Theoretical and Methodological Framework of the Dynamics of a Global Information System*

Jacek Unold
The Wroclaw University of Economics, Poland
jacek.unold@ae.wroc.pl: jacek.unold@wp.pl

*This research was supported by a *Marie Curie International Fellowship (2005-2008)* within the 6th European Community Framework Program

ABSTRACT

The research topic takes up the issue of collective behavior within a Global Information System, and a relating question of human rationality. The interests in the area of information systems have concentrated mainly on technological aspects so far. If the human component was taken into account, it has been analyzed from the level of an individual. So have all new concepts of rationality. The detailed project objectives arise from the following research questions: Is collective behavior a phenomenon of exclusively qualitative nature, impossible to structure? Does irrationality of individual actions determine irrationality and unpredictability of the whole social system of a given Information System? A model exemplification of a Global Information System is a contemporary, electronic stock exchange. The anticipated findings will help formulate a new, adaptive, paradigm of rationality.

INTRODUCTION

One of the main issues both in the theory and practice of Social and Economic Sciences is the question of integration, i.e., how actions and interactions of individuals lead to the emergence of phenomena which characterize social entireties. This topic acquires particular importance in the light of the dynamic integration processes of societies, e.g., the next stage of E.U. enlargement. The integration processes, aided with the most recent achievements in information technology, harmonize with globalization and virtualization of human activity, from social to political to business one.

The outlined issue is a background of two basic research threads proposed in the project. The first part refers to the question of human behavior within an information system (IS). A fully integrated society of the future will make a fundamental, subjective element of a Global Information System. That Global IS will be either a ubiquitous and wireless Internet or some totally different, unknown yet, technological platform. And it is crucial that so far the interests in the area of IS have concentrated mainly on technological aspects. The issue of human behavior within an IS has been generally omitted, as one belonging to other disciplines. Admittedly, since the mid-1990s we have observed some growth of interest in the domain of social aspects of the IS development (Avison and Fitzgerald, 2003), but those interests have concentrated on the specificity of individual behavior. However, the nature of global phenomena and the features of dispersed collectivities denote a necessity of a new perspective on the society and organization. No longer can we perceive the human component of an IS as independent individuals. The users of local, regional and global telecommunications networks create a specific form of a "virtual crowd", accessing the same sources of information and reacting to the same sets of stimuli. These users, through their interactions, compose the phenomenon of IS dynamics. Dynamics not understood as one referring to the flow of energy (e.g. electrical impulses), but dynamics based on the collective information processes, reflected in collective actions. The phenomenon named by H. Simon "a collective mind".

And here we find the other research thread of the research proposal: the issue of human rationality. The Western organizational culture is still based on the three main determinants: individualism, competition, and a mechanistic-reductionist perspective. As a result, the essential body of scientific achievements in the area of human behavior concerns individuals (Nelson and Quick, 2000), and this is reflected in the paradigm of rationality. This depiction,

known as Rational Choice Theory (Halpern and Stern, 1998), assumes that individuals are perfectly rational, with clearly defined preferences, and optimizing their behavior at all levels of a decision-making process. Reductionism, which is related to it, postulates that collective behavior is composed of the sum of rational behavior of all individuals. Since this "sum" is purely theoretical and abstract, it is generally accepted that all phenomena concerning a collectivity are exclusively qualitative and cannot be structured.

The deficiencies of the traditional, idealistic approach to rationality have been known and discussed for a long time. Admittedly, since Simon's idea of "bounded rationality" it has been allowed that human actions can be more "satisficing" than "optimizing", but all new concepts of rationality still refer only to individual behavior (Halpern and Stern, 1998). At the same time, it has been emphasized that there is a need for such a formulation of the rationality principle so that it can take into account the specificity of collective behavior, so different from the individual one.

The research project takes up this issue, aiming to model information processes of collectivity and to structure this phenomenon through the identification of its quantitative dimension. These findings will help formulate a new, wider approach to rationality, which could respond to the integration and globalization trends of modern societies.

