Chaos Theory And Political Sciences

Kaos Teorisi ve Siyasal Bilimler

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Abstract

The classic positivist model that has largely enabled the advancement of modern scientific knowledge is somewhat outdated. This paper aims to explore the new doors opened by chaos theory in social sciences, and more particularly in political science. The basic assumption of chaos theory is that in reality there are no closed systems with a given order. Thus, chaos is present in the most diverse phenomena, both in nature and in the daily life of humanity. The description of complex systems can be understood more simply with the butterfly effect analogy: a butterfly that flaps its wings here causes a movement of the air that can lead to a chain of events and can generate a gigantic effect elsewhere. Even small changes by individuals can bring about big changes in the entire system. Chaos has been defined as a dynamical system exhibiting deterministic, complex, irregular, non-periodic behavior and apparently random but maintaining latent order. Even if the path of chaos does not lead to a new paradigm in the social sciences, it nevertheless demonstrates its great potential for possible reflections and applications. This theory was mainly applied as a metaphor for description and analysis but the rhetoric and semantics of chaos brought with them a whole set of new concepts and terms that can be considered as a resource that allows the researcher to develop the knowledges and explore new aspects of the social and political phenomena observed. Chaos theory delivers new tools and methods for the researcher who intends to analyze statistically the evolution of dynamic political systems.

Anahtar Kelimeler: Chaos Theory, Political Sciences, Order, Disorder.

Öz

Modern bilimsel bilginin ilerlemesini büyük ölçüde mümkün kılan klasik pozitivist model, biraz modası geçmiş durumda. Bu makale, kaos teorisinin sosyal bilimlerde ve özellikle siyaset biliminde açtığı yeni kapıları keşfetmeyi amaçlamaktadır. Kaos teorisinin temel varsayımı, gerçekte belirli bir düzene sahip kapalı sistemlerin olmadığıdır. Böylece kaos, hem doğada hem de insanlığın günlük yaşamında çeşitli olgularda mevcuttur. Karmaşık sistemlerin tarifi kelebek etkisi benzetmesi ile daha basit anlaşılabilir: Burada kanat çırpan bir kelebek, bir olaylar zincirine yol açabilecek bir hava hareketine neden olur ve başka bir yerde devasa bir etki yaratabilir. Bireyler tarafından yapılan küçük değişiklikler bile tüm sistemde büyük değişiklikleri beraberinde getirebilir. Kaos, deterministik, karmaşık, düzensiz, periyodik olmayan davranış sergileyen ve görünüşte rastgele olan ancak gizli düzeni koruyan dinamik bir sistem olarak tanımlanmıştır. Kaosun yolu, sosyal bilimlerde yeni bir paradigmaya yol açmasa bile, olası yansımalar ve uygulamalar için büyük potansiyelini göstermektedir. Bu teori esas olarak betimleme ve analiz için bir metafor olarak uygulandı, ancak kaosun retoriği ve semantiği, araştırmacının bilgilerini geliştirmesine ve yeni yönlerini keşfetmesine olanak tanıyan bir kaynak olarak kabul edilebilecek bir dizi yeni kavram ve terim getirdi ve de sosyal ve politik olgular gözlemlendi. Kaos teorisi, dinamik politik sistemlerin evrimini istatistiksel olarak analiz etmeyi amaçlayan araştırmacı için yeni araçlar ve yöntemler sunar.

Keywords: Kaos Teorisi, Siyasal Bilimler, Düzen, Düzensizlik.

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Introduction

Chaos is a confusing term. The etymological origin of chaos is Greek. This concept derives mainly from mathematics and physics and, through the developments of systems theories, information, cybernetics, evolution, thermodynamics of systems far from equilibrium and chaos, with the passage of time it has been object of study of other disciplines, such as the social ones, to establish an alliance between human sciences and natural sciences and to create a "third culture" (Tinti, 1998; 7-12). The discovery and study of the concepts of chaos theory such as non-linearity, unstable equilibria, fractal ensembles, bifurcations and attractors are contextualized in an important period on the level of scientific research. The predominantly accepted definition of chaos which describes it as a long-term aperiodic behavior in a limited deterministic system, having a sensitive dependence on the initial conditions (Sprott, 2003), therefore raises some important questions, whether the existence of chaotic trends on the one hand it imposes fundamental limits of predictability, on the other hand it suggests that certain phenomena that evolve over time, showing apparently random behaviors, could be more predictable than we think because they are governed by deterministic laws.

