The New Complex Perspective in Economic Analysis and Business Management

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Introduction

From the beginning of time, people have tried to understand the reality that surrounds them to attempt to predict its future evolution and, in so far as possible, to control it. The way to come closer to this knowledge has evolved throughout history, depending on the vision that people had of the world. The concepts of complexity and chance have evolved in the same way. The evolution of these concepts has impregnated the way of understanding economic analysis and, recently, the world of business and organizations. This work is devoted to the study of the cornerstones of the evolution of scientific knowledge, and in particular their relationship to the world of economics and industrial organization.

This article can be divided into two main parts. Always focusing on the evolution of the term “complexity,” the first part deals with the progress of the dominant scientific paradigm and its influence on economic analysis; the second pertains to its influence on organizational management.

EVOLUTION OF THE CONCEPTION OF THE WORLD: DETERMINISM VERSUS RANDOMNESS

Initially, during the prescientific stage, natural phenomena were conceived as chaotic (in the colloquial sense of the term[1]). However, with the development of the natural sciences, which took place in parallel with that of mathematics, the areas in which chaos reigned shrank. In fact (Wagensberg, 1994), science was born with the aim of limiting whatever escaped from human control, and whatever escaped human control was considered to result from chance. During this period chance was conceptualized as the complement of knowledge.

The scientific developments of the seventeenth and eighteenth centuries and the success of their application in explaining and predicting natural phenomena gave strength to a deterministic vision of the world. Since it seemed that chance might definitively be exiled from the world, scientific progress was governed by the principle of strong causation: From the same causes the same consequences follow. The best example of this deterministic vision of the world is the demon of Laplace: If all the initial conditions could be known, the future could be predicted with absolute accuracy. A deterministic paradigm characterized this period.

During the eighteenth century, economics established itself as a science; as a result, economic reality was conceptualized on the basis of a formulation of deterministic universal laws. Their influence would become even stronger with the mathematical formalization of economics during the second half of the nineteenth century, as a result of the work of Pareto, Jevons, Menger, and Marshall, which extended the use of the methods of physics to economics. The principles that governed Newtonian determinism moved to economic thought. These principles were the following:

- *Locality*: A physical phenomenon can be isolated from its environment.
- *Linearity*: The interaction of different isolated phenomena takes place in an additive way, which justifies the use of linear models.
- *Stability*: The concept of equilibrium is rather important, as much at the operative level as at the tendency level.
- *Linear time*: Time is linear and does not indicate a direction.

We can speak here about an asymptotic determinism, or a tendency toward determinism rather than determinism at a practical level, since Laplace himself was a defender of the theory of probability. In fact, when the impossibility of knowing all the interacting causes as the number of implied variables increased was recognized, the paradigm evolved toward a statistical paradigm in which the principle of weak causation governed: From approximately the same causes, approximately the same consequences follow. On average, therefore, the operative laws were similar to classical ones. The difference is the environment in which they operate. In the first case we are working in a deterministic environment where the principle of strong

causation rules, while in the second case the environment is uncertain and the principle of weak causation rules. Hence, this is the reason for talking about stochastic laws, where stochastic stands for randomness or uncertainty.

This uncertainty, or operational randomness, arises from the lack of information due to the excessive dimensionality of the managed system; that is, chance is identified with the absence of information. The tools needed to deal with and formulate randomness are provided by the theory of probability and the science of statistics, both of which experienced significant development during the nineteenth century and were mainly applied to the social sciences. This statistical paradigm completes the deterministic paradigm, co-existing, applied to diverse fields, and providing distinct types of knowledge. The latter provides deterministic knowledge for systems with few degrees of freedom[2] (simple ones), while the former provides statistical knowledge for systems with many degrees of freedom (complex ones).

This determinism-randomness duality was broken up at the beginning of the twentieth century with Heisenberg's uncertainty principle, which showed that at subatomic levels the deterministic notion of trajectory makes no sense and must be replaced with a probabilistic one. However, this randomness does not arise due to the absence of information but as a consequence of the observer's very presence. The observer cannot determine how much he or she interferes in observing and measuring the process. However, the previously mentioned dichotomy continues to be valid for practical purposes in an ordinary world.