RESEARCH OBJECTIVES

An information system (IS) is a set of interacting components: *people, data/information, procedures, hardware, software, and communications* (Benson and Standing, 2002). In another exemplary approach, an IS is a system which assembles, stores, processes and delivers information relevant to an organization or to society (Avison and Fitzgerald 2003). The authors of this definition stress that an IS is a human activity (social) system which may or may not involve the use of computers. It is evident that, regardless of an approach, a social subsystem (*people*) makes a basic, subjective element of every IS.

The scope of application divides IS into micro- and macroeconomic categories, and the dynamic growth of the Internet and Internet-based information systems initiated the birth and development of a Global Information System. Owing to the interest of a social subsystem, a model exemplification of a modern IS will be in this project an IS of a present-day electronic stock exchange, because the performance of financial markets is a typical example of group (crowd) reactions (Plummer 2006).

The issue of human behavior within an IS is the most recent research trend in the discussed area. In 1994, A. Morita (1994), the founder of Sony Corp., pointed to the constantly growing gap between the world of business, and generally a society, and the new world of information technology ("IT/business gap"). It was the first human aspect within the area of IS that was detected so clearly.

The problem identified by A. Morita a decade ago concerned individual attitudes and actions. This proposal takes up a new and unrecognized issue of collective behavior within an IS. The importance of this topic results from the fact that collective information processes and collective behavior compose the basic determinants of an IS dynamics, and this phenomenon plays a key role in the development and functioning of the Global Information Society. According to C. Eden and J.C. Spender (2003), the dynamics of an organization represents changes in the various types of knowledge, in the learning and unlearning processes. At the same time, the collective knowledge cannot be understood without paying attention to the communication processes going on among the group's members (Weick, 2000). It follows that the basic determinants of the IS dynamics are: knowledge, learning and unlearning, and these phenomena relate to the information processes of collectivity. The operation of collective information processes determines organizational learning, which is a useful metaphor describing the way an organization, also a virtual and global one, adapts to its environment. Obviously, the individualistic and optimizing approach to rationality has become insufficient in that new, virtual environment, and one of the biggest challenges in the discussed area is an attempt to adapt the traditional paradigm of rationality to the new reality.

This research project proposes an innovative approach to the analysis and modeling of collective information processes and the mechanisms of collective behavior. This is the main objective of this project. This is also the first attempt of this kind in relation to the above-mentioned social issues and it should help define a new approach to rationality.

The following research questions have been formulated against the background of the state-of-the-art:

1. Are information processes of collectivity and the resulting collective behavior, which make the IS dynamics, phenomena of exclusively qualitative nature, impossible to structure?
2. Does irrationality or non-rationality, and unpredictability of individual actions determine irrationality and unpredictability of the whole social system.

3. Is there a research method allowing to identify and analyze a phenomenon of "social rationality", from its theoretical to methodological to empirical dimension?

The introductory stage of the research enables to propose the following theses:

1. Collective behavior, which is a basic determinant of the IS dynamics, does not proceed in a planned and intended manner, but is adaptive and follows certain patterns found in the world of nature.

2. Collective behavior can be expressed in a model form, which enables to structure this phenomenon, otherwise considered purely qualitative so far.

3. The identification of quantitative attributes of collective behavior will provide substantial theoretical and methodological premises for the extension of the optimizing and individualistic notion of rationality by the social and adaptive aspects.

To solve these issues and prove the proposed theses the following detailed research objectives have been set:

1. Theoretical objectives, including:

    - analysis of the theoretical foundations of an IS dynamics,
    - detailed analysis of the traditional, individualistic and optimizing, approach to rationality,
    - proposal of an extension of the traditional, individualistic and optimizing, paradigm of rationality by a social and adaptive aspect.

2. Methodological objectives, including:

    - developing a model of the IS dynamics,
    - identification of a mathematical dimension of collective behavior.

3. Empirical and utilitarian objectives, including:

    - innovative application of a logarithmic spiral, representing the idea of an isomorphic growth, on the charts of stock indexes, to forecast basic trend changes on the market.

