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SOCIO-ECONOMIC ECOSYSTEMS IN THE LIGHT OF SYSTEM PARADIGM

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Abstract. The article examines the essence, concept, features and structure of socio-economic ecosystems from the standpoint of the system paradigm. It is shown that the internal structure of an ecosystem is isomorphic to the structure of a tetrad — a complex of four stably interacting systems: object, environment, process and design. The concept of apoptosis is introduced as a predetermined cessation of the functioning of the system after a certain period of time or when the system leaves the boundaries of a certain zone of space. Apoptosis has been shown to be a natural mechanism for the functioning and development of ecosystems. The relationships between ecosystems, clusters, platforms, networks and incubators are revealed. It has been determined that the concept of an ecosystem can serve as a kind of umbrella for the concepts of clusters, platforms, networks and innovative incubators, and each ecosystem contains subsystems similar in structure and functions to the four systems of the indicated classes.

Keywords: socio-economic ecosystems, clusters, platforms, networks, innovative incubators, unit of socio-economic analysis, apoptosis of socio-economic systems.

The system paradigm which goes back to the teachings of ancient philosophers, first of all, Aristotle, developed in the works of the founders of the general theory of systems, first of all, L. Von Bertalanffy and his followers, and being the basis of social studies of T. Parsons, N. Luhmann and others [1, 2], applied to the economy, was explicitly formulated by Y. Kornai [3, 4] and subsequently developed and extended to the sphere of various socio-economic phenomena and formations [5, 6, 7, 8].

According to the system paradigm, the main unit of the socio-economic analysis including the general social analysis proposed by V.M. Polterovich [9] as the main direction of the development of the complex of social sciences, should be a socio-economic system, which is a relatively stable in time and space integration of social and economic agents, socio-economic benefits and institutions. The transfer of the center of gravity from agents to systems forces us to revise the bulk of the economic theory of orthodox and neo-orthodox directions. The system paradigm allows not only to break down the existing barriers between institutional and neoclassical theories (the formation of neoinstitutional theory, in essence, did not change the composition of the units of analysis), not only to bring together an evolutionary approach and agent-oriented modeling, but also to create a single research space for the whole complex of socio — economic phenomena.

The level of generalization set by the system paradigm, combined with the space-time analysis and concepts of the general systems theory, allows us to hope for the creation of a unified multi-level and multi-purpose socio-economic theory similar to the unified field theory in physics.

The system paradigm in its developed form introduces us to the world of socio-economic systems and their interactions, including interactions regarding the creation and circulation of material and symbolic artifacts (goods). System analysis on the basis of the system paradigm, hopefully, can become a conductor of consistency not only in economics, but also in politics, management, national economy and national ideology [10].

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Over the past 25 years, ecosystems have become one of the most actively studied types of socio-economic systems — a complex of agents, organizations connected by common location, functional relationships and participation in creating common socio-economic values [11, 12, 13, 14, 15, 16, 17, 18]. They often speak of the ecosystems of Sberbank, AvtoVAZ, Apple and others. Ecosystems can also be formed on a territorial basis (regional, city and municipal socio-economic ecosystems), and on mixed grounds (ruble zone, euro zone, etc.).

Around the same period other types of socio-economic systems — clusters, platforms, networks, and innovative incubators — were mentioned in the economics literature. The objective of this article is to analyze, on the basis of the system paradigm, the characteristics of these socio-economic systems, show their interrelation and give clear definitions of these phenomena. We show that the concept of an ecosystem can serve as a kind of umbrella for the concepts of clusters, platforms, networks and innovation incubators, and each ecosystem contains subsystems similar in structure and functions to the four systems of these classes. Thus, the choice of such entities as ecosystems, clusters, platforms, networks, and innovative incubators as units of a socio-economic analysis is not arbitrary, but determined by the universal structure of the space of socio-economic systems.

1. SOCIO-ECONOMIC ECOSYSTEMS

Socio-economic ecosystems (hereinafter — ecosystems) are now becoming a central element of the socio-economic landscape of countries. Despite the significant number of domestic and foreign publications on ecosystems, there is no exact and generally accepted definition of the term "ecosystem". Thus, M. Jacobides, K. Kennamo and A. Gaver consider an ecosystem as "a group of firms in different positions across a sector or set of sectors that have mutual co-specialization at the group level and are not unilaterally managed hierarchically"[19]. R. Adner believes that "an ecosystem is determined by the alignment structure of a multilateral set of partners that need interaction so that the focused value proposition materializes" [20]. See also [21].

