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The Science of Complexity and Organizational Learning: Emergence of a Model for the Analysis of Organizational Competitiveness[1]

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Abstract

Faced with the search for a theoretical consolidation for the analysis of organizations, the aim of the paper is to propose a model of analysis to study organizational learning from the theory of complex systems. This proposal try to meet the need arising from the questions about, how the social organization of the members of an organization and its environment is transformed to generate different types of organizational learning over time (t1-t0), and, what are the social regulatory mechanisms of the multiple imbalances and successive rebalances generated by their interaction and by the variations of their environment? To do this, in the first place, the exposed paper problem of knowledge in organizations as a problem of the theory of knowledge; besides discussing the nature of organizational learning from the main approaches of organizational analysis. This section concludes by emphasizing the need to study organizational learning as part of an emerging and disruptive process of evolution. On the second part of the paper, the way how the science of complexity is used to analyze organizational learning, explaining the complex systems approach used in this paper is proposed. The document concludes with the presentation of a new model for organizational analysis based on the approach of complex systems.

Keywords: organizational analysis, organizational learning, complex systems.

Introduction

Organizational learning is a field of academic research and professional practice with a relatively recent development. In recent years, theoretical models explaining the phenomenon have been proposed from various disciplines. This discipline is situated at the confluence of numerous fields of research, as Dodgson (1993) states, between psychology, sociology, economics and administration. In the latter, learning has an important role for innovation, strategy, productivity, decision making and organizational change. Learning ability is considered and valued as a multidimensional variable to the sources, levels of learning, culture and conditionings establish its representative dimensions. From these approaches, the learning capacity of an organization is determined by four key variables: levels of learning, culture and conditions for learning (Garzón, 2005); that characterize in two dimensions: 1)

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A static dimension, constituted by stocks of knowledge-tacit or explicit-immersed in the organization and that reside in individuals, groups and in the organization itself, and 2) a dynamic dimension, determined by the learning processes that make possible the evolution of stocks through the activation of "flows" of generation, absorption, diffusion and use of knowledge (Brontis , 1999, Vera and Crusan , 2000).

Thus, knowledge stocks are the input and output of a set of flows or learning processes that, in the terminology of March (1991), make possible the exploration and exploitation of knowledge. In this perspective , the dynamic interaction between the sources, the levels of learning, the culture and the conditions for learning, the knowledge and the learning processes that develop them determine the learning capacity of the organizations, whose effects on the results of the organization is moderated by knowledge management.

For various authors (Nonaka and Takeuchi, 1999; Krogh, Ichijo and Nonaka, 2001), the main resource of any type of organization is the set of intangible assets that generate intellectual capital; hence, organizations have an increasingly intensive activity in the generation of knowledge. Quinn (1992) agree that the future will belong to people who possess knowledge, so that the *knowledge worker* is the most important asset. (Nonaka and Takeuchi, 1999).

Moreover, Quinn (1992) mentions that the ability to manage what he calls *intellect based on knowledge* is rapidly becoming the most important executive ability of our era. Following this idea, Reich (1993) argues that the only real competitive advantage will be concentrated among those he calls *symbolic analysts*, who are equipped with the necessary knowledge to identify, solve and face new problems.

In consequence, they have emerged many new concepts: tacit knowledge, explicit knowledge, human capital, structural capital, customer capital, relational capital, etc. All of them put the accent on the set of knowledge that generates intellectual capital, which is considered as the greatest source of knowledge possibility of organizations, since it is demonstrated that, both now and in the future, it is the most competitive value important. Organizations, in an attempt to optimize their process of recruitment, facilitation, creation and management of knowledge, have tried to make these nuclei of intelligibility (Gergen, 1996), the most adaptive possible (Krogh, Ichijo and Nonaka, 2001). Given all these changes, what concepts, categories and conceptual artifacts do we have to discover the internal functioning of organizations? What new social regularities, configurations and conflicts are emerging? Is there a theoretical body capable of capturing the fundamental characteristics of complex organizations? Is it necessary to state the evolution of existing theories? Is it possible to determine a nucleus of intelligibility that manages to decipher new emergencies in complex organizational systems? At the level of organizations, how the social organization of the members of an organization and its environment is transformed to generate different types of organizational learning over time (t1-t0)? And what are the social regulatory mechanisms of the multiple imbalances and successive rebalances generated by their interaction and by the variations of their environment?

Faced with this search for a theoretical consolidation for the analysis of organizations, the aim of the paper is to propose a model of analysis to study organizational learning from the theory of complex systems. For this, the document is composed of two parts. In the first place, it is exposing the nature of organizational learning from organizational theories; emphasizing the need to study it as part of a process of emergent and disruptive evolution. Secondly, the way in which the science of complexity is used to analyze organizational learning is proposed. The main conclusion is that the conceptualization of the organization as complex system carries with it the need to consider knowledge of regulatory mechanisms multiple social imbalances and insert successive rebalances in organizational change.

Entering the game. The problem of knowing organizations is in itself, a problem of knowing in the theory of knowledge.

The efforts to know the internal and external dynamics of the organizations, has taken us within the studies of the organization, back to the approaches of the theory of knowledge, which according to Hessen (2005) are five: The possibility of human knowledge, the origin of knowledge, the essence of human knowledge, the forms of human knowledge and the criterion of truth.

In this sense Villoro (1994) offers a systematic analysis of the fundamental epistemic concepts: belief, certainty, learning, knowledge. It establishes its relationships, on one hand, with the reasons that justify the truth of our beliefs, on the other, with the reasons that can distort them. That is, the most important dilemmas arise from the ontological and epistemological point of view of knowing.

In the case of studies on organization, we seek to create a new rationality that reproduces in the study of social and human life, the same kind of sensational illumination and explanatory power that the natural sciences had already provided. (Giddens: 1997: 15).

In this sense, one of the most powerful arguments against the scientific character of the social sciences posed by modernity, is that until now they have not been able to produce anything comparable to a Natural Law (Bottomore: 1992: 26).