The outlined background and chosen research objectives clearly indicate that the issues taken up in the project will be the subject of broad multidisciplinary and intersectorial investigation.

THEORETICAL BACKGROUND

The theoretical part of the research will begin with the identification of the determinants of an IS dynamics and relating this phenomenon to the behavior of a social subsystem of a given IS, thus to the issue of collective behavior. Generally, the point will be to identify a quantitative dimension of this, otherwise known as purely qualitative, phenomenon.

The next novelty will be an analysis of the genesis and evolution of the rationality principle and its influence in micro- and macroeconomic models. The limitations of the traditional approach to rationality have been discussed for a long time. One of the research objectives is a detailed analysis of all rationality concepts known in literature, from those "individualistic-optimizing" to the most recent ones, which try to take into account social and organizational

aspects of human actions. Such a comprehensive elaboration on the rationality issue has not been found in literature so far. This part of the study will allow for the identification of the basic determinants of rationality in the Theory of Information Systems. Owing to the concentration of interests on the technological aspects of IS, this will be the first attempt to relate the issue of rationality to the IS field.

The research on collective mind and collective behavior will be conducted in a social subsystem of an IS of a stock exchange. This choice is motivated by the fact that, contrary to other collectivities, the behavior of a stock market collectivity (investors) is reflected by relatively simple and concrete indicators, i.e., price changes shown by an index chart and some "mechanical" indicators of collective activity, such as the volume (the number of shares changing hands during a session) and the total turnover (money engaged on either side during a session). In the introductory analysis we found that this social subsystem reveals all 4 attributes of a nonlinear, complex adaptive system. Such a system:]

1. Consists of a network of agents (here: investors) acting in a self-managed way without centralized control.
2. The environment in which the investors operate changes and evolves constantly, which is the result of continuous fluctuations in economy and the market situation, but it also is produced by the interactions among the agents.
3. Competition among the agents (investors) leads to a consensus, reflected by a current market trend.
4. This trend suggests the hidden existence of organized patterns of collective behavior, which is the result of the emergence of a natural dynamic structure of this social system.

The classification of a social subsystem among complex adaptive systems allows for the application of the most recent achievements of Complexity Theory and Chaos Theory. Complexity Theory can offer a range of new insights into the behavior of social and economic systems. The idea of self-organization and emergence can be used to identify and explain the dynamics of individual and collective behavior, e.g., on the stock market. Thousands of independent and difficult to observe transactions, carried out by individual participants of the market, generate an emergence of specific and predictable patterns of collective behavior. These phenomena can only be identified on the higher - collective, not individual - level of social organization. S. Kauffman's (1996) famous phrase "order for free" describes that process of "crystallization", also known as the emergence of complexity in complex adaptive systems. The fundamental challenge of this project will be finding a quantitative measure of that emergence.

To model and structure the behavior of this complex adaptive system we will use the elements of Environmental Economics - one of the most trendy areas in Economics. Further analysis will amplify the approach proposed by F. Capra (1995), who believed that the new paradigm of rationality should take into account the fact that "an economy is a living system, and one of many aspects of a large ecological and social structure." This assumption leads to the notion of an open system (contrary to the Newtonian isolated system) and entropy (Gray, 1998). This enables the introduction of an innovative research concept. The project's concept is based on a 3-element system, *society-economy-nature*, and it replaces the 2-element system, *economy-nature*, which has been applied in Economics since the 1960s. The proposed model of collective behavior will be based on this 3-element system, thus allowing for the identification of dependencies in its 2-element subsystem, *society-nature*. This will help identify and describe phenomena, which are observed in the surrounding world of nature and, to the same extent, are expected to regulate behavior of the crowd. This is the actual, as opposed to only formal and declared, introduction of the ideas of open system and entropy to Economic and Social Sciences.

