COMPLEX SYSTEMS, VECTORS OF COMPLEXITY

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ABSTRACT: *COMPLEXITY IS MANIFESTED THROUGH ITS COMPONENTS, COMPLEX SYSTEMS. SYSTEMS, REGARDLESS OF THEIR NATURE (SOCIAL, ECONOMIC OR INDUSTRIAL), ARE INCREASINGLY COMPLEX. A COMPLEX SYSTEM IS A SUSTAINABLE ARRANGEMENT OF INTERCONNECTED ELEMENTS (SIMPLER SYSTEMS) THAT FORM A UNIFIED WHOLE. COMPREHENSIVE THINKING IS NEEDED TO UNDERSTAND COMPLEX SYSTEMS. ORGANIZATIONS ARE COMPLEX SYSTEMS AND THEREFORE MANAGERIAL THINKING MUST BECOME A SYSTEMIC THINKING, WHICH EXPLAINS THE DYNAMICS OF THE INTERACTION BETWEEN ALL STRUCTURAL AND FUNCTIONAL COMPONENTS OF THE ORGANIZATION.*

KEY WORDS: *COMPLEXITY, COMPLEX SYSTEMS, INTERCONNECTION, COMPLEX THINKING.*

The purpose of understanding the nature of complexity, regardless of the field in which it is studied, could prove crucial in understanding society and improving our means of action on it. Because, it should be said, politics, economics, ecology, sociology and even psychology deal primarily with these complex systems.

The problem of complex systems and their modeling is very current. It is all the more so as many problems arise today through the globalization of the economy, urbanization, new technologies, juvenile delinquency, Covid and others. These issues are extremely complex.

In defining complex systems there are a multitude of definitions, some of which complement each other, but none of them are exhaustive.

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A complex system cannot be exhausted by a definition, there is a paradox of defining a complex system: any definition implies a reductionism, and any reductionism is contrary to the concept of complexity.

"A complex system is a sustainable arrangement of interconnected elements that form a unified whole. Businesses are complex systems that exist in even more complex systems - markets, industries and states. "

"A complex system that works invariably has evolved from a simple system that has worked."

"It's Gall's law: all complex systems that work are born of simpler systems that work. Complex systems are full of variables and interdependencies that need to be organized as they should in order to function. The complex systems created from scratch will never work in reality, because they were not subjected to the selection of their environment during their development. "

Regarding complex systems, R. Rosen[5] shows that they show surprise, novelty, counterintuitive behaviors, emergencies. In the same sense, developing, it can be said that complex systems are dissipative, hierarchical systems on multiple spatio-temporal scales, which show properties such as anticipation, goal pursuit, historical uniqueness, adaptation, self-regeneration, novelty and evolution, and multiplicity of perspectives.

In the research of complex systems we have to deal with both uncertainty and ignorance, but also with the emergence of novelty, a situation that necessarily involves both methodological pluralism (there is no single explanation for behavior) and value judgment and hence the need for procedural rationality and not just substantial rationality.

Systems, whether social, economic or industrial, are increasingly complex.

A system is characterized by input-output behavior and internal behavior. So this means that a system can be seen as data:

- a transfer function that transforms - at a given moment - a set of external variables, called system inputs, into another set of external variables, called system outputs, depending on the value of a set of internal variables, called system states,

- a transitional function that describes the evolution of the (internal) states of the system over time under the action of its inputs and external events.

The two main types of systems which are physical systems and software systems are perfectly interpreted in this context: in the case of physical systems, the variables usually live in continuous spaces, while we remain in discrete spaces at the level of software systems.

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[5] R. Rosen, *On Complex Systems*, European Journal of Operational Research, 30,, 1987 pp. 129--134.

A system is obtained recursively by integration from other systems. We are talking about a "complex system" when the systems involved in this recursive integration process become too numerous and / or too heterogeneous.

Industrial systems resulting from a V-cycle engineering process often fall into this category. The production of such industrial systems requires hundreds of engineers from several specialties. In the automotive industry, a "vehicle" project thus represents on average a workload of 1,500 man-years, spread over 4 years, involves 30-50 different trades and involves budgets of billions of euros. In the context of information systems, large IT infrastructure projects often span several years, involving teams of several hundred full-time IT specialists and budgets of several hundred million euros. Therefore, the development of this type of project poses major difficulties today, because no one is able to fully understand systems of this type.

The complexity of industrial systems remains, of course, a vague and subjective notion, but it corresponds to a strong industrial reality: it characterizes the systems for which the mastery of design, maintenance and development poses significant problems, related to their size. technologies used, which make the whole difficult to understand. In this sense, complex industrial systems are distinguished from other technically complicated systems whose design difficulties can be solved by a single talented engineer.