In this work, an ecosystem will be understood as a spatially localized complex of uncontrolled hierarchically organizations, business processes, innovative projects and infrastructure systems that interact with each other during the creation and circulation of material and symbolic goods and values, capable of long-term independent functioning due to the circuit of these benefits and systems.

The system economics method makes it possible to identify the features of ecosystems compared to other socio-economic systems, to determine the natural systemic structure of ecosystems, to reveal the essence of the processes of interaction of ecosystem components with each other and with the external environment, ensuring its homeostasis, including the exchange of space and time resources and intensity and activity of their use.

The features of ecosystems compared to other socio-economic systems can be summarized as follows.

1. Localization in space and continuity (unboundedness) of existence in time.

2. Internal integrity, territorial proximity, close links between components and participants of ecosystem activities.

3. Ability to self-reproduction of the ecosystem as a whole and its main components. The presence of mechanisms that keep the ecosystem from spatial expansionism and spatial contractionism. Homeostasis.

4. Self-development through the use and mutual transformation of non-consumable environmental resources (space, time, energy) and in-system genetic selection.

5. Circularity (isolation, wastelessness).

6. Structural isomorphism of the ecosystem and its environment, close connection of the internal environment with the environment surrounding the ecosystem (high permeability of the spatial boundaries of the ecosystem).

7. Existence of mechanisms for equalizing the scale of ecosystem participants (individuals, organizations,

projects) ensuring the sustainability of the development of the ecosystem.

8. Maintaining a balance between diversity and uniformity, variability and stability of ecosystem components.

9. The presence of the core and the protective layer.

10. Presence of internal stock and internal structure of values of the ecosystem as a whole.

11. Systemic non-hierarchical coordination of participants.

2. SYSTEM STRUCTURE OF ECOSYSTEMS

According to the definition adopted in this work, the following are distinguished in the ecosystem as relatively independent components:

1) organizational component — a set of organizations and independent individuals functioning as part of an ecosystem;

2) ecosystem infrastructure environment represented by various intrasystem institutions, regulations, procedures, mechanisms;

3) communication and logistics component that provides the processes of interaction of the organizational components of the system;

4) an innovative component — a set of activities, each of which is localized in space and in time, aimed at adapting the ecosystem to changes in the external environment.

Organizational component provides the structural framework of the ecosystem, the discreteness of the internal space of the ecosystem (autonomy of its participants), the continuity of functioning of the system in time. The infrastructure component ensures the coherence of the internal space and the life cycle of the ecosystem. Communication and logistics component realizes the possibility of communication and transfer of benefits between the ecosystem participants. The innovation component of the ecosystem realizes the creation of new goods, the transformation of individual components and the ecosystem as a whole.

In the system socio-economic theory [22], the basic typology of socio-economic systems is based on the identification of four fundamentally different types of systems depending on the system configuration in space and time. Systems with precisely defined boundaries in space and defined boundaries in time are among the object systems; systems with certain boundaries in time and indefinite boundaries in space are among process systems; systems with indefinite boundaries, both in space and in time belong to environmental systems; systems with precisely defined boundaries in time and in space — to design systems. In reality, most socio-economic systems can be attributed to one of these types due to the dominance of the properties of the object, environment, process or project subsystem. Object systems are discrete in space and continuous in time; infrastructure systems maintain continuity both in space and in time; communication and logistics systems function as discrete processes for the exchange of resources and information in a batch mode and contribute to increasing the homogeneity and continuity of space; innovative systems maintain discreteness both in time and in space. We see that for object, process, and design systems, mechanisms exist to limit their functioning in space or in time. The implementation of these functions is carried out through mechanisms that, by analogy with biological systems, can be called apoptosis. By apoptosis we mean here programmable, i.e. predetermined, termination of the system after a certain period of time or when the system goes beyond the boundaries of a certain area of space. Thus, for systems subject to apoptosis, space and / or time are fundamentally heterogeneous. For object systems, apoptosis is spatial in nature and automatically stops the operation of an object outside its spatial (usually territorial) boundaries. In particular, it can be said that "there is no enterprise beyond the borders of the enterprise". Of course, there are various connections of an enterprise with other systems, including other enterprises, however these connections are realized outside the boundaries of the enterprise itself. For design systems, apoptosis means the cessation of the functioning of the system after the expiration of the normative (or physical) period of its existence, as well as beyond the limits of the space allocated for its functioning. In particular, the construction