The initial results point to the possibility of a graphic representation of the analyzed phenomenon of collective behavior. The most common curve in the world of nature is a logarithmic spiral, which is isomorphic, self-similar, and based on the Fibonacci ratio Φ=1.618. The preparatory stage of the research contains the successful application of the logarithmic spiral to an index chart. Each index chart, according to technical analysis, represents the crowd sentiment on the market. This is the first attempt of this kind with reference to the emerging Polish stock market. After the necessary adjustments and tests the spiral should turn out to be a new and powerful forecasting tool.

The next innovative aspects of the project are revealed with the interpretation of the identified phenomena, especially with reference to the scientific achievements of Quantum Mechanics (Heisenberg's uncertainty principle) and Chaos Theory.

RESEARCH METHOD

The outline of the proposed research method can be presented in several basic steps:

1. Identification of the research area, based on the Theory of Information Systems, Organizational Behavior, Societal Behavior, Complexity Theory.
2. Identification of the mechanism of collective behavior (Organizational Behavior, Theory of Cycles).
3. Analysis of the identified mechanism (Theory of Cycles, Chaos Theory).
4. Synthesis: a mathematical description of the mechanism (Environmental Economics and 3-element model "society-economy-nature").
5. Exemplification and verification of the mechanism (application of a logarithmic spiral on stock indexes charts).
6. Interpretation and discussion: a new approach to rationality (Theory of Economics, Rational Choice Theory, Management, Organizational Behavior, Societal Behavior, Quantum Mechanics).

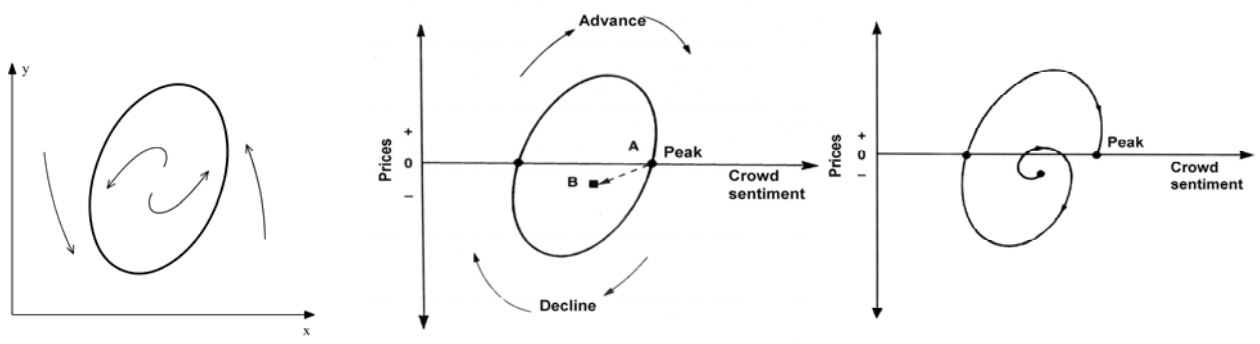
Below runs a brief description of these six stages.

Step 1) The collectivity of investors compose a non-linear complex adaptive system.

Step 2) A collectivity is created by information capable of uniting single individuals into a group. The group, then, lives its own life, a life, which depends on the exchange of information with the environment. The most significant symptom of this phenomenon is the collectivity's fluctuation during this exchange, and it reflects its dynamics. According to the Theory of Cycles such stable fluctuations between a system and its subsystem can be presented in a model form as a bounded cycle (Jordon and Smith, 1999) - Fig.1a.

Step 3) According to Chaos Theory, the bounded cycle is one of the 3 possible forms of an attractor Peters 1996). It is also a basic mechanism through which complex adaptive systems react to the fluctuations of the environment. Because this cycle is stable, it does not represent all adaptive processes. In reality, the flow of information is not a continuous process. So, when unexpected information appears (*information shock*), the collectivity tries to conform to the new conditions by changing its dynamic structure. It is expressed by a sudden "jump" from the cycle path. As far as financial markets collectivities are concerned, a jump in both *prices* (*y*) and *moods* (*x*) occurs (point A to point B in Fig. 1b). Some time later, the collectivity tries to return to the basic cycle path and this phenomenon is expressed by a spiral of the adaptation process (Fig. 1c).

