Qualitative taxonomy of socio-economic systems and system self-organization

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Abstract. This article develops the system paradigm formulated by J. Kornai, seeking to combine it with general systems theory and a space-time approach to the analysis of economic systems. According to the proposed concept, the time and space available to an economic system are considered its primary (basic) resources; this allows the resource-based view of the firm to be extended to a broader range of economic systems. The article provides a qualitative taxonomy of economic systems based on space-time boundaries, whereby all economic systems may be divided, with varying degrees of definiteness, into four classes: *object*, *project*, *process* and *environment* systems. It is shown that the smallest stable unit that is sustainable in the long run is a tetrad — a group comprising four economic systems (each of the above types) that perform their functions and exchange both time-space resources and the capabilities of using them effectively.

Keywords: crisis of economic theory, environment economic systems, object economic systems, process economic systems, project economic systems, space-time approach, system paradigm.

1 Introduction

Many researchers (Ormerod, 1994; Heilbroner, Milberg, 1995; Polterovich, 1998; Fullbrook, 2003 et al.) share the opinion that economic theory is in a protracted crisis nowadays. Fragmentation of social and economic space, the differences between agent-based and institution-based concepts of the economy, the gaps between theories of micro-, meso- and macroeconomic levels (Hahn, 1991; Arrow, 1995; Blaug, 1997; Hodgson, 2007) had an impact on the ability of economic theory to anticipate and explain the causes of economic crises of the last decade. Accordingly, the actual problem of modern economic theory is finding such a paradigm that could reflect economic processes taking place in the objective reality with a high degree of reliability.

From our point of view, the system paradigm introduced into scientific practice by J. Kornai in 1998, which is complemented with other well-known economic paradigms, such as the neoclassical, institutional, evolutionary, etc. (Kornai, 1998, 2000), satisfies these conditions. This paradigm stressed the significance of the macroeconomic system, as well as politics, ideology and other factors outside the economic space per se. J. Kornai used this approach to explain a number of phenomena emerging in transitional post-socialist economies. As it turned out later, this approach proved fruitful for considering factors related to the functioning of not only macroeconomic systems, but also other levels of the economy: the mega-, meso-, and microeconomic levels (Kleiner, 2002, 2007). This perspective has developed into the concept of a “generalized system paradigm” whereby the functioning of any economy (country, region, enterprise) is seen as the result of the processes of emergence, development, functioning, interaction, transformation and elimination of economic systems of various scales and levels. Focusing on the system factors of the economy makes it possible to employ certain definitions and concepts of general systems theory in economic analysis to explain a number of phenomena that are not plausibly explained within other paradigms, as well as to offer substantiated answers to some normative questions concerning the determination of economic policy and the choice of economic strategies at various levels (Kleiner, 2009).

Combining the systemic paradigm and the space-time approach seems promising for the economic analysis of real objects. Space-time analysis — an approach to the research and description of economic systems of various levels that takes into account the significance of their intrinsic characteristics of spatial (territorial) and temporal allocation and the configuration of each system's boundaries in space and time.

Consideration of the space-time factor allows us to allocate the space-time system morphology and create a qualitative taxonomy of economic systems based on it, while studying the characteristics of the systems' functioning and their effect on the environment makes it possible to determine their functional specialization.

The article consists of eight sections. Section 2 shows the new sight on economic systems definition based on an external, exogenous perception. Section 3 contains qualitative taxonomy of economic systems, based on the application of the space-time approach to the distribution of systems in space and time. Section 4 cites the main findings that describe the interrelationship between the space-time morphology of economic systems and their functional classification. Sections 5 and 6 substantiate the possibility of considering the portion of the space-time continuum available to a system as a distinctive type of economic resource, and of considering the capacity to use this resource effectively as one of the capabilities of a system. Section 7 shows that a tetrad – a group of four systems (each representing a different type) that interact through the exchange of surplus primary resources/capabilities — is the smallest entity of the economy capable of relatively prolonged autonomous and stable functioning. The Conclusion contains some findings that are essential for further development of economic systems theory based on the space-time approach and for the shaping of economic policy with consideration of the systemic structure of the economy.