This duality is definitively broken by chaos theory that, due to the property of sensitive dependence on the initial conditions amplifying insignificant divergences in those initial conditions exponentially, shows the existence of deterministic low-dimensional systems that behave in extremely erratic and seemingly random ways. Therefore, a different kind randomness exists and can be called output randomness instead of process randomness.[3]

THE NEW CONCEPT OF COMPLEXITY

With the arrival of chaos theory, we have a new paradigm that completes the previous ones and breaks down their dichotomy. A problem can no longer be examined merely from deterministic or statistical points of view based on its degrees of freedom, since there are other types of properties that determine the problem's behavior. Before the development of chaos theory, complexity was identified with dimensionality: If a problem had few degrees of freedom it was supposed to be simple and treated deterministically, while if its dimensionality were higher, it was supposed to be complex and treated statistically.

The property of sensitive dependence becomes a new vision of complexity, a vision more qualitative than the traditional quantitative one. The complex is qualitatively different from the simple, and it is not a consequence of a simple aggregation of elements. In fact, there are properties exhibited by the entire nonlinear system but not by the isolated components. These are called emergent properties (Lazslo & Lazslo, 1992; Solé *et al.*, 1996) and they lead to a concept of synergy suggesting that the system is more than the sum of its components. For this reason, an analysis of the elements of the system and their relationships is insufficient. Instead, it is necessary to have a global focus that pays attention to the relationships among the elements of the system and with the environment.

Complexity is also linked to feedback, adaptability, the relationship with the environment, the frontier between stability and uncertainty, or the mix between order and disorder (Morin, 1995). All of these concepts are related to the behavior of living beings and, consequently, to economic behavior. Furthermore, according to recent research on the topic (Van der Vliet, 1994; Phelan, 1995), these characteristics can be used by organizations as useful tools for their self-governance. More concretely, they can be seen as something that must be taken advantage of, spreading to societies and adaptive companies, open to the environment, flexible, and creative. Complexity has great potential for enriching our knowledge of the relationships between individual decisions and aggregate ones (Durlauf, 1997).

Hence, to analyze complex systems it is fundamental to understand their evolution and their conceptualization as a whole. Notions of dynamics, disequilibrium, and nonlinearity are fundamental to that understanding. These features contrast with those of the static standard focus, based on the equilibrium of a system conceived as the sum of its parts (the linear focus). Due to the importance of the dynamics, disequilibrium, and nonlinearity, historical analysis is fundamental to understanding complex systems because the past has a great influence on the present. Chaos theory provides tools that allow these new analyses to be carried out, tools that are necessary for understanding a complex world. For that reason, the study of the dynamics of chaotic systems can be considered as an extension of Newtonian mechanics instead of their burial.

THE NEW PARADIGM OF COMPLEXITY

A new paradigm or conception of the world (the complex paradigm) is not in contradiction to the two earlier ones: the deterministic paradigm and the statistical paradigm (see Figure 1). Furthermore, it completes the randomness paradigm and reduces the gap between the formerly irreconcilable paradigms of determinism and randomness.

Fig. 1: The new paradigm of complexity

As opposed to the traditional paradigm of Newtonian physics (the simple paradigm), the new paradigm is characterized by the following (Prigogine, 1993, 1997):

- *Globality*: It is a science of systems considered as a whole, open to their environment.
- *Nonlinearity*: Similar to globality, the whole is not merely a sum of its parts.
- *Uncertainty*: It is a science of open systems, disequilibrium, and sensitivity to initial conditions.
- *Time creation*: Time is an internal variable of the system; it is irreversible (the arrow of time) and necessary for considering uncertainty.

Time plays an essential role in the new paradigm (Nieto de Alba, 1998a).[4] The study of uncertainty is important because of sensitive dependence on initial conditions and the sudden changes of behavior (bifurcations) that the system shows. This uncertainty leads to the irreversibility of the phenomena in question, not as a consequence of ignorance but inherent in the very dynamics of the system. Time is conceived as a creator of new structures. It is an exogenous variable for the deterministic paradigm, just a mathematical parameter, which is consonant with the atemporal vision of a stable and ordered world derived from Newtonian mechanics. In contrast, in the complexity paradigm time is not considered only as an endogenous variable of the system; it is also a creator time, historical time.

This new paradigm of complexity also permits the quantification of fuzzy concepts like “level of complexity,” “degree of uncertainty,” and “number of degrees of freedom nonlinear active” (Brock & Baek, 1991). Moreover, it shows the importance of nonlinear modeling, thereby justifying its recent renaissance (Ashley & Patterson, 1989).