project of a building is usually completed after the building has been commissioned and is limited to the territory set aside for construction. For process systems, apoptosis means the cessation of the functioning of the system after a certain time has elapsed or the disappearance of the conditions that determine the possibility or necessity of this process. In particular, the process of delivering a certain cargo by rail is terminated upon receipt of the cargo by the addressee. Environment systems do not have apoptosis mechanisms.

In real socio-economic systems, the behavior of systems is influenced by both the mechanisms of apoptosis embedded in them and the awareness or perception of these mechanisms by the participants of these systems. Thus, depending on the psychological characteristics of the participants, approaching the system to zones or periods of action of the mechanisms of apoptosis may be accompanied by an increase or, conversely, a decrease in the activity and / or intensity of their activity. Psychological features here concern the participant's energy concentration near the system's borders ("claustrophils") or, conversely, in space-time zones remote from the system's borders ("agorophiles"). The perception and implementation of apoptosis mechanisms in socio-economic systems, as well as in biological ones, are very complex and insufficiently studied processes. Their research can be a significant reserve for improving the management of socio-economic systems. The above four-component description of the ecosystem structure corresponds to the representation of the socio-economic system in the form of a tetrad — a complex of four stably interacting systems of object, environment, process, and project types [23]. At the same time, the basis for the stable functioning of the tetrad is the interaction of its subsystems in the sharing of space (S) and time (T) resources. Object-type systems (objects) possess certain reserves of space S and have access to unlimited time resources T, and also demonstrate the ability (I) to efficiently use the available space; environmental-type systems (environments) have unlimited access to the resources of the space S and time T, but are not endowed with sufficient capabilities (I and A) for their effective use; process-type systems (processes) have unlimited access to spatial resources S, limited time reserves T of their operation "without rebooting" and have abilities (A) for its effective use; project-type systems (projects) have limited reserves of time T and space S and sufficient abilities (A, I) for their effective use. In a free socio-economic space in the course of their livelihoods, each system seeks to compensate for the lack of existential (space-time) and energy (intensity-activity) resources that are deficient, for which it joins stable alliances with other systems that have this type of resources in excess. The active force in the formation of such alliances are project systems. They interact with object and process systems, receiving from the first access to time resources T, and from the second — to space resources S. In turn, the design systems allow the object systems to develop the primordial abilities (A) for the efficient use of time resources, and the process systems — the primordial abilities (I) for the efficient use of space resources.

Environment systems share resources of space S with the object systems and time resources T with process systems, receiving from the first opportunities (I) to effectively manage space resources, and from the second — opportunities (A) to effectively manage time resources.

As a result, the search for partners for sustainable interaction leads these systems to be included in tetrads (see Fig. 1).

As a result, the balance of resource allocation A, I, S, T between the components of the tetrad (internal AIST-balance) is achieved by providing access to all resources A, I, S, T for each subsystem. The external AIST — balance is realized: in terms of space and time resources — by continuously receiving resources S, T from the external environment (through the environment subsystem) and returning the resource T through the object subsystem and resource S through the process one; in terms of activity and intensity resources — by a one-time acquisition of a stock of resources A, I by the project subsystem from the external environment as well as by providing the external environment with access to these resources through the environment subsystem.

The functions performed by the four tetrade subsystems are reflected in Table 1.