2 The new sight on socio-economic systems definition

From the standpoint of the new systems approach, the system is defined as a relatively separate part of the surrounding world, identified by the observer, possessing both the properties of external integrity and internal diversity. This general definition can be specified in particular cases.

Two basic distinctions of this definition may be identified based on the classical systems theory created by von Bertalanffy, Ashby, and Wiener. The first distinction is that, previously, the systems approach mainly relied on an internal, "endogenous" perception of a system. It was considered a priori as a complex of interrelated elements. We adopt an external, exogenous perception of a system: a system is basically viewed as a certain fragment of reality, distributed a certain way in space and time. The current version of the systems approach puts emphasis on the integral image of reality, or "gestalt", that is embodied in the system (see Georgiou, 2007; Haines, 2000 et al.). The second difference lies in the fact that the observer is introduced in the definition of the system, wherein his opinion is fairly subjective, because the definitions of stability, integrity and diversity are themselves subjective. This means these features are evaluated by an "public observer" — a virtual standard representative of society as a combination of insiders and outsiders of the system (cf. Luhman, 1996; Kamitake, 2009).

We mainly consider economic systems whose creation and functioning support the processes of production, distribution, exchange, and consumption of goods and which cannot exist without human participation. All the economic systems under examination are "living" systems, meaning that the functioning of each of them is based on the activity of people as individuals, collectives, groups, and/or communities. At the same time, no single person as an integral whole can fully belong to any economic system (except economic system which consists of him/herself only), whereas any economic system uses different people's intellectual, physical, emotional, and social abilities.

It is evident that enterprises, organizations, countries, and other types of economic objects are economic systems. However, we believe it would be natural and expedient to regard other economic entities and phenomena as economic systems too. Thus, institutions and institutional sets, socioeconomic processes, programs, and projects are economic systems (Kleiner, 2007).

3 Spatial-temporal morphology of socio-economic systems

Since a system is a part of the surrounding world, relatively stable in space and time, it seems that the parameters of a system should first reflect the specifics of its natural space-time location and boundaries. The first parameter to be addressed is the degree of definiteness (indefiniteness) of the boundaries that separate a system from the outside world.

The indefiniteness of boundaries and the impossibility of drawing a more or less clear demarcation between the domain in the space-time continuum occupied by the system and its complement are defined as a system's unlimitedness in the literal sense of the word (lack of limits). The circumstances under which an economic system's boundaries become indefinite need to be established from an observer's point of view. Let us start with unlimitedness in time. Since an economic system, once it has emerged, exists continuously as a rule, living through all the intermediate time stages from emergence to elimination, the duration of an economic system will represent interval $\langle a, b\rangle$ on the numerical time axis $-\infty \leq a, b \leq \infty$. The interval's boundaries become indefinite if one or both numbers (a, b) are unknown to the observer or equal to $-\infty$ or $+\infty$. Despite the fact that the lifecycle of an enterprise or the lifespan of any individual is finite, business practice and social customs are based on the assumption of the unlimited existence of an operating enterprise or an individual.

In space, unlike time, the configuration of an economic system can have as much complexity and as many relationships as theoretically possible. Spatial boundaries may be perceived as indefinite due to their remoteness from the location of a specific business agent (observer). This may be due to the observer's limited information vision — so-called "informational myopia" (inability to describe the boundaries in detail) or "informational hyperopia" (limited resolving power of the information vision). Most often, the spatial indefiniteness of a system's boundaries is empirically recorded by a business agent if the latter perceives the system's extension in space as virtually unlimited.

Now, the limitedness/unlimitedness of a system in space and in time can be used as a basis for an elementary taxonomy of economic systems (see Table 1).

Table 1. Division of systems according to spatial and temporal characteristics (L — limited, U — unlimited in either space or time).

Size (spatial)	Duration (temporal)	
	Limited (definite time period)	Unlimited (indefinite time period)
Limited (definite size)	LL	LU
Unlimited (indefinite size)	UL	UU

It is necessary to give a substantive economic description of each of these system types. It has been shown (Kleiner, 2009) that the properties of economic systems of type *UU* resemble those of the *environment*, i.e., the more or less homogeneous matter filling space; those of type *LU* typify an *object* (a part of the external world that exists outside a person and has a definite spatial form), those of type *UL* resemble a *process* (a cyclical pattern of a phenomenon's development), and the properties of systems of type *LL* typify a *project* (a sequence of steps aimed at achieving a specific goal within a specified time period).