In this regard, social constructionism seems to constitute a sort of disciplinary matrix (Kuhn, 1993) , that is, a new framework of mental coordinates to develop work in the social and human sciences, but also as a way of orienting oneself in the world daily (Ayús and Mendoza, 1999). Theorists as Gergen raised new questions count as: *How do people know as know? How does the scientist know?* And in this, as a response, it shows a new logic of knowing, that is, a model. Its core of intelligibility: Theory set of assumptions that are not explicit theory, are beyond the theory. This combination determines a practical way of knowing, that is, a methodology for the knowledge of organizations.

It is remarkable then the proposal of knowing the individual reason product of the ideas of Descartes versus the proposal of community reason as an alternative. In this respect Ayús and Mendoza (1999) distinguish their characteristics:

Chart 1.Instrumental reason versus community reason.

Modernity	Postmodernity
• ***Rational Agency*** **[Rational actor: I know and act on the world. *Cogito ergosum* (I think, therefore I exist, Descartes)].**	• ***Community rationality*** [Community of rational actors: *collective* constitution of knowing, shared production of meaning and social knowledge and actions in the world. *Communicamusergo sum* (communicate, then I exist, Gergen).].
• ***Empirical knowledge*** **[Based on experience: capture of the sense organs. Hierarchical degrees of knowing: from sensorial to understanding. The cognitive process as *tabula rasa*].**	• ***Social construction of knowledge*** [The vocabularies with which we account for the world and its objects, have nothing to do with a correspondence or representation of these, are social artifacts product of historically and culturally situated exchanges, never reduced to creations of meanings) that gives meaning to the permanence in the time of the ways in which we account for the world and not the objective (ontological) validity of those social artifacts by themselves.].
• ***Language as representation*** [Language as mediator in the cognitive act. Visual metaphor or mirror model (Ayús y Mendoza, 1999) as relevant to describe cognitive operation (observe, appreciate, as seen, etc.).Adequacy, correspondence between perception and object of perception, guarantee of objectivity].	• ***Language as an action*** [Language as "game" (Wittgenstein, 1953) that leads to organize the forms of interaction that institute and constitute social life. Language as "way of life", symbolic instance through which we "do" things Bakhtin, M. (1981), by telling them in the interactive social world. The language does not help to describe the action, but is already in itself a game of actions, among which finds its descriptive qualities. Language is that social space for the constitution of social relations.]

Source: Ayús and Mendoza (1999)

In this chart, the difference between individual Rationality and Community Rationality is clearly stated, which helps in the clarification of theoretical concepts and methodology, as well as in the design of the theory. Now let's take this discussion to the dimension of organizational knowledge and learning. (Ayús, R. y Mendoza, R. 1999 y Pérez Mayo, 2013).

Nature of organizational learning: How do they know the organizations?

Nonaka and Takeuchi (1999) argue that there is a reason why Westerners tend not to talk about the creation of organizational knowledge: they assume that the only way of thinking about organizations is to consider them as "information processing" machines, which implies an explicit knowledge of a formal and systematic nature.

For these authors, the Japanese companies have a very different idea of what is knowledge, for them the knowledge is tacit mainly, not very evident and difficult to express, That has its roots in the deepest of the actions and the individual experience, as well as in the ideals, values and emotions of each person, unlike the vision of western knowledge that expresses itself with words and numbers, manifesting only the tip of the iceberg.

In specific terms, tacit knowledge can be divided into two dimensions: the technical dimension and the cognitive dimension. Although they cannot be easily enunciated, these implicit models control the way we perceive the world around us. The difference between explicit and tacit knowledge is the key to understanding the different conception of knowledge of Westerners and Japanese. Explicit knowledge can easily be "processed" by a computer, transmitted electronically or stored in databases, but the subjective and intuitive nature of tacit knowledge hinders its processing or transmission in a systematic or logical manner. For that knowledge to be transmitted and disseminated among the members of an organization, it is necessary to turn it into words or numbers that everyone understands. It is precisely during the time it takes that conversion from tacit to explicit and back to tacit, how knowledge is created in organizations.

Polanyi (1966) states that tacit knowledge commonly consists of habits and cultural aspects that we hardly recognize in ourselves. In the field of knowledge management reference is made to knowledge that only the person knows and that is difficult to explain to another person.

The importance of tacit knowledge lies in:

1. It generates a new point of view about the organization.

Instead of conceiving it as a machine for processing information, it is considered a living organism in which the members of the company can and should have a generalized understanding of its principles, where it is going (mission and vision), type of world in which you want to exist and how to bring that ideal of the world to reality. Personal ideas, intuition and hunches, other subjective elements, are an integral part of knowledge. It also includes ideals, values and emotions, as well as images and symbols. These elements, qualitative and somewhat vague, are indispensable to understand the way in which the Japanese visualize knowledge. The most important learning comes from direct experience. A child learns to eat, walk and talk through a system of trial and error; learn with the body, not only with the mind. Similarly, Japanese executives emphasize the importance of learning from both direct experience and the trial and error system.

2. The essence of innovation is the recreation of the world according to an ideal or a particular vision.

Creating new knowledge means literally re-creating the company and everyone who belongs to it, within a constant process of personal and organizational renewal. It is not the responsibility of a chosen few, but of all those who participate in the organization. The creation of new knowledge does not only consist of learning from others or acquiring it from abroad. Knowledge must be built on its own and often requires intensive and laborious interaction among the members of the organization. The tacit knowledge allows then, to understand and explain the emergencies that occur within the complex organization, while the explicit knowledge does not. However, as proposed by Krogh, Ichijo and Nonaka (2001), for it to have value, tacit knowledge must become explicit. If we talk about knowledge in the organization, it is essential to return to the concept of organizational learning. This acquires different connotations according to the theorists who study it. Below, some conceptions of organizational learning are presented:

- Chris Argyris and Donald Schön (1978) "the detection and correction of error"
- Fiol and Lyles (1985) "the process of improving actions with better knowledge and understanding"
- Dodgson (1993) "The way companies build, provide and organize knowledge and routines around their activities and within their cultures and adapt, develop organizational efficiency by optimizing the use of the extensive skills of their employees."
- Huber (1991) "If through their information processes, the range of their potential behaviors is changed ".

