TOWARDS A NONLINEAR APPROACH OF THE MODERN SOCIETIES

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Abstract:

The paper points out the impact of modern theory methods of synergetic over the analysis of sociology and economics. These methods are able to capture much more subtle and complicated issues on which the society rules are based. The society is a nonlinear system with a hierarchy of instabilities, entailing the occurrence of increasingly complex collective structures. The factors responsible for this innovative change are the fluctuations, the subjective elements or the unusual decisions which are basically neglected in the classic type models. Nevertheless, at the moment when the parameters of mechanisms related to the evolution and interaction between individuals reach a critical level, these non-essential innovative factors are encouraged and are able to overthrow the global order.

Key words*:* synergetic, critical fluctuations, control parameters, slaving principle

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Synergetic [1] as an interdisciplinary science considers that reality is non-linear and complex and the lower fluctuations or uncertainty factors are found everywhere. Non-linearity comes from the fact that component subsystems influence each other, so that their actions cannot be separated from those of their neighbors. From this point of view, development of nations, cultures, societies is not the simple statistical amount of individual actions, in which each individual is regarded separately. Moreover, socio-economic phenomena present distinct qualitative properties as against those of individual parts.

Classical models always lead to a fatalist behavior and to a strict dependence on initial conditions. Everything is given at the same time with the cause law which fully determines the system condition and its evolution. But the

modern theory of the nonlinear systems gives the possibility for the organization and unexpected evolution.

Synergetic comprises several analysis methods [3]. Some examples are given below.

Haken model – Slaving principle and order parameters [4], [5], [6]

From mathematical standpoint, the evolution of a complex system consisting of a high number of sub-systems is described by a set of variables $\mathbf{u_i}$ which varies over time according to the following relation:

$$\frac{du_i}{dt} = \mathrm{F_i}(u_1,...,u_n;\alpha) + \mathrm{e_i}(t) \quad (1)$$

where F_i are non-linear functions and α is the vector of *control parameters*.

The uncertainty factors deriving from internal or external fluctuations are taken in computation by the random functions $e_i(t)$. The control parameters (α) are the slowly varying over time (internal or external constraints etc.). When one or several control parameters are changing, the former status of the system could get destabilized leaving room for a new status with distinct qualitative properties. An example in this sense is the laser. Another one is the fluid warmed at basis over a certain critical temperature. The four-footed animals could change their gait if surpassing a certain speed, or a group of individuals is set up over a certain value of communication parameter. A typical control parameter is the quantity of information stored at a society level. Below an optimal value, the information crisis leads to disorder, when the excess of information inhibits the organizational processes.

The previous examples show that the natural systems and social - economic systems which exceeded the critical threshold could be described by a lower number of variables. The *slaving principle* from synergetic proves a similar, much more general, situation: around the instability areas, the behavior of individual elements is determined by only few macroscopic measures, called *order parameters*. This is a consequence of cooperation between parties and of their orientation towards common directions. In view to explain this phenomenon, we shall present the mathematical model proposed by Haken:

The system consists of several equations like:

$$\frac{dh}{dt} = (\alpha - \alpha_c)h - h\sum_i g_i u_i \quad (2)$$

$$\frac{du_i}{dt} = -\gamma_i u_i + h^2 \quad (3)$$

(g_i are junction constants, h is the order parameter) where, for simplicity, fluctuations are neglected.

In critical moments, when $\alpha \cong \alpha_c$, the following condition exists

$$\gamma_i >> |\alpha - \alpha_c| \quad (4)$$

allowing for approximately solving the equation if considering $du_i/dt = 0$ (u_i is quickly absorbed). Thus, it results

$$u_i = \frac{1}{\gamma_i} h^2 \quad (5)$$

Here, one could observe that the first equation *follows* the second, in other words is *subdued* to the second. Finally, there is a single equation of evolution:

$$\frac{dh}{dt} = (\alpha - \alpha_i) h - h^3 \sum_i \frac{g_i}{\gamma_i} \quad (6)$$

In a certain sense, *h* describes the degree of order in the system. Therefore, Haken considered it as an order parameter. The technique of eliminating the variables with quick relaxation (adiabatic approximation) is called *the slaving principle* (Haken). Another formulation could be: in the instability moments, only few variables for the system evolution remain. These are called order parameters. The other one relax extremely fast to equilibrium values. On a research timeline, one could consider the variables with fast relaxation as being kept at their equilibrium values, these being strictly determined by the order parameters.

In Haken example, the respective equation with $dh/dt = 0$ admits two different types of solutions (+) and (--), depending on the way $(\alpha - \alpha_c) < 0$ or $(\alpha - \alpha_c) > 0$. We could identify the (+) and (--) status by imposing a totalitarian regime of right or left, while the modes u_i – the entirety of communication channels, such as written media, television etc.