Figure 1: Formation mechanism of a spiral of the adaptation process of collectivity: a) bounded cycle; b) information shock and "jump" from the cycle path; c) spiral of the adaptation process.



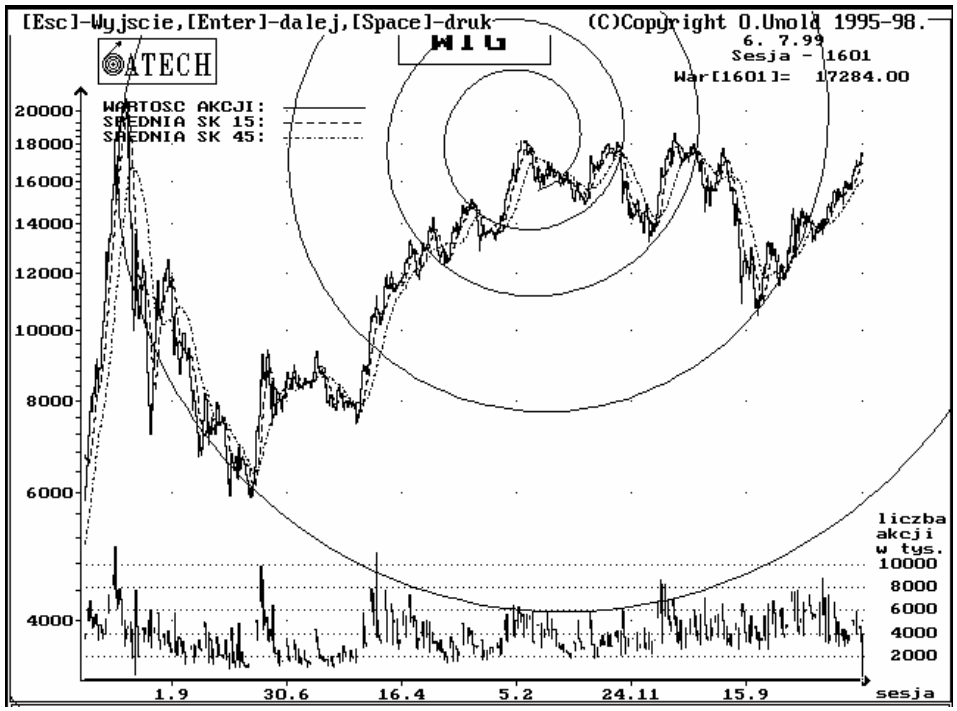
a b c

Source: author's research based on (Plummer, 2006).

Step 4) The key question is, What kind of a spiral represents these phenomena (because there are several different spiral movements)? This base can be found in the world of nature, because a collectivity also forms a natural system (Frost and Prechter, 2001). Thanks to the proposed 3-element model (*society-economy-nature*) we can look for analogies between its two natural subsystems: *society (collectivity)* and *nature*. The most common curve in nature is a logarithmic spiral. The tail of a comet curves away from the sun in the spiral. Distant galaxies, hurricane clouds, ocean waves and whirlpools swirl in spirals, as do many other natural phenomena. The construction of the logarithmic spiral is based on the Fibonacci ratio Φ=1.618, known as the Golden Ratio or Golden Mean. It defines the ideal proportions.