This concept of organizational learning fits perfectly with those of tacit and explicit knowledge within the organization, it could be said in a broad sense and relating these three concepts, that organizational learning is achieved when the experiences and actions of the individuals that make up the organization make changes positive for the organization and can be manifested as explicit knowledge.

However, when what matters is how the social organization of the members of an organization and its environment is transformed to generate different types of organizational learning over time (t1-t0), and, what are the social regulatory mechanisms of the multiple imbalances and successive rebalances generated by their interaction and by the variations of their environment? The organizational model analysis to study the evolution of learning are limited; but not because of lack of explanatory consistency, but because the arrow of time is incorporated into thresholds of continuous and non-disruptive change. In other words, the approaches shown provides an explanatory cross - sectional model and gradual change; where time is implicitly incorporated, but not as a process but as a comparison of two situations based on specific moments: a point in the past with respect to some of the present, without making explicit the thresholds of successive change. Faced with this, the proposal of the science of complexity is a useful meta-theory to analyze organizational learning as a process of emergent evolution. Let's see why.

The organization from the proposal of complexity

If we talk about learning processes, we have to understand, from the theory of complexity, that learning is modified when emergencies arise. Emergence, considered the essential feature of complexity, is the appearance of unexpected and unexplained structures and / or patterns in complex systems (Trainor, 1909). According to the Dictionary of the Royal Academy of the Spanish Language, emergency (from the Latin emergens) means: "action or effect of emerging; occurrence or accident that survives "; as an adjective: "what is born, comes out and has the beginning of something else"; as a verb, its meaning is more limited since it is defined as: "the action of emerging, of sprouting or leaving water or another liquid".

In the sciences of complexity, the word was used by the first evolutionists to correct or rectify the concept of biological evolution in order to introduce in it, the characteristics of unpredictability of (apparent) freedom of a cause and of novelty about an existing reality, in addition to an inability to explain with the knowledge frameworks of the different sciences in which it is presented.

Henri Bergson (1907) **1** uses this notion of emergence, when it speaks of *creative evolution*, to underline the diversity and complexity of the evolution of living beings and qualifies it as "the almost infinite multiplicity of interlaced analysis and synthesis". In this conception of the French philosopher, emergence understood as "creativity of evolution" is antagonistic to the Darwinian idea of evolution. Loyd Morgan in his work published in 1923 "Emergent *Evolution* "uses the same idea, before the boom it has had in the studies of complex systems.

The word emergency, in this new sense, emphasizes the unpredictable novelty and the disconnection or apparent lack of causality of a given effect, together with its inexplicability according to the existing knowledge of physics, takes "almost" a metaphysical sense and it is "almost" converted into a synonym of the word creation when it is used in the metaphorical sense as "creation of an artisan" and only lacks the characteristic "of being created from nothing" to be taken in a theological sense. Reason why we insist that any study on the emergency must rest on a formal definition.

The idea of emergence as a philosophical doctrine is associated with the appearance of new categories of behavior that cannot be derived from the elements of the system (Patte, 1989), which has been associated with vitalism or metaphysical ideas of creationism, which were not well accepted in the beginning by the scientific community. However, with the popularization of the mathematical models of complex systems in morphogenesis (Cocho et al., 1987), Thom's Theory of Catastrophes (1975), Prigogine's Dissipated Structures (1983) and Mandelbrot's Fractals (1977), Synergetic of the Haken (1983) as well as a deeper understanding of the chaotic and dynamic changes by symmetry breaking, the concept of emergence understanding has become a scientifically respectable notion (Patte, 1989).

A couple of emergency examples will help you estimate your idea: in language, the meaning of words is not determined by the rigorous definition of the word, but by the context in which they are immersed, and by their applications to the real world , therefore, meaning is an emergent property, inherent in language as a system. If we isolate the words from their context, while retaining the rigor of their definitions, we would surely lose the meaning. The same happens when we try to explain the phenomenon of life through an anatomy book, it explains life according to the components of a corpse, with this approach the meaning of life is lost, which is also an emerging priority of the system. Proceed then to seek emergency in organizations through the new logic of understanding reality.

Theoretical nature of the complex systems approach. The dispute between Logical Positivism and Genetic Constructivism

Today there are different approaches that address the study of economic and social phenomena from the perspective of the science of complexity. The research program of Adaptive Complex Systems by John Holland (1996) has its epistemic foundation in the rational choice and logical positivism; uses *analogy* as a tool for logical structuring, while game theory and computational language are the operative tools to construct its theoretical architecture. The explanation of the phenomena is based on the imputation of analogous attributes between the behavior of a biological system and a socio-economic system. In this aspect, the "complex" has two meanings: on one hand, complexity is measured according to the number of tasks or functions performed by a system and on the other, according to the number of interactions and information flow that the elements that they integrate it. This approach is characterized by constructing formal models to analyze economic phenomena in the form of algorithms (tags); which represent the way in which the agents code the information to adapt to the conditions of their environment and make economic decisions. The ultimate goal is to mathematize interaction patterns under the assumption of a rationality limited by context, where agents interact to identify optimal patterns according to the objective of the system (for example, greater innovation, better relationships, etc.).

There is another aspect of the theory of complex systems that works more as an explanatory meta-theory, than as a mechanism of mathematical formalization. This recognizes that even when mathematically is possible to find explanatory associations, not all the logical structures of knowledge of a system are limited to that. That is to say, not all the interactions and explanatory associations of the elements (subsystems) of a social or economic system are susceptible of mathematical formalization. This aspect has been built from the questioning of logical positivism through the genetic epistemology developed by Jean Piaget (1978, 1982) and Rolando García (1997, 2000, 2001, and 2006). Using *homology* as a logical structuring tool, the construction of the system has as its starting point not only the explanation of what, when and where about its behavior (made explicit in the Holland models); but also the search for explanations about how one goes from one phase to another of evolution and which are the regulatory mechanisms of their multiple imbalances and successive rebalances. In this aspect, the system is built according to the theoretical framework and the available empirical material of the phenomenon and is not taken for granted, as in Holland's approach. Under this approach, a system is not complex because of the number of interactions and information flows between its components; but by the interdependence of its elements or subsystems. Ontologically, none conditions the existence of the other in total form, but their interaction creates emergent properties in semi - decomposable systems, analyzed under the premise that they contain emergent properties that are more than the sum of their parts. **2** What implications does the adoption of this approach have for the study of organizational evolution?