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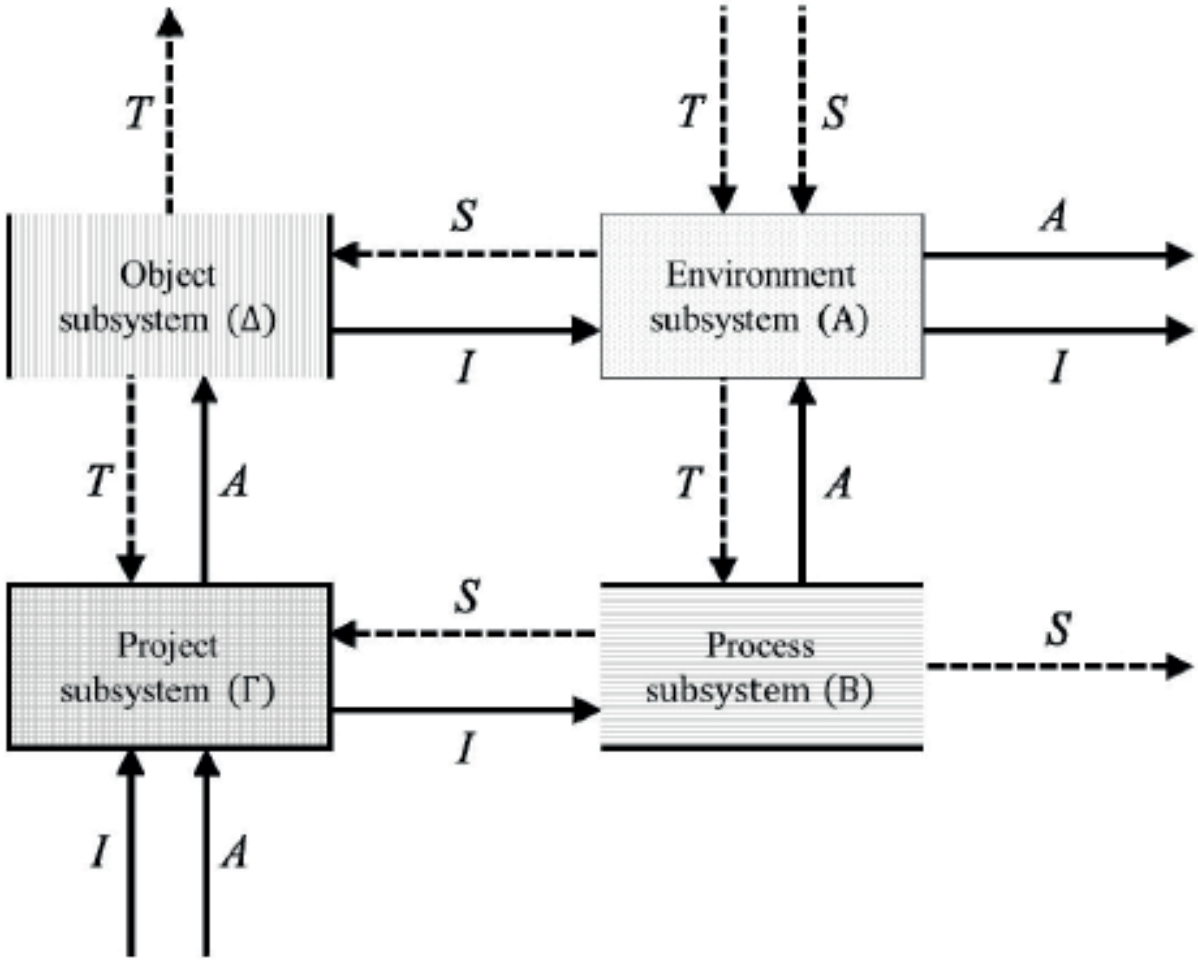

Fig. 1 Structure and functions of the tetrad

Table 1

Functions of the tetrade subsystems

tetrade subsystem	functions of the subsystem
Object subsystem	Converter S → T, A → I. Donor T for the external environment
Environment subsystem	S, T recipient (receiving from the external environment), donor A, I (direction to the external environment)
Process subsystem	Converter T → S, I → A. Donor S for the external environment
Project subsystem	Recipient A, I from the external environment, the recipient S, T from the internal environment. Converter S, T to A, I

It should be emphasized that the tetrad, despite its relative simplicity as a small-sized model of an ecosystem, is a kind of microcosm, in a generalized form reflecting the structure of a very wide class of systems of various scale and nature. In a certain sense, the tetrad can be considered as a universal archetypical model of a socio-economic system.

The correspondence between the components of the ecosystem and the structural elements of the tetrad as a system model of the ecosystem is presented in Table 2.