Examples of object systems are enterprises, individuals, organizations, regions, and countries. Environment systems include the Internet, the stock market, the postal service, the national legal framework, an institution, and mass media. Process systems include higher education, science, art, innovational diffusion, inflation, and a country's economic growth. Project systems include the construction of a building, restructuring of a business, election of a CEO, hosting of the Olympic Games, etc.

Thus, we can see that objects, environments, processes, and projects are not only the most significant and widely researched economic phenomena and systems, but in fact they account for the entire range of their types.

Let us introduce the following symbolism to identify the four types of systems: $\mathrm{A} = \{\alpha\}$ — the set of environment systems, $\mathrm{B} = \{\beta\}$ — the set of process systems, $\Gamma = \{\gamma\}$ — the set of project systems, and $\Delta = \{\delta\}$ — the set of object systems. The use of the first four letters of the Greek alphabet to designate the basic types of economic systems is not accidental: by their place in the alphabet and their shape, they correspond to the distinctive features of the four basic system types.

Figure 1 shows a pictorial representation of the four system types. The thicker horizontal borders of some rectangles in Fig. 1 represent the limited lifespan of a given system, and the thicker vertical borders represent the limited space.

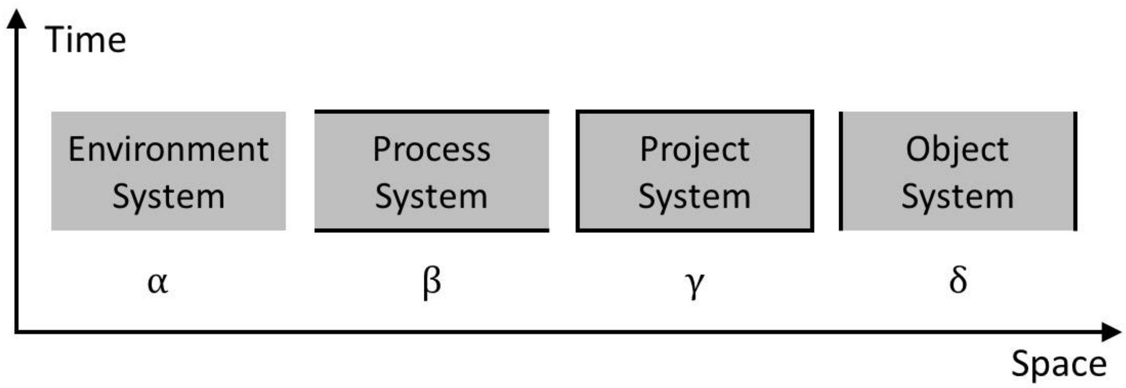

Fig. 1. *Symbolic representation of the four types of economic systems in conventional "space-time" coordinates.*

The space-time qualitative taxonomy makes it possible, on the one hand, to examine all these economic entities and phenomena from the same perspective as integral economic components and types of economic systems and, on the other hand, to identify and classify their essential structural and functional distinctions.

4. Functional specialization of socio-economic systems

It turns out that each of the four system types has a particular functional specialization, which allows them in concert to reliably carry out all four kinds of economic functions: production, distribution, exchange, and consumption. It has been shown (Kleiner, 2011) that these functions are distributed among the systems of types α, β, γ, and δ in a distinctive way. Namely, each system carries out exactly two of these functions: one as its main function and one as its auxiliary function. Table 2 shows the distribution of the basic economic functions among the types of economic systems.

Table 2. Distribution of general economic functions among systems of various types.