The company as an open complex system

The elements that justify the conceptualization of the company as a complex open system are: first, because the systems approach allows to research organizational evolution having as a starting point the delimitation of three trends present in any evolutionary process: 1) the continuity of the functions of assimilation and accommodation in phases of continuity and structural discontinuity on the part of the agents that operate in the company, 2) the structural stability generated by the agents' interactive solution to current problems and not considered in their actions, and, 3) the structural discontinuity, present when the solution of the internal requirements and the environment cannot be processed by the competences reached by the agents of the company, which justifies the search for a new level of structural stability. This approach to complex systems moves away from the scientific explanation based on subsumption to general laws established once and for all **3** (Nomothetic Laws of the Natural Sciences), and is closer to that where the organization is explained according to social laws of variable and mutable character (Ideographic Laws of the Social Sciences), **4** where their organizational evolution is developed by the interaction of the environment and the networks of agents within the company. In this systems approach, the explanatory model of the organizational determinants of a company does not fit the search for a single static equilibrium and the mechanisms needed to return to it (see diagram 1), but for the study of multiple imbalances and successive restructuring, no longer of continuity, but of structural discontinuity, with functions of assimilation and accommodation of functional continuity (See diagrams 2 and 3).

In third place, the leadership of the social organization of the local agents within the company is claimed. With the analytical lens of complex systems, it is possible to identify the type of participation that could potentially generate changes in their environment; which implies to conceive the institutional and organizational change in an adaptive way, but not only in function of its environment; but also as a product of the change in informal social organizations, composed of groups very close to the interior of the company.

In summary, the starting point to establish the analytical utility of complexity science is that: since all complex systems are subject to the same functions and transformations as the evolution of the company, it is conceptualized as a complex system. At this moment it is necessary to ask ourselves about how the complexity science contributes to enrich the study of organizational evolution?

Nature of the Model

The starting point to study the organizational evolution is to conceptualize the company as a system of emergent properties arising from the interaction of: 1) its internal components (subsystems) and their environment, and, 2) the determination mechanisms that allow the operation of their interactions. Second, the company conceptualized as a complex system is by definition a learning organization. In this sense, it is considered that there are at least three levels: in the first is the company as a system, in the next level is the engineers, grouped in operational subsystems, and level third that correspond to the individual. These levels maintain links given under a set of formal and informal elements that govern their social relations; within which agents pursue and fix the limits of their legitimate interest; providing in turn the rules of conduct for their collective action by facilitating and organizing the interest of the actors.

Thus, the organization of companies occurs through the operation of two subsystems: 1) the first one gives an account of how local agencies process the requirements of their environment; and, 2) the network subsystem that covers the type of relationships established between the local agencies of the company with respect to other companies located in Mexico or abroad. Third, local agencies are the groups of individuals that articulate their interests within the company as a social organization. Here, the key behavioral assumption is that their actions are socially constructed through a process of learning and organizational skills, which allow reducing the conditions of uncertainty and information for decision making.

Explanatory dynamics

The complexity science of Jean Piaget, Ilya Prigogine and Rolando García suggests that the dynamic behavior of a complex system is marked by intermittent phases of stability (moments of evolution) and structural instability (moments of transition). In different degrees, both phases depend on internal and external fluctuations, generated, the first, by the contradictory interaction of its components within the system (linked to problems related to the organization of the company) and, the second, by the oscillations of the environment (change in the framework of incentives applied to its operation). In both intermittent phases, learning processes are generated due to the interaction between the subsystems of the company and its operating context.

Here the question is how the actors that determine the organization react to different problems and solutions (internal and external fluctuations), typical of their activity. That is, what happens after the company as a system passes a certain threshold of problems that cannot be processed by existing organizational competencies? And what are the mechanisms that determine the selection of new forms of organization to stabilize the organizational learning process at another level of structural stability? For a moment imagine the functioning of the system where the environment is interactively adjusted to the internal organization of groups and individuals, forming stable organizational patterns over time (reproduction). The continuous reproduction of the formative process of the organization is ensured to the extent that the decoupling of the accumulated knowledge regarding the new requirements is successfully processed with the social organization of the local agencies in their internal relations and with their environment.

In other words, the company as a system has the capacity to absorb both the decoupling (fluctuations) of magnitudes already present in its operation, and those whose magnitude had not been present before. This situation is possible because the subsystems that integrate it maintain sufficient channels of communication between them and that the functions of assimilation and accommodation of their competences are sufficient to resolve these fluctuations and maintain structural stability, without qualitatively important changes. What happens when a decoupling between the organizational competences and the requirements of the environment is generated?

What happens when the new demands cannot be processed by the competences of the existing social organization between its components and the environment? According to the model of comparative statics of scheme 1, when this happens, gradual changes are made in time that adapt the behavior of the company in its new environment; but without specifying the critical thresholds on when and how changes will occur in each phase of evolution (See Figure 1).

In the light of the science of complexity, this decoupling takes place when the system (the company) is beyond a critical value of control of fluctuations (structural uncoupling), not processed by the existing social organization in local agencies. In this case, the company faces a phase of increasing instability (moments of transition), where organizational evolution occurs under the random cover of multiple imbalances and successive restructurings (bifurcation points) following the basic mechanism of trial and error of solutions; after which a new form of social organization appears that stabilizes and resolves the contradictions generated by the structural decoupling of the system on a new level.5

In other words, the successive construction of organizational skills and knowledge of each evolutionary moment is presented when local agencies encounter an external or internal disturbance (changes in the environment and endogenous contradictions), that is when existing organizational competencies cannot resolve the new problems derived from their environment or productive activity. At this point, local agencies have two options: 1) it remains of their productive activity without changes, with the disadvantage of a loss of competitiveness, or 2) local agencies begin a process of assimilation and accommodation under the mechanism dialectics and stochastics to adapt the operation of the company in new moments of organizational evolution.