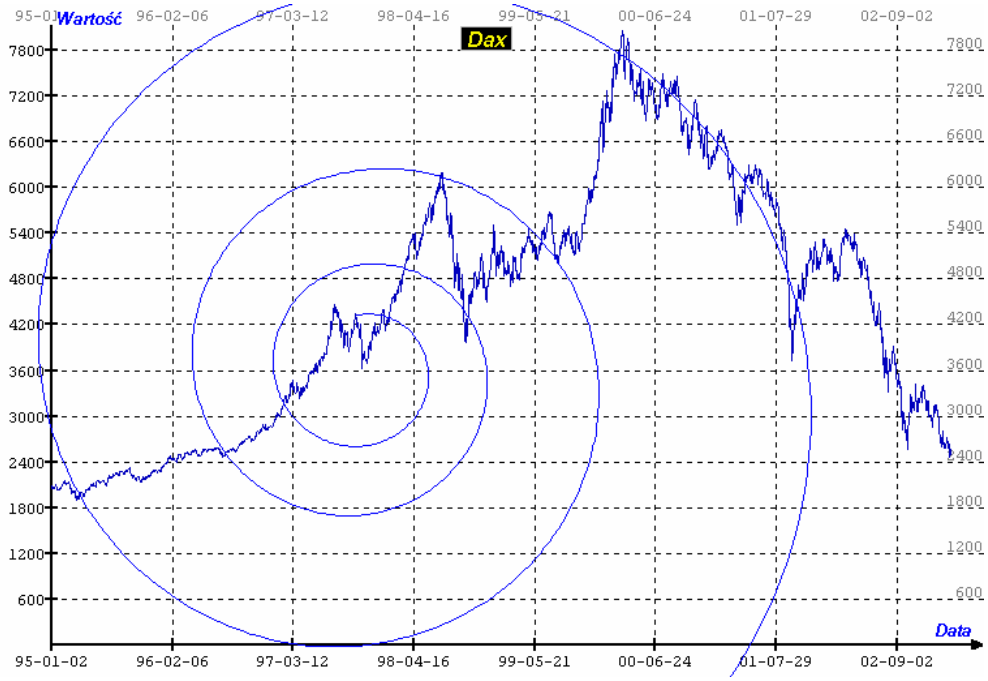
Step 5) According to the 3-element model, this natural law, permeating the Universe and described by the Fibonacci ratio Φ=1.618, should refer to the dynamics of collective behavior as well. Since adaptations to the exchange of information spiral and financial markets reflect psychology and the dynamics of the crowd, the spiral identified in price formations also should be logarithmic. During the introductory stage we confirmed that, indeed, the top of each successive wave of higher degree on the index chart is the touch point of the logarithmic expansion.
Figure 2 presents how the golden spiral applies to the Polish emerging stock market. The spiral embraces all the vital turning points of the WIG chart, starting at the peak of the first wave of the bull period (March 1994), through a year-long bear market (1994/1995), the second, very extensive, bull market, to the end of the next corrective wave (in July 1999).

Figure 2: Logarithmic spiral on the Warsaw Stock Exchange Index (WIG).



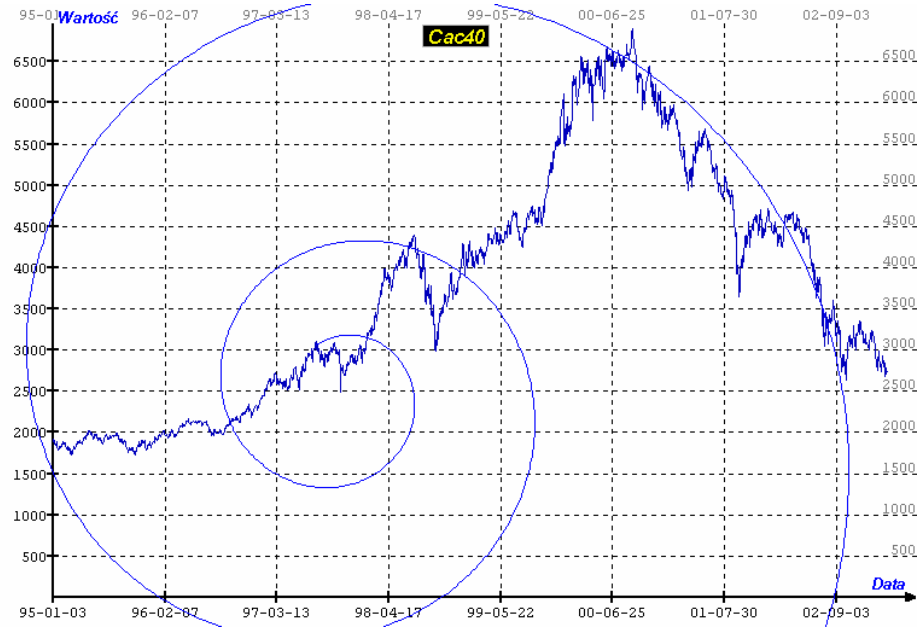
Another figure (Fig. 3) confirms the logarithmic extension at the German DAX index (January 2005 – March 2003).