In the light of the considerations set out so far, it seems necessary to "predict the unpredictable", that is to know the non-deterministic part of the dynamics of evolutionary systems. It is therefore necessary to consider that unpredictability is a new category that replaces, in complex systems, what was defined "randomness" of any deterministic phenomenon whose evolution is foreseen over time and whose fate can be anticipated. In other words, "complex systems present in their structure a series of points that specialists call bifurcations and that are characterized by the fact that they are extremely sensitive to the slightest disturbance" (Ibáñez, 2006:82) and the same cause can have a multiplicity of effects.

Many studies on complexity tend to free themselves from those systems of equations on which, in many ways, chaos theory is based, to make use of an interpretative framework and computational tools that prove to be more flexible especially for disciplines less formalized by the mathematical point of view. Not surprisingly, social scientists find a wider field of application in the most recent techniques that make use of simulation and computational modeling than those of chaos theory. However, the studies of chaos in the social sciences have also been limited for other reasons.

According to many scholars (Capra, 1996) complexity can be considered as a general field of study that is divided into different lines of research including chaos theory. The other fields of study that in recent years have been attracting a lot of interest are mainly represented by the development of cellular automata, genetic algorithms, computational modeling, fuzzy set theory, artificial intelligence, advanced data mining techniques, multi-agent and network analysis.

According to Castellani and Hafferty the social sciences and sociology in particular, can be recognized as disciplines of complexity, but for this recognition to reach a status of maturity, it is necessary that scholars of these fields acquire a greater awareness and dexterity of the techniques of functioning, especially of the agent modeling, computational mathematics and dynamical systems theory.

This work is part of an attempt to familiarize the main concepts of the mathematical theory of chaos in the political sciences. Most of the studies on chaos and non-linearity, and more generally on the use of mathematics in the social sciences, are in fact carried out mainly by physicists, engineers and mathematicians but, in order for scientific research in this sector to achieve actual developments, it is important intervention by social researchers is necessary. On the other hand, observations, improvements and criticisms are constructive when an effective awareness of the issues at stake is acquired. It is clear that the mathematician and the social researcher have distinct roles with different skills, but if there are meeting points, albeit fleeting, between mathematics and political sciences, in order to generate value on a cognitive level, it is important to develop and share a code that favors their communication.

When we want to analyze and apprehend political or social phenomena, we face a scientific object which is by definition different from that of the exact sciences. Political scientists and sociologists have thus discovered that a high degree of unpredictability of the future is the essence of the human adventure. However, some studies and research projects over the past two decades have assumed that the concepts and tools of chaos theory are an inherent part of the properties of political science.

Crises and rapid changes are present in our world. Political systems also, are complex because they are made up of a large number of mostly unpredictable components. So there is no definitive order in political systems. Specifically, it is about differentiating processes from structures. The structures are ephemeral manifestations with which we intend to explain the processes, but they are not immutable. Therefore policymakers must be prepared to manage such chaotic phenomena (Farazmand, 2003: 340). Part of the solution can be provided by chaos theory which can help us understand and manage the complex problems that arise from highly complex dynamic systems. Chaotic systems can be distinguished from the two other types of system: the constant system, that concerns systems that converge toward a steady state, such as feelings of national identity that often converge toward equilibrium. The other type concerns systems that exhibit stable oscillatory behavior in a repetitive pattern, similar to electoral cycles. The chaotic system, on the other hand, demonstrates an irregular oscillatory process, like countries that float through anarchy, civil war and democracy (Peled, 2000).