As a result, the only factors that are truly omnipresent in each evolutionary moment (phase of structural stability) are functional and not structural in nature. These factors are linked to the assimilation of what is new to the preceding cognitive structures, and to the adaptation of these to the new acquired skills and knowledge. The first means the incorporation of an external element (object, event, etc.) in the organizational competencies of the company; while accommodation represents the need under which assimilation is to take into account the particularities of the elements that must be assimilated. In this way, organizational evolution proceeds by reorganization and rebalancing with parallel actions of functional continuity and structural discontinuity (See figure 2).6

On the other hand, the operation of the described structural discontinuity is key to study the continuous and disruptive change in a relative way, never in an absolute way since although the new social organization is at a level that solves the organizational problems that caused the crisis from the previous moment, this raises new problems that will be the source of the next level of disequilibrium.

In this way, organizational evolution changes over time depending on how the environment evolves or the unresolved contradictions of its local agencies within the company. Substantial changes will take place when contradictions cannot be processed by the social organization of the agencies at a given level of structural stability, producing successive moments of transition (bifurcation, trial and error points) before consolidating another phase of stability. Thus, when the irreversibility of time is incorporated into the evolutionary scale of companies, a dynamic equilibrium model adjusted to different phases of structural stability, characterized by a social organization and specific institutional arrangements, is conceived.

In summary, the question of structural stability and bifurcations (structural discontinuity), states that the historical course of the system is characterized by two clearly defined trends: a) a succession of phases of relative structural stability, where deterministic laws dominate, and b) a set of unstable phases near the bifurcation points, where the system "chooses" between several possible futures and where the elements of chance play a preponderant role (See diagram 3). Thus, the organizational evolution of the company is the result of a combination of necessity and random, where its temporal behavior is the result of an *order of fluctuations (*Prigogine and Stengers, 1983: 35-45).

So far, it is considered that the science of complexity allows us to understand the structural discontinuity of organizational evolution; with specific determination mechanisms in each phase of structural stability. However, it is still pending to know the mechanisms that determine the selection of new forms of social organization that stabilize organizational learning processes at a new level of structural stability. According to Piaget (1978) and García (2006), these mechanisms are related to the functional continuity of the evolution of a complex system.

In this case, the processes that mediate between one equilibration and another, that is, between a phase of structural stability and another, are the functions of assimilation and accommodation that operate under mechanisms of dialectical and stochastic determination. Here, the dialectical mechanisms are activated when the uncoupling of accumulated knowledge regarding the new requirements cannot be processed by the existing social organization between its components and the environment. That is, they only take place in those cases where it is necessary to build new organizations to solve this structural uncoupling (adopted by Piaget, 1978 and 1982).

However, also in stability intervals the function of assimilation and accommodation is presented in the *reproduction* of the organization, taking into account the mechanisms of interaction between local agencies and their environment.7 In such a way that, while in phases of structural instability, the dialectical and stochastic mechanisms will produce forms of novel social organization (*production*),8 in moments of stability the assimilation and accommodation functions of local agents will generate the *reproduction* of new forms of actions. In this scenario, it is considered that the complexity science of Piaget, Prigogine and García is useful specifically in relation to: The study of organizational evolution considering determination mechanisms that occur between a state structurally stable and from one to another branch point, corresponding to different ways of determining mechanism (i.e. causal mechanisms for interaction, mechanical, statistical, structural and teleological).

The discernment of the elements at random, near the critical points of bifurcation, not to make an exact prediction of the future behavior of the local agencies that exercise the organization; but to analyze the problems opened by the new evolutionary moment. The identification of those contradictions or disturbances that can generate new processes of learning and construction organizational competences applied to the resolution of novel problems. Fluctuations that, under certain conditions of systemic instability, may correspond to a set of competences resulting from the interactions of local agencies within the company and its environment.

The classification of two trends in organizational evolution: a) on one hand, the structural discontinuity resulting from the jump from one level of structural stability to another qualitatively different from the previous one; and b) the functional continuity of assimilation and accommodation, operating in both stable evolutionary moments as in moments of transition, on the other. In this situation, the science of complexity integrated into the study of organizational evolution raises the following questions:

What are the environmental conditions that generate phases of stability (moments of evolution) and structural instability (moments of transition) to the operation of the company?

What is the relationship between the processes of organizational learning and the construction of competencies in phases of stability and structural instability of the company?

What are the thresholds of the evolutionary and transition moments, established by the transformation of the requirements of the environment?

In times of structural instability, what are the probabilistic paths to choose?

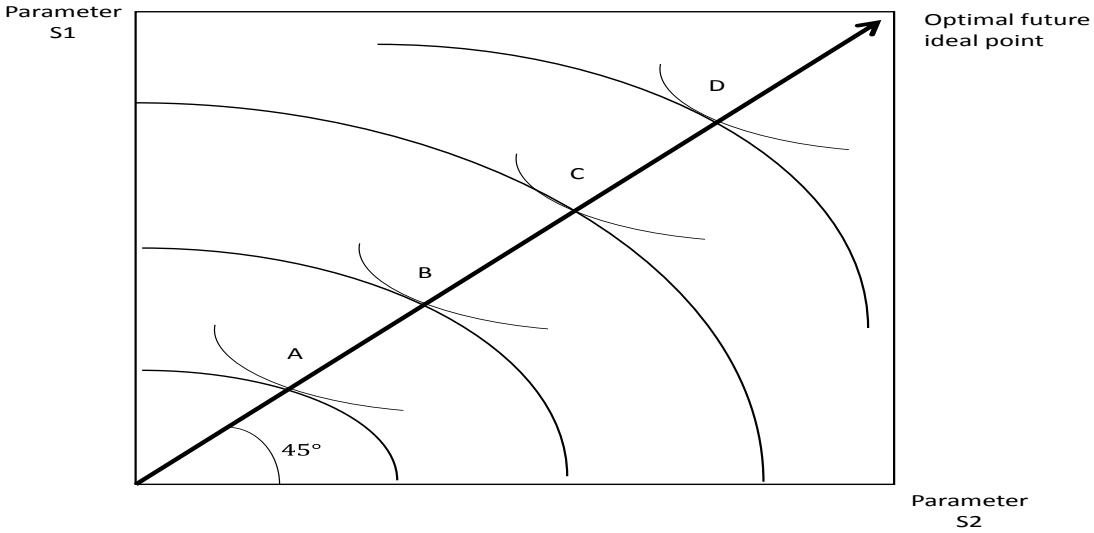
How are the organizational competencies of a previous evolutionary moment refunctioned (t1-t0) with those developed in the next one?) What new processes of organizational learning arise as a consequence?