No.	System type	Main function	Auxiliary function
1.	Object (δ)	Production	Consumption
2.	Environment (α)	Consumption	Distribution
3.	Process (β)	Distribution	Exchange
4.	Project (γ)	Exchange	Production

Therefore, there are two systems that bear "shared responsibility" for executing each function: for the production function — systems δ and γ; for the consumption function — systems α and δ; for the distribution function — systems β and α; and for the exchange function — systems γ and β. It is worth noting that the pattern of functional distribution among the different classes of systems sets up a distinctive circular structure of links between classes of systems; that structure is brought about by the existence of common functions among certain pairs. This structure of functional distribution allows partial redundancy between one system and another. Thus, the function of production, which is the main function of an object, may be temporarily executed by a relevant project. Similarly, the function of distribution, which is the main function of a process, may be locally executed by a relevant environment. For example, if a target-specific logistical process in a business should fail, the task of distribution of resources needed for production can be implemented using alternative components within the business's internal environment. Thus, an object system can be replaced locally (in terms of time) by a project system, and a process system can be replaced locally (in terms of space) by an environment system.

Each economic system's activity can also be considered from the point of view of its effect on the change of homogeneity of the spatial-temporal whole. To formulate in a uniform way the system-wide results of the functioning of economic systems, the output of economic systems should be viewed as the resultant decrease/increase in space diversity and time differentiation — i.e., changes in economic conditions as a result of transition from one spatial point to another and movement from one temporal moment (period) to another. The balance between variability and stability of an economy determines the degree of its harmonicity (Kleiner, 2008). Table 3 shows the influence of the functioning of economic systems on an economy's variability characteristics.

Table 3. Distribution of basic general system functions between various system types.

No.	System type	Main function	Auxiliary function
1.	Object (δ)	Diversification	Stabilization
2.	Environment (α)	Stabilization	Unification
3.	Process (β)	Unification	Differentiation
4.	Project (γ)	Differentiation	Diversification

Therefore,

- environments and processes are responsible for improving space homogeneity,
- objects and environments facilitate greater time homogeneity,
- objects and projects ensure space differentiation,
- projects and processes support time differentiation.

As a result, we can see that the distribution of general system (variable) functions is built on the "double spiral" principle as it was with distribution of general economic functions between the four system types. This ensures the reliability of the economy as a whole.

5. Space and time as primary resources of a socio-economic system

To carry out the processes of production, distribution, consumption, and exchange, an economic system uses amounts of space (S) and time (T) available for it at each moment in time. For example, an enterprise freely uses either owned or leased production facilities; a project uses the time allocated for its completion. An economic system is, on one hand, *located* in space and time and at the same time it makes use of its respective portions of space and time.

Meanwhile, an environment-type economic system (α) has, by definition, unlimited access to both space and time. For such systems, these resources may be considered *unlimited*. A process (β) has a *limited* life span and *unlimited* access to space (S). A project (γ) is localized both in time (T) and space (S), which allows its resources of space(S) and time (T) to be considered as *limited*. An object (δ) has *unlimited* access to time resource (the "ongoing concern" principle), whereas its space resource (S) is *limited* (see Table 4).

Table 4. Characteristics of economic systems in terms of access to space-time resources.

No.	Economic system	Space resource (S) of the system	Time resource (T) of the system
1.	Object (δ)	Diversification	Stabilization
2.	Environment (α)	Stabilization	Unification
3.	Process (β)	Unification	Differentiation
4.	Project (γ)	Differentiation	Diversification

Economic systems that have unlimited access to a given resource act as donors, providing a portion of it to other systems (recipients) that have a shortage of the resource. Specifically, the exchange of tangible and intangible assets between market agents can be interpreted as a crossflow of space-time resources of economic systems. And the systems for which the allocated space (and/or allocated time) is limited need the expansion of available limited space (time) and act as recipients of space (time) resources.

It is worth noting that the characteristics of *availability* of space-time resources may be used for qualitative taxonomy of economic systems, by virtue of the principle of systems duality (Kleiner, 2002), instead of the characteristics of space-time *allocation*.

Thus, space and time as necessary conditions for the functioning of economic systems can be considered as basic (primary) resources of the economy. Space and time are spent (the former is *occupied*, the latter *elapses*), which gives us additional grounds for considering them as resources of economic activities.