It is in this sense that chaos theory provides a methodological tool that helps us better understand the problems that make up a panorama where politics, chaos and the current social environment are linked. When we refer to a chaos policy, we speak of a complex, open and dynamic political system, founded on a multiplicity of heterogeneous variables interconnected in a coherent manner, characterized by being extremely sensitive to disturbances and variations of quantitative or qualitative degrees that would prevent any accurate prediction of future behavior.

1. The world as a set of complex subsystems

If we give a simple definition of complex systems, we can say that they are open systems made up of more or less complex components that interact with each other through numerous non-linear interactions. The thesis that natural, social, economic, political systems are complex, deterministic, unpredictable and unstable subsystems of what we usually call the world, which in turn is a super or hypercomplex system, is now accepted by scientific literature.

With complexity, the reductionist vision of classical science is overcome and a holistic perspective is welcomed in the study of systems, characterized by non-linear dynamics, which allows us to see emerging phenomena that cannot be identified from the individual components of the system but from the global interaction between them. These emerging properties give rise to new forms of self-organization. Technically, "we speak of self-organization when the dynamics of the system have attractors towards which the system tends to move, if it is in the basin of attraction of one of these." (Bertuglia and Vaio, 2009, p. 321). According to Byrne (1998), the adoption of new ways of conceiving science that sees its future in complexity was necessary to meet the challenges of the changes of recent decades such as post-industrialization, the global economy, environmental collapse, political and cultural conflicts and all those events, the study of which proved inadequate with the traditional tools of science. According to Morin (2007), if on the one hand the complexity becomes the bearer of that sense of uncertainty for a long time rejected, on the other it proposes the development of a multidimensional thought that shows how the various specialized disciplinary categories contemplate common aspects that at the same time need to be distinguish and communicate.

The interdisciplinary nature of complexity, which makes a precise and commonly accepted definition of it difficult, has nevertheless generated numerous misunderstandings which, as Castellani and Hafferty (2008) recall, need to be dispelled. If on the one hand, over the last fifty years, the complex approach has been used in very many areas of investigation, on the other hand, it should be borne in mind that complexity is a sector of empirical research with very specific characteristics that is not bound by a particular political or moral agenda and also far from being considered as a kind of wholeness, it is beyond a metaphorical vision or an almost spiritual attitude according to which every aspect of reality is necessarily interrelated with another.

Another misconception to be overcome is the frequent identification of chaos with complexity. Surely the studies of chaos theory concerning irregularities, bifurcations, attractors, sensitivity from initial conditions and fractal ensembles have given a strong contribution to the study of complex systems by proving that they are unstable, more difficult to control and know, operate in a position far from equilibrium (Kauffman, 1995; tr. it. 2001) and can give rise to spontaneous processes of self-organization. However, chaos is not complexity. Therefore, not all chaotic systems are complex. Indeed, even very simple systems are chaotic. Rather, it happens that, starting from a restricted and "simple" set of initial possibilities, as time goes on, the universe of possible evolutions of a chaotic system can become increasingly complex. Vice versa, a complex system does not necessarily show chaotic behavior. Indeed, complexity "is configured as a particular intermediate situation between stable equilibrium and chaos, a situation in which the system manifests a behavior that is different from both the tendency to stable equilibrium and the tendency to chaos" (Bertuglia and Vaio, 2007 p. 304).

By generalizing the typology of the complex system, whether natural or social, we know that it is open and presents, before its point of catastrophe, periods of stability and equilibrium. When the system reaches the point of catastrophe (as a characteristic parameter of the system increases up to its critical point) there is discontinuity. At this point the behavior of the system, described by a variable choice that will characterize it, follows a non-linear trend. Complex systems, even if they have fluctuations, are still attracted towards stability, that is towards the production of entropy which therefore represents an attractor for such systems. Systems are therefore usually immunized from fluctuations, from the "bubbling" of elemental activity and from deviations from the average laws of entropy production that this "bubbling" generates relentlessly. It will then be said that the system is resilient. However, when a internal or external force, acting on the system, reaches high enough values to make it come out of the linear region - which is understood to be deterministic - independence from fluctuations can no longer be guaranteed.