What events, what technology (s) will disappear (n) and what innovations will be presumably accepted for the organization of the companies?

Is there a possibility that some particular type of relationships between local agencies and their environment may generate new organizational coordination regimes?

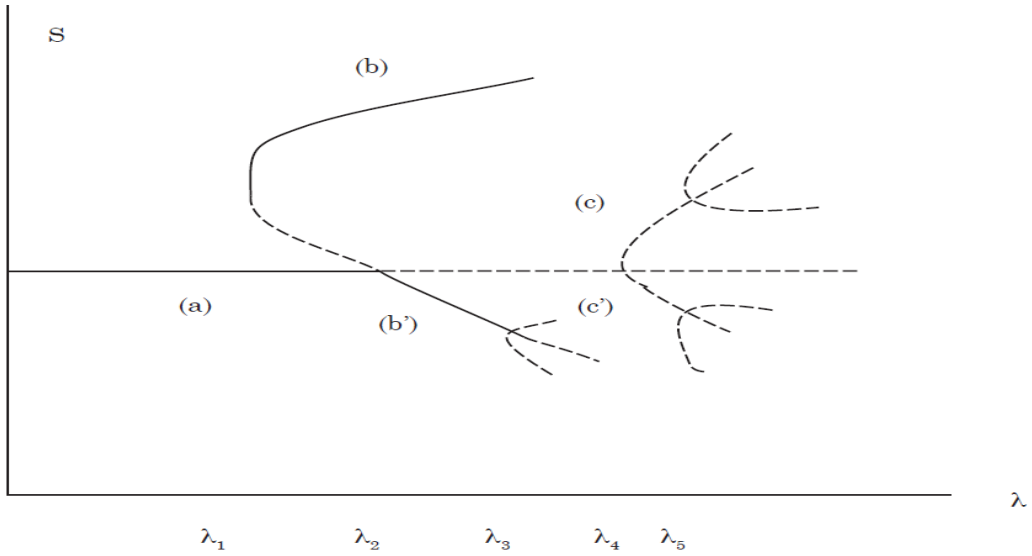
In conclusion, the conceptualization of the organization as a complex system entails the need to consider the knowledge of the regulatory social mechanisms of the multiple imbalances and successive rebalances inserted in the organizational transformation.

Figure 1.General Equilibrium and Comparative Static Models (reversible time)



Source: Adopted from Edgeworth's box, cited by García, (2015, p. 38)

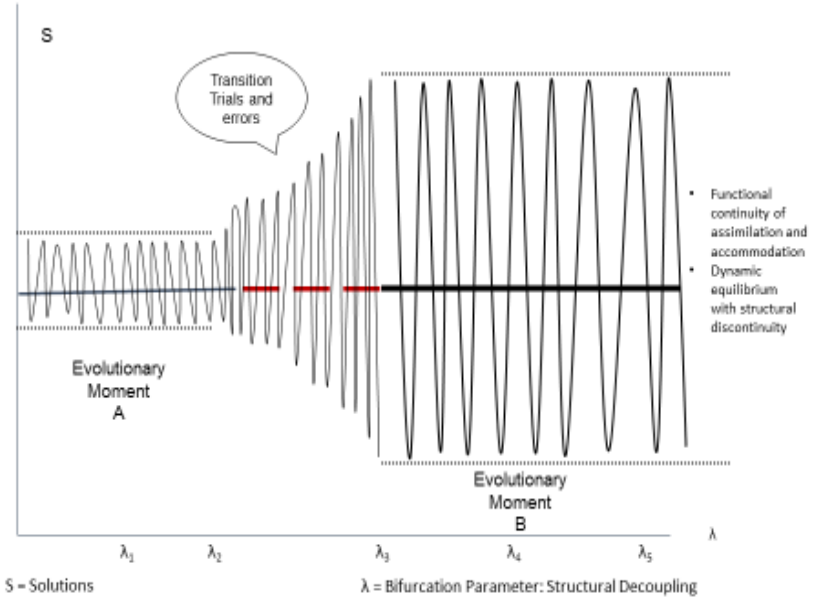
Figure 2.Diagram of Phases of Structural Stability and Functional Continuity of Organizational Evolution



S = Solutions, λ = Bifurcation Parameter: Structural Decoupling.

For $\lambda < \lambda_1$ a phase of stationary structural stability occurs, this set of states forms the branch (a). For $\lambda = \lambda_1$, two other sets of stationary states are possible (branch b and b'). The states of b' are unstable, but they can be stable for $\lambda < \lambda_2$,while the states of the (a) branch become unstable. For $\lambda < \lambda_3$, the branch b' is unstable and two other stable branches appear. For $\lambda < \lambda_4$ the unstable branch (a) reaches a new bifurcation point, from which two new branches arise that will be unstable until $\lambda < \lambda_5$

Figure 3. Phases of functional continuity and structural discontinuity of organizational evolution.



Source: Adopted by Prigogine and Stengers (1983), cited by García (2015, p. 51).

1It is important to establish the difference and lack of relationship to avoid confusion between Bryan Bersong, the creator of the conjecture and Henri Bergson the French philosopher.