THE NEW ECONOMETRICS OF COMPLEXITY

Econometrics can be defined as the discipline that, drawing on models provided by economic theory, facts observed in the real world, and tools provided by statistical theory, is in charge of analyzing economic relationships by elaboration of the econometric model. These models are able to explain the underlying system and recognize the relationships among its variables, predict its future evolution, and analyze the implications of economic policies. When the economic reality is evaluated, it is necessary to realize that the category of behavior usually observed is seemingly disordered, erratic, and even unpredictable. It is this kind of behavior that we are attempting to model.

There are two methods for modeling this behavior: models that are based on an extrinsic or exogenous explanation of complexity, and those that incorporate it in an intrinsic or endogenous way:

- Models that are based on an extrinsic explanation (traditional or linear econometrics) are those whose endogenous dynamics, without external forces, are linear and simple. To produce complex behavior, therefore, it is necessary to introduce random external interferences (variables external to the model but influencing it, such as meteorological variables, political events, and uncontrollable human factors).
- Models that are based on an intrinsic explanation of complexity (disequilibrium econometrics or nonlinear econometrics) are based on hypotheses that lead to complex dynamics. The model’s very dynamics (the endogenous dynamics) are what generate this type of behavior observable in the real world. With these models it is not necessary to use random perturbations to build a model with complex behavior.

In conclusion, on the one hand, the importance of nonlinearity and sensitive dependence on initial conditions in the generation of a complex system is evident. Nowadays, it is hard to justify that the observed complexity in the real world must be the result of merely linear relationships and random interferences that, in fact, do not provide us with information about the dynamical features of the system. On the other hand, it is necessary to admit the existence of random perturbations in the real world (for instance, the influence of the environment or economic policy, imperfect or asymmetric information, and measurement errors[5]).

Hence, it is necessary to arrive at a synthesis of both points of view, emphasizing on one hand stochastic (and maybe chaotic) nonlinear models and their wealth of behaviors (as a consequence of the property of sensitive dependence), and embracing on the other hand the possibility of measuring the uncertainty or complexity of the economic reality with new instruments.

THE EVOLUTION OF ORGANIZATIONAL MANAGEMENT

When we focus on the administration and control of economic resources, the evolution of these areas has not been very different from the evolution of general science. At first, it was common to deal with problems using an analytical approach in order to reach exact solutions or statistical approaches; this approach was dominated by use of the ceteris paribus clause. The role of managers was fundamentally observing the causal structure of the organization to keep it under control (Stacey*et al.*, 2000), hence in this context intelligence[6] was considered as a purely instrumental activity that used knowledge in order to reach goals that provided a solution to specific problems. The local aspects were more prevalent than the global ones, order and equilibrium more than disorder and disequilibrium, and the cause-effect principle was more in evidence than a holistic principle according to which each element depends on the group and every element influences the other elements. The resulting regular and stable models led to punctual[7] or periodical[8] attractors (Nieto de Alba, 1998a). For these attractors, stability[9] comes from the fact that all the trajectories behave in a similar way in a vector field (Guastello, 2001), and consequently only regular and predictable ways of behaving are contemplated.

On the other hand, the era of uncertainty (corresponding to postindustrial or immaterial economics) is characterized by the fact that the system loses its stability and predictability features, together with the rise of unstable and uncertain environments. Science appears dominated by the holistic approach. The intellectual aspect prevails over the material aspect. In this context, therefore, intelligence is considered an activity that creates information and originates goals. Managers use their skills and knowledge as sources of innovation. The global and long-range vision implies the acknowledgment that distant effects generate uncertainties and long-term crises. Also, disorder and disequilibrium principles are considered to be the source of innovation. The importance of chance stands out and, together with causation, leads to intrinsically unpredictable forms of behavior.

Finally, the behavior of the system is no longer stable or predictable, and is likely to produce chaotic attractors[10] (Nieto de Alba, 1996). The emergence of this kind of attractor provides systems with a more richly varied behavior; in fact, there is growing empirical evidence suggesting that systems with a greater propensity to survive are those that can generate a variety of responses as diversified as the observed states in mathematical chaos. Hence, the new vision of the era of uncertainty appears when we leave behind the industrial and material economy of the mechanical period and advance toward the postindustrial and immaterial economy, or information economy (Nieto de Alba, 1998b).