6. Activity and intensity as a system's capacity to use space and time resources effectively

Having access to space-time resources is a sine qua non for the functioning of economic systems. To use these resources, economic systems should have the energy or capacity to utilize space and time resources (cf. Giddens, 1981). When it has space (time) constraints, a system, other conditions being equal, has to use the basic resources (space and time) initially allocated to it in a more economical way, to perform within a unit of space (time) a greater number of actions than it would in the absence of such constraints. Systems with a limited life cycle, other conditions being equal, act economically in an *active* way, i.e., tend to perform a significant number of actions within a unit of time. Systems that are limited in space, function in an *intensive* way, i.e., they tend to use their available space intensively. One can speak of two kinds (forms) in which the energy of economic systems is manifested; energy expended for effective use of the space occupied by a system (intensity) and energy expended for effective use of the time span allocated to a system (activity). Thus, any economic system uses four kinds of resources/capabilities in its activities: space (S) and time (T) resources; capacities of effective use of space (I) and effective use of time (A) (in toto, the system of resources of an economic system can be designated as AIST).

Systems of different types have different characteristics in terms of the presence of specific capacities (Table 5).

Table 5. Capacities of economic systems to use space and time effectively.

No.	Economic system	Capacity of effective use of space	Capacity of effective use of time
1.	Object (δ)	Present	Absent
2.	Environment (α)	Absent	Absent
3.	Process (β)	Absent	Present
4.	Project (γ)	Present	Present

Can an economic system's capabilities be transferred, as resources, from one system to another? They certainly can. Thus, project-type systems are capable of effectively using both space and time resources. Project system's participants, aware of its lifetime, are guided by that lifetime and live at an accelerated rate. Interaction with other systems encourages the latter to accelerate their time velocity. Initiating a project to manufacture new products is known to energize the staff, enhance labor productivity and increase return on capital. Interaction of a project system with a process one helps intensify the latter's activities and extends its lifetime. Object systems pass to environment systems their capacity to intensify the use of space without which environment systems are unable to work effectively. Process systems, through their interaction with environment systems, enhance the capacity of environment systems to use their time resource effectively.

The economic system's goal should be seen in ensuring the system's partnership advantages, understood as its attractiveness for inclusion into various partner relations with other systems. System's resources and capabilities should be used to ensure stable partnership advantages.

7. Results of exchange of the primary resources/capacities of socio-economic systems

The analysis of the functioning of economic systems through the prism of exchange of the primary resources/capacities makes it possible to make a few suggestions on the structure of inter-system interactions during economy's self-organization. Since the performance of the economic system is generally determined by the access to resources and capacities to use them, the stable functioning of any economic system requires its continuous supply of those resources/capacities. This section describes the most economical configuration of a group of systems that carry on a balanced exchange of resources/capacities. It is shown that this is possible if each economic system is included in a relatively stable group of four economic systems of different types. Economic systems are arranged into groups — particular “quartets” or tetrads — comprising systems representing all the types.

Homeostasis will occur in an economy if the relationships between economic systems are such that an economic system, having a surplus resource or capacity, acts as a donor transferring this resource/capacity to one or several systems that have a shortage of this resource. The most economical form of organization of economic systems, providing a balance of space-time resources and capacities, is represented in Fig. 2.

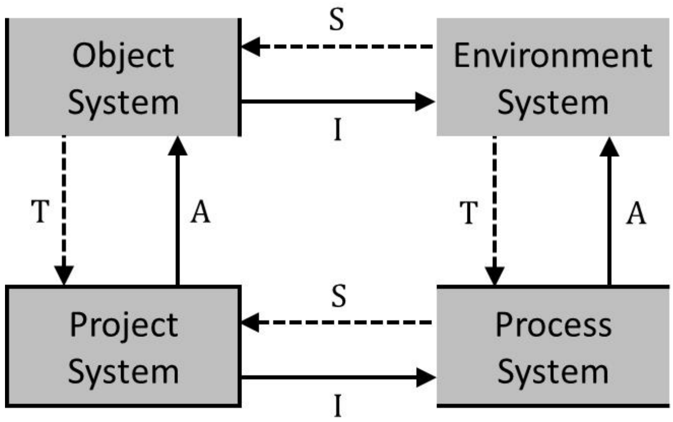

Fig. 2. *Economic tetrad as a form of exchange of* AIST *resources/capacities.*
Symbols: A — *capacity to use time,* I — *capacity to use space,* S — *space resource,* T — *time resource.*