Sometimes we speak of systems on the edge of chaos (Kauffman, 1995; tr. It. 2001). In these situations the system is unstable if certain fluctuations can amplify up to invade the entire system pushing it to evolve towards a new regime that can be qualitatively different from the stationary states of entropy production. At this point, the system can still tend towards equilibrium, or it can move towards the point of non-equilibrium which is given the name of the point of catastrophe or the edge of chaos. Ultimately, therefore, when a complex system is subjected to a high force, external or internal, it undergoes fluctuations that make it unstable. In such conditions of instability the system reaches the point of catastrophe and at this point a new regime evolves, impossible to predict a priori.

It is easy to understand that the "edge of chaos" is paradoxically a critical point, because it is at the same time, a point of dynamic stability and instability. Unpredictability is the consequence of this paradox. It can be said that at the point of catastrophe, on the edge of chaos, the prediction is "unpredictable" rather than probabilistic, while among the points before the catastrophe we can speak of the predominance of deterministic laws. Therefore, since the evolution of a complex system is a continuous alternation of equilibrium (strong determinism) and non-equilibrium (weak determinism), it is easy to understand how classical science is not outdated but should only be considered insufficient (weak). The role of the point of catastrophe is fundamental as it arises as a break with the past: the reassuring presence of the a priori is missing.

2. Deterministic chaos theory, exact sciences and social sciences

The world has always been a complex system in continuous and unpredictable evolution. This lapidary statement contains the most burning problem that the 21st century proposes to us and with which we must confront and which requires a revolution of thought to be faced. Henry Poincaré at the end of the 19th century, spoke of the unpredictability of a system of three bodies interacting with each other. Later it was shown that unpredictability is typical of chaotic systems and that contrary to what is commonly thought, chaotic behavior is apparently messy. If we manage to acquire some new intellectual categories it will be possible to identify a new way of "seeing", "experiencing" and "building" the world. The difficulty of adapting to the dizzying pace of change in the current world derives above all from the inability to predict its changes in advance and to accept that the world is a constantly evolving system, which has become increasingly complex due to the small number of subsystems that compose it and of the growth of their interactions, has made what yesterday we thought unpredictable is now an inevitable reality.

Since the end of the 19th century, scientific and philosophical thought has experienced profound moments of transformation and questioning of the main theoretical and practical foundations of knowledge such as time, space, perfect determinism, the relationship between causes and effects.

The discoveries of quantum mechanics with Bohr's principles of complementarity, Heisenberg's uncertainty and Einstein's relativity revisited that idea of science based on the correct prediction and replicability of the result of an experiment, bound by certain conditions of observation and control and advocate of a nature considered fundamentally simple and orderly. The subsequent appearance of chaos theory further contributed to redesigning the terms of the question, proclaiming the "end of certainties" (Prigogine, 1996). These studies first marked a clear departure from rigid determinism, defined as "a particular thesis on the causal structure of the world ... so strong that, given a complete description of the entire state of the world at a given instant of time, then, with the help of read, any past or future event can be calculated" (Hempel, 1952: 271). This vision was advanced mainly by Laplace according to which "we must consider the present state of the universe as the effect of a given previous state and as the cause of what will be in the future." (Laplace, 1814; tr. it. 1967: 243-4).

As Bertuglia and Vaio (2007) recall, science, starting from the Enlightenment period up to the beginning of the twentieth century, confused the concept of determinism, i.e. the possibility of identifying direct links between causes and effects that can be expressed by means of laws, with the linearity of the laws themselves, i.e. the assumption that the link between causes and effects is proportional. "Attributing the properties of linearity to determinism involves the assumption that a deterministic model, being therefore linear, must necessarily contain all the information needed for the exact and complete prediction of the future, as happens, precisely for models linear" (ibid: 279). With chaos theory, however, the idea of determinism, far from being an exclusive feature of linear systems, is extended, albeit in weaker but certainly more realistic terms, to non-linear ones as well.