According to the classical and neoclassical school of thought (Fayol and Taylor), management in the industrial or material period corresponds to management in the stability zone. It is an equilibrium management between the organization and its environment when faced with closed and predictable changes, that is, when what is going to happen is already known, so that, given an uncertain future, an organizational intention is possible *a priori*. Management is *reactive*, which means that its adaptation to change operates always from the past to adapt to a certain future *a priori*. It is also an unenthusiastic risk-averse management, dependent on official control. In terms of type of climates and social culture, the goal of productive efficiency neglects both human realization and social integration in the workplace, which affects supervisor-employee relationships negatively and, consequently, the motivation for productivity, solidarity and social integration, and motivational ethics as a whole. This last one, an ascending value that complies with the organizational culture, is subjugated by the descending values of centralism and hierarchy.

On the other hand, moral silence causes organizations to develop a tendency toward conflicts, which arise when apparent cooperation is translated into tension and internal competition. In organizations, a bureaucratized and hierarchical management takes place and creates restrictive limitations among different organizational levels and in the necessary collaboration among them. Furthermore, this kind of organization, in conflict with the necessities of the environment, is deficient in its learning capacity. Control aids the critics and external evaluators, and is restricted to the fields of accounting and finance (Nieto de Alba, 1999a: 27-33).

According to Nieto de Alba (1999b: 98-111), in the era of predictable uncertainty or weak instability (a model of administration by groups of projects that take place in short periods of time and with a prevalence of horizontally coordinated networks[11]), even if uncertainty and changes are managed, they are still considered predictable and controllable as a function of the level of information. Management is thus *anticipative* in the sense that it operates from the present in anticipation of the future. It practices consensus management in which hierarchies and departments are replaced with networks and processes, and in which the task leads to the rank. Ethical values emerge bottom up; ethical auto-control of the quality of the work occurs; attitudes are transmitted based on day-to-day relationships; and moral silence is no longer present.

Intelligent organizations characterize this era. Information systems are those that conform to the organizational structure, and changes are contemplated as an opportunity for evolution. Furthermore, management is based on simple learning, and environmental information is a variable that can be predicted to allow for planning, control, and learning within temporary horizons. Control is based on values such as trust, loyalty, participation, commitment, and responsibility.

In the era of unpredictable uncertainty, in contrast to the previous one, uncertainty and change are no longer stable and predictable. Management is based on the complexity paradigm and has a series of notable characteristics (Nieto de Alba, 1996: 102-6): Limited uncertainty is managed, and organizations are considered to be systems of nonlinear feedback and "nonequilibrium." Management is creative and innovative. The future must be created instead of anticipated; one's own environment needs to be created through feedback relationships with that environment, otherwise we would be in the presence of an organization that simply adapts to the given environment, an organization that would continue doing the same thing until the environment changes.

However, what intelligent management leads to is an organization of a dissipative type, that learns and adapts, but from a future that is created by the organization itself. Adaptation from the past makes no sense. In strategic management, especially important are disorder, conflict, and uncertainty as sources of creative strategies. We are dealing with a process of spontaneous self-organization that can construct a new order of innovation and a new strategic direction. Values are bottom up and top down. The moral principles of the system feed the ethical and moral bases of the organization following a feedback process. Management must be based on complex group learning in the pursuit of strategies and in the conformation of the organizational culture. Planning, control, and learning are simultaneous, since uncertainty shortens periods of decision. The chaotic models of administration can be distinguished qualitatively. The "hidden model" is the essential characteristic of the category, and individuals are regularly irregular. Control seeks the capacity to alternate ordinary or technocratic management that plans/supervises ordinary activity and extraordinary or strategic management that focuses on the concern for the long term through learning.

Under this management model, "chance teams" are the form of organizational control related to creation. This evolution leads us to study in more detail the characteristics of a new model of management in which, between success and failure, an intermediate area of creative chaos is presented, one that demands new organization, management, and control models.

COMPLEX MANAGEMENT

The evolution of scientific thought and of management itself shows the necessity of a new focus in terms of nonlinearity. This new kind of management is located in areas of indecision and presents a high degree of flexibility and learning capacity that allows it to create, instead of anticipate, the future from an innovative force. One key is that it approves the establishment of new organizational models to rule the decision process[12] rather than losing time and resources in analyzing the environment

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Fig. 2: Modifying the basic hypotheses of management thinking

(Nieto de Alba, 2000: Chapter 4). The technocratic models of management must be left behind; we must give way to strategic management and control.
Once we have reached the conclusion that a successful business organization works on the edge of chaos, if we really observe how managers behave when they confront open change and we interpret their specific behavior from a complex dynamical systems perspective, we feel forced to point out, without attempting to be exhaustive, some of the most important features[13] of this new form of management that are the direct consequences of modifying the basic hypotheses of management thinking (see Figure 2).