2Although the study of complex systems applied to the social sciences has been proposed by Jean Piaget, Illa Prigogine and Stengers since the early eighties, it was not until the nineties that a special interest arises for its homologous application in several disciplines. In the United States some works related to the social sciences and the science of complexity have been published, among which Harvey and Reed (1994), Hayles (1990 and 1991), Reed and Harvey (1992 and 1996) and Byrne, (1998). In the tradition of evolutionary economics and studies of technological change, there are names like Peter M. Allen, Dorien De Tombe, Richard R. Nelson whose most representative works are published in Leydesdorff and Van den Basselaar (1994). In Mexico, the works of Fernando Cortés (1993, 2001 and 2008) and Rolando García (1997, 2000, 2001 and 2006) have traced a path of theoretical-methodological elaboration for the social sciences in our Latin American countries. In John Holland's side, interesting applications for neoclassical economics have occurred (Anderson , et al, 1988), in the economics of transaction costs (Foster, 2000); in the analysis of " Knowledge Management" by Stacey (1996) and McElroy (2003); and, in the analysis of organizational behavior (Axelrod and Cohen, 2000).

3It refers to the scientific explanation of Hempel-Popper (1970 and 1973, respectively), which is based on a model of legal coverage, where a fact is explained when it is shown to fit into a pattern; subsuming it in a legal form statement.

4Unlike the explanation based on universal laws where it is enough to know the fundamental relation of the phenomenon to predict reversible processes; in the company immersed in the deterministic chaos (irreversible time), the initial key conditions to understand the emergence of its qualitative novelty are mutable as time progresses. Its future development is uncertain and the conditions of change are governed by historically irreversible random processes. In this case, the type of social laws referred to are of an explanatory nature in the sense that they enumerate possibilities, but never stable certainties.

5If this happens, we are faced with the presence of feedback that allows us to adjust and correct these decoupling not considered at the beginning of this particular phase of evolution. However, it can also happen that the components of the system do not incorporate the decoupling they face into their activity; remaining on an unstable path where their patterns of social organization are reinforced; but without reaching a new stabilization moment.

6This process Piaget (1978:35) calls maximizing equilibrium, to the extent that it "cannot be conceived as a simple march towards equilibrium, since in addition (to be) constantly a structuring oriented towards a better equilibrium; any balanced structure remains in a definite state even if more later retains its special character without modification"; which "(...) never indicates a point of detention, if it is not on a provisional basis". Therefore, each phase or evolutionary moment raises new problems insofar as it resolves the previous decoupling, constituting the source of initial imbalances that will make crises in the next moment of transition.

7The mechanisms of interaction of organizational reproduction refer to the following categories of determination: "1) causal determination or causation: determination of the effect by the efficient cause (external), 2) Interaction (or reciprocal causation or functional interdependence, determination of the consequent by reciprocal action, 3) mechanical determination: of the consequent by the antecedent, by the general with the addition of efficient causes and mutual actions, 4) structural (or totalistic) determination of the parts by the whole, and, 5) teleological determination: of the means by the ends or objectives" (Bunge, 1972: 29-31).

8The mechanisms of statistical determination (stochastic) are the result of the joint action of independent or semi-independent entities, and the mechanism of dialectical determination (or qualitative self-determination) is the product of the entire process by internal struggle and by the eventual subsequent synthesis of its opposite essential components (Bunge, 1972:30).

Reference

Argyris, C. & Schön, S. (1978). Organizational learning: A theory in action perspective. Reading. MA: Addison-Wesley.

Anderson, Philip; Kenneth J. Arrow y David Pines (1988). The Economy as an Evolving Complex System. New York. Addison-Wesley Publishing Company. Santa Fe Institute.

Axelrod Robert & Michael Cohen (2000), Harnessing complexity: an organizational implications of a scientific frontier, New York, Basic Books, A Member of the Perseus Books Group.

Ayús, R. & Mendoza, R. (1999) De la ontología muda, a las retóricas de la calidad. Aproximaciones al construccionismo social. Administración y Organizaciones. Noviembre.

Bergson, H. (1907), L'evoluzionecreatrice, Athena, Milán.

Bottomore, T. B. (1992) Introducción a la Sociología. España: Editorial Península.

Brontis, Nick (2000). La gestión humana y el aprendizaje organizacional, Intellectual capital. MC Master University, Canadá

Bunge, Mario (1972), Causalidad; el principio de causalidad en la ciencia moderna, Buenos Aires, Argentina. Universidad de Buenos Aires. Traducida por Hernán Rodríguez. Tercera Edición.

Byrne, David (1998), Complexity Theory and the Social Sciences, New York, Routledge

Cocho, G., Pérez-Pascual, R., & Rius, J. L. (1987). Discrete systems, cell-cell interactions and color pattern of animals. I. Conflicting dynamics and pattern formation. Journal of theoretical biology, 125(4), 419-435.

Cortes, Fernando & Rolando García (1993) "Muestreo estadístico, bases de datos y sistemas complejos". En Ignacio Méndez Ramírez y Pablo González Casanova (coordinadores) Matemáticas y Ciencias Sociales. Centro de Investigaciones Interdisciplinarias en Humanidades. UNAM. Miguel Ángel Porrúa Grupo Editorial. México, D.F.

(2001) "Nociones de la epistemología genética aplicadas a temas de discusión en las ciencias sociales. Un par de ejemplos" Estudios Sociológicos, Vol. XIX, No. 57, pp. 641-651

(2008) Escobar Agustín & Mercedes González de la Rocha (2008) Método científico y política social: A propósito de las evaluaciones cualitativas de programas sociales, México, D.F., Centro de Estudios Sociológicos. El Colegio de México

Dodgson, M. (1993). Organization learning, review of some literatures, in organization Studies, Vol 4 (3) 375-394

Fiol, M & Liles, M (1985).Organizational learning. Academy of Management Review, Vol. 10, 4, p. 803-813

Foster, John (2000) "Is there a role for transaction cost economics if we view firms as complex adaptive systems?" Contemporary Economic Policy, Vol. 18, No. 4, pp. 369-85

García Jiménez, Humberto (2015), Sistemas Complejos e Innovación Ambiental del Sector Automotriz en México México, D.F. El Colegio de México y la Universidad Autónoma del Estado de Morelos. ISBN: 978-607-462-801-2.