Table 2

Tetrad as a model of socio-economic ecosystem

Ecosystem components and characteristics	Tetrade elements
Organizational component of the ecosystem	Object Subsystem of the tetrad (δ)
Infrastructure component of the ecosystem	Environment subsystem of the tetrad (α)
Communication and logistics component of the ecosystem	Process subsystem of the tetrad (β)
Innovative component of the ecosystem	Project Subsystem of the tetrad (γ)
Types of existential resource flows circulating in the ecosystem	Exchange of space resources (S) and time (T) between the tetrad subsystems, as well as with the external environment
Types of energy flow circulating in the ecosystem	Exchange of abilities between active (A) and intensive (I) activities of the tetrad on the use of space and time
Ecosystem area	The amount of space available for the functioning of the tetrad
Ecosystem life cycle	The period of functioning of the tetrad

Thus, a picture of the functioning and interaction of the system components of an ecosystem, presented in the form of a tetrad, looks like.

3. CLUSTERS, PLATFORMS, NETWORKS, INCUBATORS

The functioning of a modern market economy is based on the formation of various kinds of systems for coordinating socio-economic subjects [24]. By the end of XX century coordination of economic entities such as clusters [25, 26], platforms (see, for example, [27]), networks [28, 29], and innovative incubators [30] are in the focus of attention of researchers. The study of each of these types of socio-economic entities is carried out independently, using independent approaches and methods. The use of the system paradigm allows us to systematize these objects, highlight the key properties of each of them and answer the question whether this list is complete and whether we can expect the emergence of new units of socio-economic analysis. We show below that each of these formations in a stylized form can be identified with one of the four tetrad subsystems, and each ecosystem contains clusters, platforms, networks and incubators. There are many definitions of each of these concepts in literature. The following definitions are intended to reflect the key features of these systems, placing them in the context of the system paradigm.

Cluster is understood as a set of object systems connected by relations of functional dependence and territorial proximity. Obviously, the cluster itself, as well as its components, is one of the object systems. The cluster is a discrete system relative to space and continuous — relative to time.

Platform is understood as the union of technological, communication, institutional and other infrastructure environments in which the studied socio-economic systems are functioning. The platform as an association of environment systems also belongs to the class of environment systems. Platforms are continuous in space and in time. The network allows dual understanding. On the one hand, the network can be considered as one of the types of infrastructure for the implementation of logistics and communication interactions between socio-economic entities. In this case, the network is considered as a kind of environment system. On the other hand, a network is often understood not as a static structure, but as a dynamic process of exchanging material, informational or symbolic goods. With this understanding, the network is considered as a set of time-limited processes of moving material, informational,

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symbolic and other values and, therefore, from a functional point of view, is among the process systems.

Incubator (in the broad sense of the word, including incubators of innovations, business incubators, incubators of institutes, etc.) is defined as the totality of innovative projects implemented within this socio-economic system. The incubator, as well as its components, is one of the design systems. The incubator should be considered as a discrete system in time and space.

These properties of the types of systems considered allow us to arrange them in the quadrants of the two-dimensional space-time coordinate system, reflecting the discreteness / continuity of each given system relative to space and time (Fig. 2).