They can also be distinguished within complex systems "a kind of natural purpose" for natural systems and which can be approached by science, but also "a social purpose" for human systems and which, in addition to the scientific approach, must be addressed and in terms of value judgments, with moral aspects and even with aspects of spirituality. In fact, N.Georgescu Roegen shows that the result of the economic process is not only the high entropy, specific for natural processes, but also the joy of living.

Simple systems and complex systems are disjoint categories. To be better understood, complex systems require to be coded and formalized in more than one formal system.

The world of mechanisms, whether simple or complicated, is a surrogate, artificial world, created by traditional science, which has reached a turning point, where it becomes imperative to change the scientific and technological paradigm. Even though we now live in a world of computers and even if some say that a computer is something complex, in fact the computer is just a complicated artificial thing, a mechanism, of course a very useful one especially now that we have entered the economy based on knowledge. Let us not forget, however, that what makes the real world complex is precisely non-computability.

Comprehensive thinking is needed to understand complex systems[6].

[6] Josh Kaufman, *The Personal MBA: Master the Art of Business*, Worldly Wisdom Ventures LLC (Publisher), 2013

"Organizations are complex systems and therefore managerial thinking must become a systemic thinking, able to encompass and explain the dynamics of interaction between all structural and functional components of the organization."[7]

J.L. Le Moigne shows that the education system only teaches analytical models[8]. It is true that they can be taught more easily than systemic models. So these people transpose closed, deterministic models, more suitable for complicated problems to complex problems. The long domination of the Cartesian school meant that the students were not taught with this intellectual gymnastics which consists in passing from one register to another in order to adapt either to a situation of complexity or to a situation of complication.

It is also noticeable the outdated aspect of the diagrams of the consultants who say that by identifying the players, the forces involved and the competitive positions of each one we can deduce the way in which the action will take place.

A good leader is one who knows how to deal with uncertainty and not one who seeks to eliminate it.

Instincts, sensations, feelings and emotional intelligence cannot really be represented by algorithms. So, as E. Morin[9] says, the actor must be included in the action.

A complex system is, by definition, a system that is considered irreducible to a finite model, regardless of its size, the number of its components or the intensity of their interaction. For an observer, this is complex because he considers the meaning of the unpredictable potential of behavior on its own. Complexity is a property attributed to the phenomenon observed by the actor due to the representations he makes about it. However, the phenomenon can prove to be complicated, only complicated, because it is determined and reducible to a unique and completely calculable model. But if complex systems cannot be reduced to explanatory models, they are no less understandable.

We can build models that are themselves potentially complex. Symbolic constructions with the help of which we can reason action plans within these complex systems, anticipating their consequences through deliberation. By trying to apply the simplification of the complex to the complex, the complexity is aggravated by mutilation without necessarily solving the problem in question. Thus, analytical modeling through complicated problem-solving models proposed by mathematics and decision statistics and others, involves the closure of systems. These models often lead to methods that look for a problem that suits them, while modeling contemporary complex systems looks for methods that suit them.

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[7] C. Brătianu, *Strategic Thinking*, ProUniversitaria Publishing House, Bucharest, 2015

[8] Jean-Louis, Le Moigne, *La théorie du système Général, théorie de la modélisation,* Presses Universitaires de France, editia a 4-a, Paris 1994

[9] E. Morin *The Seven Knowledge Necessary for the Education of the Future*, Paris, UNESCO, 1999.

Epistemological references have given rise to a new definition of a complex system. It is a system built by the observer who is interested in it. The complexity being represented by a tangle of interdependent interactions; the system is represented as an intelligible mess and completed by interdependent actions.

Later, systemography appeared, which is the modeling of a general system. The reasoning used is borrowed from photography. We construct models of a phenomenon perceived as complex, deliberately representing it as through a general system. Then we see the appearance of corrections to the analytical method by methodology. In systemography, there are three phases:

• framing: building the model by isomorphism with a general system

• development: documenting the model through the homomorphic correspondence of the model with the perceived features of the phenomenon.

• interpretation: simulation of possible actions on the model to anticipate possible consequences in phenomena.

Newtonian mechanics and classical thermodynamics had as objects of research systems in static or dynamic equilibrium, easy to describe by systems of linear or nonlinear equations. Problems begin to arise when systems operate far from thermodynamic equilibrium and their mathematical description becomes difficult mainly due to the uncertainty of their evolution[10].

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