Usually, the order parameters are quantities of collective nature, with any microscopic detail *subtracted* with a qualitative level different of the individual elements one. These macro-social quantities are *slaving* the individuals and groups behavior and are, on their turn, made up by their actions, more or less aware of the events significance [2]. The order parameters denote measurable quantities (for example, the electromagnetic field of a laser, the number of persons joining an opinion), but also qualitative characteristics (for example, the geometric shapes of patterns, the layouts in a society). The slaving principle provides a major advantage:

in certain conditions, close to critical areas, the system could be described by few collective variables only, which are changing by themselves, under close inter-dependence conditions. Thus, the high number of variables necessary in view to characterize the complex interactions at local level was diminished, a huge amount of information being compressed.

Typical relations between order parameters and individual parts are to be found in several humanistic sciences. Here are some examples: *Language* is an order parameter. It is preserved much longer than an individual or than a nation is changed over time by individuals. On the other side, a child is learning the language and is formed within it. WE are hereby observing a circular causality. Another order parameter is the *number of persons with a certain opinion orientation*. Any individual is influenced to change his opinion proportionally with the number of those already having a new opinion. For a well integrated group, the order parameter is the *lifestyle* of the group that the participant is adopting and envisages it permanent achievement. In terms of normative acts, we have to remind the set of laws which, at least in a democratic country, are adopted by its citizens. By means of laws, the society is solving individuals' conflicts, favoring a certain behavior type. Another order parameter refers to the *scientific theories* called by Thomas S. Kuhn as paradigms. Theories are built up by scientists and students are learning from them. As such, they are slaved by theories and concepts.

Social systems are, generally, very complex. Therefore, instead of considering the system evolution by taking into account each and every individual factor, we would be rather interested in its dynamics close to instability. According to slaving principle, there are only few quantities in these areas able to characterize the macro-social dynamics in a simple but comprehensive manner. This is, in fact, the phenomenological method proposed by Haken: further to practical identification of order and control parameters set, phenomenological equations are written where order parameters are the variables and the control parameters are the constants. Slowly changing the control parameters entail spectacular phenomena: the system is loosing its stability and shifts to new situations characterized by the occurrence of new parameters or by sudden changes in the values of former parameters. In most cases, several new types of situations are finally possible and only low fluctuations, as subjective elements of changes, determine the choice of the situation at the unstable moment of transition.

Weidlich model [10]

A quite different model is the one proposed by Weidlich, which is explaining the collective behavior of migrations or of public opinions formation, starting from the micro-level of individual's decision. Weidlich does not pay attention directly to certain collective variables and phenomenological equations, describing the evolution of macro-social quantities average values in the presence of fluctuations. He is rather studying a prototype individual, perceived as statistical exponent of the collective behaviour. The model is thus focusing on building up the probability that someone choose a specific behaviour alternative. One could observe that, once this probability found, subjective factors generating uncertainty or disturbances are already taken into account. The macro-social level refers to the evolution of the number of persons with certain behavior. The equations characterizing the collective situation take, this time, into account the general probability of finding in the society at moment *t* a number of n persons with certain behavior.

Other models

A more complex phenomenological model takes into account all the variables characterizing individual parts. The variables are altogether included in the *situation vector* q, slaved on its turn to a number of non-linear equations with control parameters.

Allen and his collaborators [9] applied this model for analyzing the urban regions development. From micro-social standpoint, the evolution of population in a town local area is mathematically described by non-linear differential equations, whose terms refer to economic capacity and production, etc. of each region. In Allen's view, the development of an urban region results from the dialogue of determinist equations of inter-actions between the town regions and a wide range of disturbances outside the description model. In the instability moments, disturbances amplify and lead to town restructuring, so that its structures are not resulting from a certain *global optimization*, from certain functions of *collective utility*, but are due to successive instabilities close to bifurcation points. Allen's model reveals the way in which, starting from the same original distribution, different urban structures could be developed.

The studies on neuronal networks or on iterative strategies (games) iterative provide an original way of characterizing liberal social processes, where

an individual is gathering step by step the necessary information in view to reach optimal decision. The individual perceive the reality in his own way and afterwards filter the information in order to make a decision. This decision depends on the expected success level and on his preferences. There is one question arising: is he able to realize if the decision taken is optimal? Normally, an individual does not know if the change perceived in his close environment is due to his action or to other changes in the system. This type of imperfect acknowledgement ensures an uncertainty in making optimal decisions, so that, though a person's behavior follows a fixed strategy, it could entail unexpected collective dynamics, due to the impossibility of perfectly connecting the behaviors of all society members, as actually expected [8].

Human behavior is dynamically modeled, step by step, without being deduced from general principles as in case of classic theories. The individual is allowed to continuously reassess his decisions and preferences. The society evolution could be computer assisted simulated.