It is to be noted that a tetrad is not simply a group of four systems of different types, but an entity having a distinct ring structure: the pairs "object — environment", "environment — process" and "project — object" have close mutual relationships of a symbiotic type, whereas the pairs "object — process" and "project — environment" do not directly interact. A typical example of a tetrad on a micro-level is a cluster consisting of four systems: 1) a company manufacturing goods (object); 2) a dealership network distributing goods (environment); 3) a system of sales enterprises (sales process); 4) equipment suppliers (capital construction project). Such clusters can operate both based on bilateral contracts between firms representing the above-mentioned four system types and through their integration, i.e. consolidation into one legal entity.
An economic tetrad is a minimum economic entity in terms of composition, which is capable of autonomous functioning and reproduction. However, this can only take place within a limited time span whose duration depends on the time resources of the limited life cycle systems (projects and processes) comprising the tetrad. To extend the functioning of a tetrad as a complex entity and its constituent object and project subsystems, it is necessary to replace projects and processes whose life cycles have expired with systems of the same types in a timely manner. This means that the economy needs to have a sufficient pool of projects (plans, programs, measures) and processes (including organizational procedures, market moves) for quick and timely support of tetrads' functioning. Organizing the functioning of the economic systems that make up tetrads promotes the stability of the economy at large.

8. Conclusion

This article develops, generalizes, and refines the system paradigm proposed in the economic research by J. Kornai. In our opinion, combining the space-time analysis with the system paradigm approach has huge potential for developing economic theory, overcoming crisis, in which has remained, as well as for improving management practice.
It has been shown that, based on the nature of their spatial and temporal boundaries, economic systems may be naturally divided into four classes, forming a qualitative taxonomy: environments, processes, projects and objects. It is also shown that homeostasis of the economy can be secured if the systems organize themselves, due to their functional specialization and exchange of the primary

resources/capacities, into specific ring-shaped structures comprising four systems of different types (tetrads).

Researchers need to deepen the classification of economic systems according to parameters of localization within the space-time continuum, combined with a behavioral classification of economic systems. The most important problem is the theoretical and empirical study of the interconnections among three groups of characteristics of economic systems: the internal structure of the systems; the configuration of their space-time boundaries; and their economic behavior. Studying these issues paves the way toward constructing, designing and deploying in economic space all types of economic systems with the assigned behavioral properties. In addition, of significant interest are the theoretical and methodological studies of measuring and correlating systemic properties, scales and structural characteristics of systems.

This article's findings also give grounds for a number of practical conclusions that are essential for formulating and pursuing economic policy.

1. An economy can function stably if each object system (in a microeconomic context, a business) operates as part of economic tetrad: “business — market environment — economic process — project”. Each element of the tetrad, the elements' interaction within the tetrad, and the entire tetrad's functioning – need to be continuously monitored. Thus, tetrads should become a focus of specialized regulation. In particular, business management needs to be combined with the management of tetrads comprising the business.

2. The management of a tetrad as a relatively stable complex of economic systems should be combined with the regulation of interaction among tetrads. It is necessary to study the structure of tetrads that are contiguous and interactive with a given tetrad. We also need to energize in a timely manner the channels of that interaction, which allow projects to be replaced as they complete their life cycles and allow processes to be replaced as they need to be updated.

3. In modernizing the economy, special attention should be given to combining the innovation project/process part of tetrads and their conservative object/environment part. Society, in each moment of time, needs to have a pool of investment projects and financial-economic processes available to economic entities, whereby those projects and processes can be inserted into tetrads to replace systems as they complete their life cycles.

4. Ensuring stability of the economy requires legislative changes to create a legal framework for the creation, functioning, and liquidation not only of businesses (and similar object-type systems), but also of process, project and environmental economic systems, as well as their groupings in the form of tetrads.

Acknowledgments. The research was accomplished with the support of the Russian Science Foundation (project No. 14-18-02294).

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