1.

In dealing with innovative environments, a necessary condition is the assimilation of new technologies and investment in intangibles, mainly in those related to experience and professional capacity. Sass (1994) refers to the importance of R&D investments to meet the challenge of the growing complexity in the organization.

Success in such environments requires continuous creativity and it is the company itself that should foment this through “creative destruction,” that is, by causing uncertainty in a deliberate way to encourage creativity and innovation. A survey carried out by Ikujo Nonaka (1988) showed how companies such as Honda recruit people trained in other companies with the aim of introducing “new blood.” In Canon managers are also pressed constantly to transmit a sensation of crisis to employees. Innovative strategic thinking must develop new models, techniques, and prescriptions for each situation; these must be based on experience and on qualitative similarity with wellknown situations (Stacey, 1994).

2. In a dynamic organization, the core of strategic management is the capacity of managers continuously to develop an active and changing calendar of problems. In order to cope with these problems it is necessary that management be carried out through a process of complex learning in real time where, by means of dialog, new and different forms of making things are invented, and the organization learns how to do so as it immerses itself in the problem.

   This kind of learning assumes that hypotheses are questioned and mentalities modified. It is what the scientists call “symmetry rupture” in natural systems(Stacey, 1994).

3. Also, in order to identify and confront strategic matters once a problem is detected, political interaction is tackled by managers; before going ahead in a new direction, they try to obtain the necessary support to legitimate their proposals. This political activity of support creation is spontaneous and self-structuring, in the sense that it is informal and is not included in formal procedures, although at various points in this activity formal procedures are necessary to legitimize the elected options, and assign resources to the exploration of problems (Stacey, 1994).

   Since open and not very clear problems advance with political interaction and learning to give rise to new strategies with the possibility of success, formal structures of the organization come to play a more outstanding part.

4. Success in this kind of management depends on the ability to combine, within this creative stress, technocratic or ordinary management of the daily activity, as it applies controls in a more rigorous way for repetitive and predictable tasks, with nonordinary and chaotic management of the nonordinary structural change of the organization.

   It is important to point out that for this kind of *strategic management*, control must be understood as control *in general*, that is, control over the restrictive conditions surrounding uncertainty. This is essential for the emergence of new strategic orientations. The way work is organized, the attitudes employees hold, and the technologies they use are the key elements in creating the restrictive conditions that emerge through dialog and process (Kiel, 1994).

   Uncertainty in its limited form, applied to strategic situations, is of vital importance for the emergence of new orientations for the organization (Stacey, 1994). Tight management control can inhibit the enormous potential for improvement that exists in organizations. Unstable systems require a style of leadership that is able to recognize when a small *change* can lead to an enormous result in terms of changing relationships, altering work processes, and examining the deep structure of order that underlies the superficially apparent chaos (Kiel, 1994).

   In this direction, Stilwell (1996) points out how chaos theory shows that very precise planning is not beneficial since there are too many variables that can change and alter a precise plan.

5. There is no sharp difference between management and control. Work groups are based on loyalty and commitment, which guarantee the control of the system’s global behavior (Nieto de Alba, 1998b). Managers grant authority to their subordinates to expand and strengthen the content of their decisions, thereby allowing employees to control many aspects of their daily responsibilities and gain greater levels of authority within the organization. In this way, employees’ empowerment gives them the necessary tools and support to find solutions or innovative ways of confronting change and complexity (Stilwell, 1996).

   This is translated into an organizational design characterized by the following features (Navarro Cid, 2000): flexible organizational structure of “fractal, informal, or amorphous” type that avoids authoritarianism and formal groups[14]; stimulus of workers’ polyvalence; presence of self-managed groups with capability to set goals; creation of negentropy [15]; existence of opposed forces to generate contracultures; direction by values; and minimum critical specifications with regard to the decisions to be taken based on a mission and group of nuclear values.

6. In organizations working in a state of limited uncertainty, like a system of nonlinear feedback, continuous strategic performance is maintained based on general qualitative models of the structure and position of the organization, so that managers are able to identify and understand them when they face them, since the long-term future of the company is unpredictable in statistical terms (Stacey, 1994).