An example of simple iterative model, taking into account individual strategy, was developed by ***B.A.Huberman***.

It considers a group of interacting persons proposing themselves to cooperate or not in view to produce a collective asset. Each member is reassessing his decision with a certain ratio. The choice depends not only on the currently perceived situation, but also on his expectations on how this choice would affect the collective asset and the others actions in the future. Though he cannot directly observe the efforts of his neighbours, the individual has the opportunity of knowing the collective asset value at any moment in time and, consequently, to accurately realize the share of members who are actually cooperating [11].

When setting up his action strategy, the individual has two types of expectations:

a) The future of the collective behaviour is directly influenced by his choice, in inverse proportion with the group size. Thus, if ${}^{*}f_c={}^{*}n_c/n$ is the share of members actually cooperating at present and n is the group size, his action of cooperating (or not) would stimulate the cooperation (or not) of an additional number of members ${}^{*}f_c/n$ during each period $1/\alpha$.

b) The interactions effect felt by the other members as a follow up to his decision is lasting a limited time H.

These expectations are leading to a rational strategy of conditional cooperation. Individuals cooperate if they perceive the cooperating share ${}^{*}f_c$ as

exceeding a certain critical value, ${}^{*}f_{crit}$, for which the benefit they expect in the future becomes positive.

Likewise, un uncertainty is introduced between the share of those proposing themselves to cooperate f_c, and the share of those actually cooperating, ${}^{*}f_c$. Several possible causes exist in relation with this uncertainty. For example, a member could try, though it is not sure that he will succeed to contribute due to unpredictable impediments. On the other side, he could finally contribute, though it is not the case, due to limited rationality. In this situation, for a fixed value f_c there will be several possible values for the share ${}^{*}f_c$. Since ${}^{*}f_c > {}^{*}f_{crit}$ is the cooperating condition for a member, it results that a certain probability $r_c(f_c)$ exists that an individual would contribute to the collective asset, presuming, at that moment, that f_c members trying to cooperate exist in the society.

The probabilistic nature of action, arising from the diversity of beliefs or from limited rationality, leads to spectacular collective phenomena. For example, full cooperation could persist in the groups with to large size to sustain it indefinitely. Similarly, total non-cooperation could unexpectedly arise within groups with predictable cooperation. Increased uncertainty and diversity is shortening the time towards unexpected transitions.

The previous models show that a social - economic system consisting of actors with even very simple preferences and decision criteria has a complex behaviour, often unpredictable, due to the sequence of instabilities it is forced to cross over when local random factors become significant.

This approach is somehow solving the philosophic problem of freedom and necessity: in fact, necessity is installed when the system turned on a certain branch of the bifurcation, though low (insignificant) deviations from average values, deduced from the non-linear equations of the theory, could occur. Moreover, freedom means the system possibility of choosing in the neighborhood of bifurcation points. The choice is determined by internal decision makers, insignificant, or by the presence of uncertainty which, at that moment, amplifies and entails oscillations at global level between several possible situations. Instead of being continuous, the evolution is rather arborescent, depending on history, on all steps taken by successive choices. At this moment, Onicescu raise a qualitative issue with significant importance for the social system: the internal decision maker is the individual able to become aware of the existing situation. The development rather appears as a desired evolution than a random one, alongside with

decreasingly effects of the uncertainty arising from limited rationality or imperfect knowledge.

Conclusion

The classical approach of socio-economic phenomena always leads to fatalistic trajectories and a strict dependence on initial conditions. Everything is given with the causal law which determines the condition of the system and its evolution. But modernist theories allow the possibility of organizing and unexpected developments.

The main approach which explains the behavior of the modern societies is that of Haken focusing on the macro level interactions. Social-economic systems can be characterized by considering the influence of macroscopic variables (order parameters) upon the individual parts with their interactions. Order parameters refer to collectivity, groups, institutions or various types of social decisions closely interdependent with the individual actions. In instability moments, it occurs that only few order parameters completely characterize social and economic evolution, without being necessary to appeal to microscopic factors. Thus, the reality can be described in a simple and comprehensive manner - the slaving principle in the theory of synergetic.

At upper floor there are control parameters depending on outside constraints or variables changing in time. Those parameters can be steady „macroscopic structures" (government, institutions, group norms) appeared by need to keep control or general order. Society fossilizes as far as bureaucracy develops or increases the number of control parameters.

Creativity, restructuring and uncertainty appear especially in the groups where individuals do not know each other very well to adopt together decisions by transfer or contagion. They are rather autonomous, but have interpersonal influence relations.

A complementary approach is that of Weidlich explaining the collective behavior of migrations and of the public opinion from the micro level of individual decision. Equations that characterize the collective situation consider this time the overall probability to find n people with a certain mode of behavior.

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