García, Rolando Coord. (1997), La epistemología genética y la ciencia contemporánea: Homenaje a Jean Piaget en su centenario, Barcelona, España, Gedisa Editorial.
(2000), El conocimiento en construcción. De las formulaciones de Jean Piaget a la teoría de sistemas complejos, Barcelona, España, Editorial Gedisa.
(2001), "Fundamentación de una epistemología en las ciencias sociales" Estudios Sociológicos, Vol. XIX, No. 57, pp. 615-20
(2006), Sistemas Complejos: Conceptos, método y fundamentación epistemológica de la investigación interdisciplinaria, Barcelona, España. Gedisa Editorial.
Garzón Castrillón, M. A. (2007). Marco teórico del aprendizaje organizacional, avance de tesis posdoctoral, Universidad de Sao Paulo, Brasil.
Gergen, K. 1996 (1994) Realidades y relaciones. Aproximaciones a la construcción social. España: Paidós.
Giddens, A. (1997) Las nuevas reglas del método sociológico. Buenos Aires: Amorrortu.
Haken, Hermann (1983). Synergetic. An Introduction. Berlin: Springer Verlag.
Harvey, D. L. & Reed, M. H. (1994) "The evolution of dissipative social systems", Journal of Social and Evolutionary Systems, Vol. 17, No. 4, pp. 371-411
Hayles, N.K. (1990), Chaos Bond, Ithaca, NY, Cornell University Press
(1991), Chaos and Order, Chicago, University of Chicago Press.
Hempel, C.G. (1970) Aspects of scientific explanation: and other essays in the philosophy of science. New York. Editorial Free.
Hessen, J. (2005) Teoría del conocimiento. México: Editores Mexicanos.
Holland, John H. (1996) El Orden Oculto, de cómo la adaptación crea la complejidad, México, D.F., Fondo de Cultura Económica. First Edition in Spanish, 2004.
Huber, G.P. (1991): "Organizational learning: The contributing processes and the literatures". Organization Science, vol. 2. Reimpresión en Cohen, M.D. y Sproull, L.S. -eds.- (1996): Organizational Learning. Sage, Thousand Oaks, USA (pp. 124-162).
Krogh, V. Ichijo, G. & Nonaka, I. (2001) Facilitar la creación de conocimiento, como desentrañar el misterio del conocimiento tácito y liberar el poder de la innovación. México: Oxford.
Kuhn T. (1993):"Afterword's" In World Changes. Thomas Kuhn and the Nature of Science. P. Horwich, Ed., Cambridge, Massachusetts and London, The MIT Press, pp. 311-341.
Leydesdorff, Loet & Peter Van den Basselaar (1994), Evolutionary Economics and Chaos Theory: New Directions in Technology Studies, Londres, Pinter Publishers.
Lloyd Morgan, C. (1923) Emergent Evolution. London: Williams & Norgate.
March, J. G. (1991).Exploration and exploitation in organizational learning. Organization Science, 2, 71.
McElroy, Mark W. (2003). The New Knowledge Management: Complexity, Learning and Sustainable Innovation, United States of America, Butterworth Heinemann
Mandelbrot, B. B.; Gafen, Y.; Aharony, A. & Peyriere, J.; (1977) (1985) Fractals: Their Transfer Matrices and their Eigen - Dimensional Sequence. J. Phys. A. Match. Gen. 18 335-354. Printed in Great Britain.
Nonaka, I & Hirotaka Takeuchi (1999) La organización creadora de conocimiento, Cómo las compañías japonesas crean la dinámica de la innovación. México: Oxford.
Pattee, H. H. (1989). Simulations, Realizations, and Theories of Life. In C. G. Langton (ed.), Artificial Life (Santa Fe Institute Studies in the Sciences of Complexity, 6). Redwood City, CA: Addison-Wesley, pp. 63-78.
Pérez Mayo, A. R. (2013) Discurso, representaciones sociales y narrativas en las organizaciones. Caso de 3 cuerpos académicos de la UJAT. Tesis Doctoral. UAM-Iztapalapa.
Piaget, Jean (1978), La equilibración de las estructuras cognitivas: Problema central del desarrollo, México, D.F., Siglo XXI Editores
(1982) Las formas elementales de la dialéctica, Barcelona, Editorial Gedisa,
Popper, Karl Raimund (1973), La lógica de la investigación científica, Madrid, España, Editorial Tecnos, Traducción por Víctor Sánchez de Zavala.
Polanyi, M. (1966) The Tacit Dimension. London: Routledge.
Prigogine, Ilya & Isabelle Stengers (1983) La Nueva Alianza: Metamorfosis de la ciencia, Alianza Editorial, Madrid, España
Quinn, J. B. (1992). Intelligent enterprise. New York: Free Press

Reed, M & Harvey, D.L. (1992), "The new science and the old: complexity and realism in the social sciences" Journal for the Theory of Social Behavior, Vol. 22, pp 356-79

(1996) "Social Science as the Study of Complex Systems", en Kiel, L.D. y Elliott, E. (Eds) Chaos Theory in the Social Sciences, Annor Arbor, University of Michigan Press.

Reich, R. (1993): El trabajo de las naciones, Buenos Aires, Javier Vergara Editor.

Stacey, Ralph D. (1996), Complexity and Creativity in Organizations, San Francisco, Berrett-Koehler Publishers.

Trainor, L. E. H. (1909) Remarks on emergence in physics and biology. En Goodwin, B. y Saunders, P. (Eds.) Theoretical Biology. Edinburgo: Edinburgh University Press.

Thom, T. (1975): «Dun modele de la science á une science des modeles», Synthese, 31, 1975, 359-374.

Toffler, A. (1990). Powershift: Knowledge, Wealth and Violence at the Edge of the 2lst Century. Bantam Books. New York.

Vera & Crusan (2000).Situated action: A symbolic interpretation in cognitive Science, 17(1) 7-48.

Villoro, L. (1994) Creer, Saber, conocer. México: Editorial Siglo XXI.

Wittgenstein, L. (1953). *Philosophical investigations*. Nueva York: Macmillan.