Figure 3: Logarithmic spiral on the German DAX.



Yet another one (Fig. 4) reveals a similar pattern at the French CAC40, from January 1995 to March 2003.

Figure 4: Logarithmic spiral on the French CAC40.



Last but not least, the Hongkong Hanseng index, analyzed in the time frame June 1987 – April 1999 (Fig. 5).

Figure 5: Logarithmic spiral on the Hongkong Hanseng index.

Step 6) The logarithmic spiral is self-similar and isomorphic. It follows that information processes of collectivity are also isomorphic. The identification of isomorphism and self-similarity in the analyzed system is of great importance in the proposed research procedure. The spiral in Fig. 1c represents a new, modified form of the attractor presented in Fig. 1a. This spiral is a metaphorical equivalent of a *fractal attractor (strange attractor)*. This metaphor has a deep theoretical grounds, as a logarithmic spiral actually is a fractal. Most importantly, however, it suggests the occurrence of a certain form of rationality of collective behavior (see the sequence: *fractal-recurrence-collective mind*). Also the identified phenomena of cyclical recurrence and adaptability can be tentatively recognized as an expression of collective rationality. Another research thread which will be used to theoretically explain the identified phenomena and justify the method incorporated in the project is Heisenberg's uncertainty principle, with the example of the dual nature of electrons (unpredictability of behavior on the individual level, predictability on the collective level of an "electron cloud").

INITIAL FINDINGS AND CONCLUSIONS

The initial observations should be confirmed in the world's most representative markets and this will allow to prove the universality of mechanisms controlling the behavior of complex adaptive systems.

The identification of a fractal attractor (strange attractor) in the model of a social system carries far reaching theoretical and methodological consequences. It implies self-similarity and recurrence of system behavior. Recurring patterns of behavior in an organization are called organizational culture, and the notion of "organizational culture" is used interchangeably with the concept of "collective mind" (Eden and Spender, 2002). Thus, the identification of a fractal attractor in the analyzed social system suggests, on the grounds of Chaos Theory, the occurrence of rationality of collective behavior and defines the model representation of the adaptability of collective behavior – a spiral movement. It is worth to stress that the concepts of *collective mind* and *organizational intelligence* add a crucial qualitative dimension to systems analysis. They add the missing internal social dimension to the technical or mechanistic dimension, which is the focus of the classical theory of systems and organizations.

The initial findings suggest that the decision-making process of collectivity is adaptive and follows specific patterns found in nature. Therefore, unlike the decision-making process of an individual, this process can be expressed mathematically and ought to be predictable. In other words, individual behavior, which is often irrational and unpredictable, is expected to compose an adaptive, spiral and, thus, predictable process of collective decision-making.

If the proposal theses are confirmed, the main scientific result will be the formulation of a new paradigm of rationality. In the era of globalization and virtualization we shift our interest from traditionally perceived "physical collectivities" to a "dispersed, virtual crowd", which is a totally new social phenomenon. The realization of the project will allow to reach the theoretical grounds of a new paradigm, which will refer to the behavior of crowd and the notion of adaptation as a more natural reaction to information stimuli than optimization. Moreover, adaptation will not exclude traditional optimization. Optimization will remain a specific case of adaptation, applicable to strictly deterministic decision situations. This way, the project will contribute to an understanding of mutual interactions between societies and individuals. It will examine and structure the unique influence that social processes exert on the decision-making processes of an individual. In this sense we will be able to speak of *system rationality*, which should not depend on the rationality or irrationality of the system's components.

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