The discovery of chaos theory is traditionally traced back to the publication in 1963 of the article Deterministic Nonperiodic Flow by Edward Lorenz, in which the American mathematician devised a non-linear dynamic model for the description and prediction of convective motions in the atmosphere and found that small variations in the initial conditions they produced large variations in the long-term behavior of the system; in addition to this phenomenon, known as the sensitivity of a system with initial conditions and which became famous with the well-known metaphor of the "butterfly effect" according to which a flapping of the wings of a butterfly in Brazil could cause a tornado in Texas. Lorenz's study and subsequent works by Mandelbrot, Ruelle, Feigenbaum, Yorke and others marked the birth of so-called deterministic chaos, an apparent contradiction in terms, since chaos is commonly associated with an idea of disorder and lack of rules, while the concept of determinism is attributed to predictable and regular phenomena (Bischi et. al., 2004). If, on the one hand, therefore, the discovery of deterministic chaos imposes restrictions on the predictive power of science, on the other it allows the detection of hidden and regular structures in apparently random. The theory of deterministic chaos is in fact considered as a theory of order (Capra, 1996), a hidden order that underlies phenomena with irregular appearances (Gleick, 1987; tr. It. 1989).

3. Chaos and randomness

Recognizing the dynamic nature of a system and studying any instability, chaos theory allows hidden regularities to emerge through the identification of "traces" of determinism; the presence of these elements makes it possible to describe the system and provide a short-term forecast. In the light of what has been described, chaos can therefore be understood as a class of signals that have an intermediate behavior between a regular and predictable trend and an accidental or unpredictable one. Thus, the difference between determinism and chaos paradoxically manifests itself in the sensitivity to the initial conditions that determine the trajectories of the evolution of a dynamic system. Two almost similar initial conditions can lead the complex, chaotic system to two very different evolutionary dynamics. Since complex systems are chaotic, it is therefore impossible to predict their evolution as well. To understand how determinism (order) and chaos (disorder), apparently contradictory paradigms, coexist in the same system, it's useful introduce the instrument of catastrophe by affirming, moreover, that complex systems evolve through catastrophes.

Chaos shows that currently there is still a tendency, revealed in our everyday language, which associates the notion of chaos with those of disorder, turbulence, anarchy and confusion. These interpretations of chaos are often associated with random behavior, which is a state of maximum entropy, a characteristic that does not represent the particularity of chaos in the technical sense of the term.

In fact, chaos is not random at all because in a system that has randomness, anything is possible. In a chaotic system, given a specific point in the system's trace, the next point also cannot be predicted. Even so, it is among a large number of possible future states, but this number is never infinite. In this chaotic phenomenon, it is impossible to predict what is possible to happen, what will happen is a consequence of a set of alternatives greater than one, but less than too many that would be impossible to process (Byrne, 1998). Even if a trajectory can also exhibit random behavior, it normally follows certain evolutionary trends, even if it is much more complex and non-periodic than imagined at first glance. In a much more restrictive perspective, trajectories can also be interpreted as a transitional paths through which the system passes to reach another point of stability. (Jong, 1999) In terms borrowed from applied mathematics, chaos refers to complex, irregular, non-periodic deterministic behavior with an appearance of randomness but conserving an invisible order. For all that, statistical practices cannot completely be rejected because even deterministic models retain a complete collection of statistical measures (Brown, 1995).

4. Chaos and political science

In 2008, in full financial crisis due to the unexpected collapse of some American banking systems, a perplexed Alan Greespan, one of the most quoted economists, chairman of the United States Federal Reserve until 2006, admitted before the United States Congress about the his beliefs: "I found a flaw. I don't know how serious and lasting. But the mere fact that it exists has upset me. The deputy who questioned him asked him: "In other words, you discovered that your worldview, your ideology, was not right, that it did not work." The economist replied: "Precisely. That's right. This is exactly what struck me. Because I went on for more than forty years in the absolute certainty that it worked perfectly".