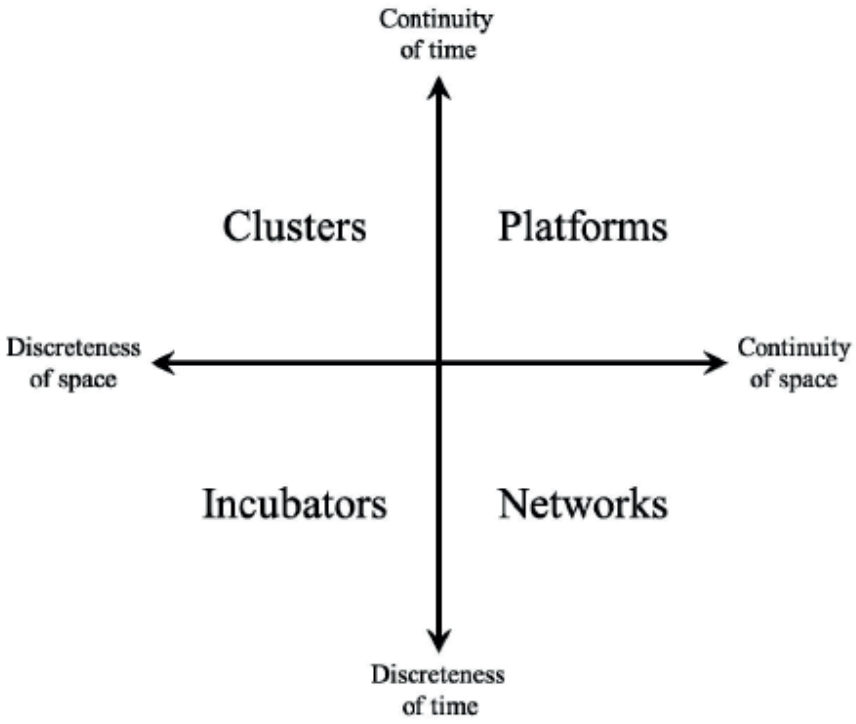

Fig. 2 Clusters, platforms, networks, incubators in a discrete-continuous structure of relations with space and time

4. CLUSTERS, PLATFORMS, NETWORKS, INCUBATORS AS COMPONENTS OF ECOSYSTEMS

The organizational component of the systems consists of separate organizational units, each of which arose in connection with the implementation of functions common to the ecosystem and therefore is functionally connected with a number of other similar units. In addition, due to the localization of the ecosystem in space, all components of its organizational component are in relations of territorial proximity. This means that the organizational component of an ecosystem is nothing more than a cluster. The infrastructure component of the ecosystem is designed to create opportunities for unobstructed (direct) interaction between the participants of the ecosystem, primarily between the elements of the cluster entering the ecosystem. Thus, the infrastructure component of the ecosystem plays the role of the environment necessary primarily for the effective functioning of the cluster. The communication and logistics component of an ecosystem provides the realization of the opportunities provided by the infrastructure component to support the exchange of material, informational, symbolic and other benefits between organizational units. Finally, the innovation component, which includes activities related to various kinds of innovations, practically plays the role of an innovation incubator. Together, clusters, platforms, networks and

incubators belonging to the same ecosystem complement each other, ensuring that the ecosystem can function independently due to unlimited repetition of production and reproduction cycles (circulation of resources and products). It can be noted that neither clusters, nor platforms, nor networks, nor incubators have such a property separately from each other. Thus, in the clusters there are no (or are in their infancy) integration-communication mechanisms and innovative impulses; platforms lack a mechanism for concentrating efforts on a limited portion of space-time to exist independently which leads to the dominance of centrifugal tendencies; the main feature of network structures is the lack of mechanisms for the emergence and incubation of innovations, which leads to the attenuation of such systems; Finally, the long existence of innovative incubators is impossible without the support of organizational, communication and logistics systems.

Thus, the successful functioning of cluster, platform, network and incubation systems is possible only within the framework of ecosystems that ensure their mutual support, interaction and reproduction.

In general, we see that ecosystems should be considered as the basic units of socio-economic analysis. And clusters, platforms, networks and incubators are integral parts of ecosystems.

5. FINAL REMARKS

Since producer-user chains in ecosystems are locked within the system itself, ecosystems are a type of systems with a pronounced "egocentric" orientation. The main goal of such systems is to maintain their own functioning and - to a moderate degree - their own development. In this sense, ecosystems are closer to object and project systems than to environment and process ones. Therefore, the platform component of ecosystems plays a role rather of a connecting link, or a border strip between the ecosystem and the surrounding world. The value vector of the ecosystem is directed inward, not outward of the ecosystem. Creating shared values in ecosystems should be the main focus of their activities.

Accordingly, the consolidation of efforts and organizational units and individual participants in ecosystem activities should be supported through the distribution of available funds in favor of the cluster and incubation components of the ecosystem, as well as intra-ecosystem networks and platforms. A special role here should be played by the methods of strategic planning of ecosystems (see [31]), as well as the methods of matching the type of enterprise collective with its strategic profile [32]. Transferring these methods from enterprises and clusters to ecosystems requires further research.

The development of an ecosystem approach to structuring an economy undoubtedly leads economic theory away from neoclassical ideas about the market as a homogeneous "pile of sand grains", differing from each other mainly in size. Each ecosystem is a special planet with its own history, culture, genetic mechanisms of inheritance of characters. Since ecosystems, by definition, lack centralized management, self-organization mechanisms, including self-restraint and self-moderation ("alignment"), should be organically built into the institutional structure of ecosystems.

It is possible that the period of "open innovations", which followed the period of "closed corporate innovations", will move into the period of "ecosystem innovations", synthesizing the development of open innovation platforms and isolated innovation incubators.

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