entropy”, interpreting the negentropy principle of information: “Information is a negative contribution to entropy” [7]. Note that formula (1) does not make it possible to explain the presence of negentropy.

### 3 Results

The essence of the development of the innovation process in the innovation capabilities management system can be represented in the form of the following block diagram (Fig. 1).



**Fig. 1.** Innovation process in the innovation capability management system

At the same time, the development of the system for managing the innovative abilities of agro-industrial complex entrepreneurial structures is due to a change in entropy, and the sign of the change in entropy indicates that the process is changing direction. If  $dH/dt > 0$ , then the process of equilibrium (relaxation) of the information system is carried out, in this case the entropy of the system with a finite set of states becomes maximum, while all states are equally probable. Under the condition  $dH/dt < 0$ , then the innovation system is in the process of self-organization. In this system, a semblance of order is formed. If  $dH/dt = 0$ , then the system may be in the stagnation phase. Therefore, after determining the magnitude and sign of the change in entropy over time, it is possible to trace the evolution of the information system at the current time. With progressive development, negentropy (negative entropy) increases in the system. An increase in negentropy means an increase in order. Consequently, negentropy is recognized as a measure of order, orderliness, and leads the system to a stable state.

## 4 Discussion

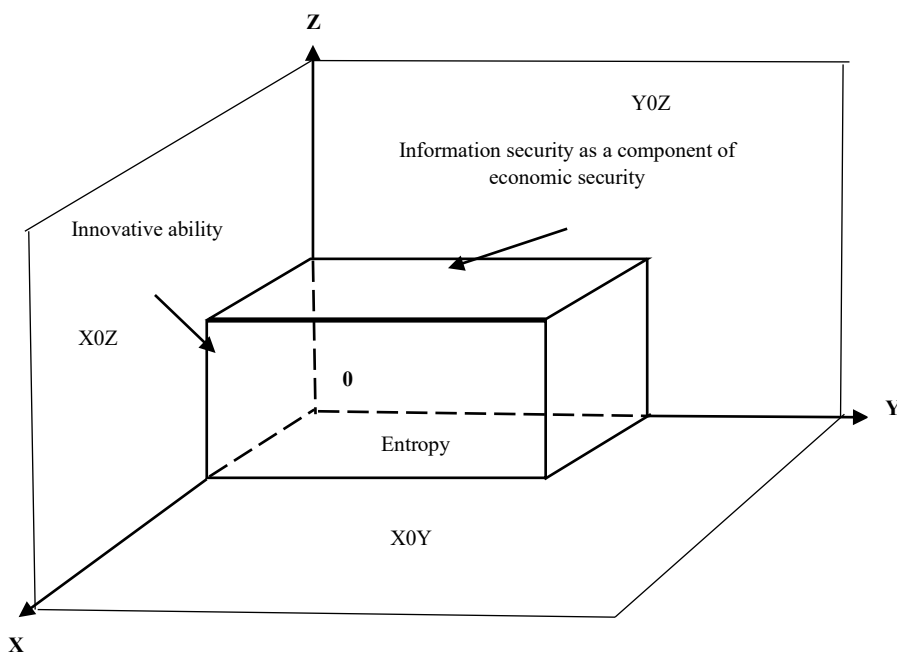
Entropy as an approach is of interest in the framework of studying the innovative capabilities of an enterprise, because an uncontrolled increase in entropy contributes to an increase in uncertainty or chaos in the innovation process. This circumstance will eventually become the cause of the unstable state of the system. Consequently, an increase in innovative entropy means the transition of the system from less probable states to more probable ones. To assess the effectiveness of innovations, it is important to directly assess the change in the level of entropy in the affected systems.

The change in entropy is a consequence of deviations from the trajectory of the development of the system and can be caused by two factors:

- endogenous interaction of the constituent elements of a complex system;
- interaction of the system with the exogenous environment, that is, “due to the inflow of information from the outside or the outflow of information from the outside” [8].

Since entropy determines the level of uncertainty or unpredictability of information about the system, the best indicator is characterized by the lowest entropy.

Figure 2 shows the relationship of the entropy-information security triad as a component of economic security-innovative abilities on three projection planes.



**Fig. 2.** The relationship of the entropy triad - information security as a component of economic security - innovative abilities

Entropy is projected on the horizontal plane ( $X0Y$ ), innovative abilities with existing resources for innovation - on the frontal plane ( $X0Z$ ), information security, as a component of economic security - on the profile plane ( $Y0Z$ ). It is important to consider innovative abilities as a tool aimed at ensuring economic security in the context of its component information security of agro-industrial business structures. The reliability of the state of the object of the innovation process can be assessed by the value of its information entropy.

## 5 Conclusion

In the digitalized objects of the innovation process of the business structures of the agro-industrial complex, the decisions made in the information security system as a component of economic security are based on Big Data technologies in order to process these arrays for adaptive security management of innovation processes and risk reduction.

The system for managing innovative abilities is the process system of business structures in the agro-industrial complex. This system reproduces key competencies to effectively organize and implement innovation processes based on available resources and development goals.

The entropy approach within the framework of the study of innovative abilities and information security as a component of economic security makes it possible to assess the state of the system. At the same time, the innovative processes taking place in the business structures of the agro-industrial complex require the creation of a special structure capable of providing a sufficiently high level of security.

In modern conditions, various digital solutions are being successfully introduced in the agro-industrial complex, and the digital economy is being actively introduced into the ecosystem. The main task of digitalization in the business structures of the agro-industrial complex is not only to increase the value of the business through innovative abilities, but also to provide all the necessary, properly structured information.

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