Probably it is not necessary to hear about Greespan to get an idea of how unpredictable today, in the eyes of all, the dramatic events of epochal significance that took place on the environmental, social, cultural and political level that were not intuited in advance and managed with foresight.

There are no universal absolute laws when it comes to the social sciences. Paradoxically, this empirical world is governed by casuistry. Absolute universal laws are an illusion, since the growing complexity of social phenomena prevents us from giving infallible answers to the problems that are imposed in the framework of human relations. Democracy is the political summum, to intervene on these collective problems, or to govern the chaos and imprint an order.

Chaos theory is a branch of mathematics which, by analyzing the dynamics of a system with its possible instabilities, allows hidden regularities to emerge, identifying "traces" of determinism. This is clearly a different determinism from that imposed by the classical view of science because it insinuates itself into non-linear systems that are extremely sensitive to initial conditions. According to Brown (1995), social systems have all three fundamental characteristics of chaos: periodicity, sensitive dependence on initial conditions and only short-term prediction.

In fact, they are aperiodic as they are often the result of behaviors that are repeated over time, but never in the same way, because they are the result of a unique and unrepeatable path; then they present a sensitivity from the initial conditions, given that small perturbations change and sometimes distort the history of a phenomenon; for these reasons it is possible to contemplate a forecast only in the short term. Furthermore, social systems are characterized by an almost total lack of linearity (McBurnett, 1996). Despite these characteristics, the study of chaos in the social sciences has met with much resistance due to a number of general reasons. First, chaos theory requires a massive use of mathematical analysis that is generally not the subject of study by social researchers (Harvey and Reed, 1996). Furthermore, as Trobia (2001) recalls, unlike studies of chaotic dynamics, most of the methods and techniques of social research consider social phenomena as if they were static, limiting themselves to photographing a certain situation at a given time.

Reality is a social construction, in which movement, transformation and renewal prevail. For this reason, a constant review of our methodological principles is becoming increasingly necessary. Chaos theory applied to political science provides plausible paths for the interpretation of political phenomena from perspectives that do not border on the lapidary. Its study and understanding is important if we intend to provide solutions to the different theoretical and methodological challenges that reality imposes, without this meaning that there is a solution for each and every one of the social problems, since human behavior cannot be defined by means of models, be these scientists or mathematicians.

Chaos theory is on a par with complex thought theories, in which Edgar Morin (1990: 146) develops his dialogical method in which all uncertainties are confronted, but which breaks with dialectical confrontations. For him, "complexity is the dialogical order/disorder/ organization. But behind the complexity, order and disorder dissolve, distinctions fade. The merit of complexity is to denounce the "metaphysics of order." Morin's dialogic "allows duality to be maintained within unity. It associates two terms that are both complementary and antagonistic" (Morin, 1990: 106)

A diversity of paths to consider; chaos, total error and not the sum of errors, is a trend where uncertainty and heterogeneity converge. From the realm of uncertainty (García, 2011): "the need in the accident and the accidental in the need, is one of the fundamental ideas of a new science, which some call, together with the theory of relativity and quantum mechanics, the third great scientific revolution of the 20th century: chaos theory. This theory, which is barely over thirty years old, has opened a promising line of research to understand complex and contradictory phenomena that seemed indecipherable to human knowledge and has dialectically transformed the idea of determination in science."

There is a new dialogue between the methodologies of the exact sciences and the social sciences, which leads to new theoretical proposals of a transdisciplinary nature. From history, Fernand Braudel was inspired by the theories of uncertainties of the Nobel Prize in Organic Chemistry, Ilya Prigogine, to argue his concept of world-economy. Immanuel Wallerstein, equally influenced by both scientists, takes up those founding approaches of chaos theory in his proposal on the world-system, in which he also attempts to update Ludwig von Bertalanffy's systems theory, to the unpredictability of imbalance-disequilibrium as an explanatory pattern of change. In the social sciences in general and in political science in particular, the last four decades have seen a profound theoretical debate between systems theory (Luhman, 1992) information theory (Castells, 2006) and certain neo-Marxist efforts (González Casanova, 2012 3), for building bridges between science, technology and social thought. For the understanding of the relationship between politics and chaos, the contribution made by Ilya Prigogine from the physical-chemical field is decisive, by postulating that "chemical imbalances do not always lead to anarchy, but sometimes allow the spontaneous appearance of perfectly ordered organizations or structures, dissipative structures, and thus showed that non-equilibrium states can lead to both disorder and order" (Casau, 2009).

In this sense, the field where the limits between myth (necessity-accident) and chaos pierce today is in the understanding of international politics. The world-system, the role of nation states, governance and world governability; a set of concepts associated with the idea of world order, clearly antagonistic to chaos, to runaway globalization (Arrighi and Silver, 2001).

From the theory of the world-system, Immanuel Wallerstein (2005, 4) locates the disruptive character of chaos, but also locates the ordering elements that give system and with it certain regularities and laws that allow understanding the contradictory realities that try to be governed by political means, in whose sense intellectuals can influence. Crisis and chaos are assimilated one to the other. Given the complexity involved in international politics, and the struggle for power as the engine of "disorder", critical geopolitical thought offers plausible ways of interpreting chaos. War and armed conflicts are its maximum expression, but its essence lies in the search for an ordering power, for certain "balances".

Chaos theory is particularly useful in the field of peace research. Chernus (1993) asserts that the quest for order at all costs can only lead to failure. For him, it is paradoxical that states resort to the military option in order to bring order and peace to our fragmented societies.

Firstly, the more the potentialities are diverse and present in a given situation, in terms of both the role of the actors and the interactions between them, the greater the probability of peace

(Galtung, 1975).

Second, chaos theory seeks to model entire systems, emphasizing patterns of overall behavior rather than isolating cause-effect relationships of specific parts of the system (Mesjaz, 1988). Through this approach, chaos theory has shed light on the fact that many social systems are not simply ordered or disordered: some are ordered at times and disordered at others; still others, indicating a constant chaotic behavior, show an important more global stability. Therefore, the notion of stable chaos and randomly ordered points indicate a new way of conceiving peace. Chaos theory allows us to grasp nature and society which is inherently peaceful not because it is orderly but rather because it is fraught with disorder. "Nature would become the model for peace not only because of its diversity and associative qualities but especially because of its transcendence of the distinction between order and disorder" (Chernus, 1993: 113).

Finally, the author sees peace as a random cycle that repeats itself at all levels of actions between people, including the base that is the family up to the level of nation states. Therefore, many peaceful policies are needed to create a peaceful environment for the creation of an overall peaceful politics, with each level of politics demonstrating a harmonious pattern of organization.

Betts (2000) has pointed out that the application of chaos is important for national security and state strategies. Sometimes the results of the applied strategies are not the desired ones of the governments and to get the intended effects, the application is in chaos. This complex phenomenon excludes the control of the causes that produce the desired effects. For this reason, it has been noted that there is little connection between the previously designed strategies and the achieved results. The author emphasizes the characteristic of sensitivity to the initial conditions of chaos theory because he perceives war as a non-linear system that produces erratic behaviors, through disproportionate relations between inputs and outputs (Beyerchen, 1992). However, Betts concedes that although nonlinearity is common to military strategies, it is not absolute or dominant. "If chaos theory meant that no prediction is possible, there would be no point in any analysis of the conduct of the war" (Betts, 2000: 20). Although there is a lack of faith in the predictability of strategies, one should not reject all prediction at the same time as denying all rational aspects of strategy. Finally, it should be emphasized that the non-linear perspective alters the structure of the problem since military strategy deliberately seeks imbalance, that is, a means of beating one's enemy rather than seeking a mutually acceptable balance.

More precise but still rhetorical examples of the application of chaos theory in the field of international relations can be found in the case of revolutions (for example, that in Iran in 1978-79), considered as non-dynamic dynamic changes from the massive eruption of chaotic uncertainties and bifurcations (Radu, 2000). Other authors refer to small-scale events (such as the role of an individual like Adolf Hitler or Alexander the Great) creating bifurcations and having large-scale chaotic consequences (Farazmand, 2003).

Weisberg (1998) observed, using a particularly original application of chaos theory to political science, that the more frequent the measurement, the greater the observed change. He finds more electoral change when measuring these changes at shorter time intervals. The aspect of chaos theory concerning fractal objects is interesting in order to understand electoral change. According to this theory, scale is important when dealing with certain objects because it allows you to measure many more irregularities with a finer unit of measurement. Fractal geometry suggests a similar result when measuring change over time in political science. In addition, the author confirms the linearity of voting intentions in elections, but points out that certain small events during the campaign can be responsible for larger changes. In the long term, chaos makes predictions about politics impossible.

Conclusion

This paper aimed to explore the new doors opened by chaos theory in social sciences, and more particularly in political science. Thus the main foundations of chaos theory were laid out and sought to understand its uses in the political sciences. Even if the path of chaos does not lead to a new paradigm in the social sciences, it nevertheless demonstrates its great potential for possible reflections and applications. A chaotic system is certainly unpredictable but it is perfectly described by simple and deterministic equations. A system is defined as deterministic when it is possible to predict (calculate) its evolution over time: the exact knowledge of the system at a given instant; the initial state, allows to calculate (predict) precisely the state of the system at any other time.

First, this theory was mainly applied as a metaphor for description and analysis. The rhetoric and semantics of chaos have brought with them a whole set of new concepts and terms which are particularly useful in order to grasp political phenomena, such as, for example, points of bifurcation, sensitivity to initial conditions, self-similarity, oscillations, dissipative structures or even entropy. This new and rich vocabulary can be considered as a resource that allows the researcher to develop his knowledge and explore new aspects of the social and political phenomena observed. Because not only do these terms bring with them the precision and experience of the mathematical and physical fields, but they sometimes also lift the veil on certain aspects of our phenomena whose meaning and/or full implications may have escaped us.

In addition, and mainly applied in the fields of public policy and the sociology of organizations, chaos theory has introduced a more empirical and quantitative approach. Chaos theory offers new models and tools for researchers based on which the evolution of political systems can be analyzed. all these new tools and models are a good complement to the traditional scientific tools. The innovative aspects of chaos theory are promising in terms of the analysis of the temporal evolution of actors and political institutions. The evolution in space, that is, its trajectory, allowed to the built system is of only three types. The first, defined as stable, static or dynamic equilibrium, provides that the state of the system stops and does not change anymore; it is said to crystallize (static) or "spin around", caged, in a Euclidean space called the "limit cycle" which does not allow it to evolve. In the second type, the trajectory of the system in space moves in an irregular way, so much so that it is said that it has "gone mad" and cannot reach an equilibrium. The third type is the one called "edge of chaos" or "edge of chaos". In this case, the trajectory of the system is attracted to a particular region of space called the "attractor basin" within which the system moves, fluctuates, more or less regularly, around an attractor while maintaining an unstable dynamic equilibrium.

Biological, economic, political and social systems live on the edge of chaos. But if a perturbation, defined as critical, manages to "blow up" the system beyond the "edge of chaos", out of its attracting basin, therefore far from its attractor, it can fall into chaos or find a new equilibrium completely different qualitatively from the one from which it has been removed. The system is evolutionary. Chaos theory can be briefly concluded with Laplace's famous mathematical intelligence: "We must therefore consider the present state of the universe as an effect of its previous state and as the cause of its future state. An intelligence which, for a given instant, knew all the forces of which nature is animated and the respective positions of the beings that compose it, would embrace in the same formulates the movements of the largest bodies in the universe and of the lightest atom: nothing would be uncertain for it and the future, like the past, would be present in its eyes."

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