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Threshold Effects in the Social and Political Processes. Social-Energy Approach

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Abstract: The purpose of this research was to investigate the threshold effects in the social and political processes through the creation mathematical model of the social system. As the basic approach used by the author's socio-energy approach. As a result, on the basis of created the mathematical theory of a computer modeling of the impact of the information of one social system to another, which has revealed pattern of such processes as reflexivity and also the presence of characteristic peaks (bifurcation points).

Key words: Modelling · Threshold effects · Systematic social-energy approach · Complex social systems · non-linear dynamic systems

INTRODUCTION

Well known physicists, chemists and representatives of some other natural sciences know about the threshold effects. However this term is used relating to society. You can hear about the threshold effect (e.g., chain reactions and the effect of critical mass and others) in social and political processes from media, sociologists, economists and politicians. However, it is difficult to find a direct scientific evidence of such effects in society, the definition of its parameters and conditions in the open scientific literature. Most likely, it is connected with the difficulty of determining the parameters of the social environment, because the analogy of the natural sciences deals with exact figures. In fact, this effect means determination of parameters and accuracy of their determination. It is impossible to speak about conditions of their occurrence without it. However, social processes cannot be accurately determined. Parameters that are assigned to a social system are usually artificial. They can be incorrect by their definition. So how do you use them to determine the effect, for which the slightest vibration of its basic characteristics leads to an absolute change in the state system?.

In order to cut this Gordian knot, you need to change the approach to the social system and to abandon attempts to assign her own parameters of a private nature, trying to determine the state of the given system. On the contrary it is necessary, to refer to the indirect or distributed parameters across individuals. Really, to find out whether there will be a chain reaction in a piece of pure uranium, you are not going to do an experiment and to try to measure the density of the neutron flux inside him. You will take into consideration the weight and pressure of the surrounding environment. It is easy to give an exact answer about possibility or impossibility of occurrence of this reaction after these changes. We did not research the state of the system directly, but the conditions affecting it. Of course, this only makes sense when it is easier to define these terms, rather than the system state. We also should mention that, in general, the social system is more difficult than uranium, because neutrons, unlike humans, do not have free will and therefore the ability to make their own decisions.

Author proposes the social power (SEA) approach. It is able to circumvent these problems appearing during the studying of social and political processes. The basis of SEA is a systematic approach, where the social system is considered from an energy point of view. This allows considering intra-and extra-systemic processes such as modification or redistribution of energy within the system and between systems. Moreover, wiener processes are

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the internal representation of the processes in the system through the physical analogy. Wiener process - in the theory of stochastic processes – is a mathematical model of the Brownian motion (it describes the Langevin equation) or of a random walk in continuous time [1-2].

Also the term of "social power" or simply "energy" – E is introduced. Here this term means the quantity that characterizes the potential of the social system to do a work. Attempts to introduce such a term were made before, but with no further use for the creation of a mathematical model, it was limited by generalities [3].

Basis of mathematical model. This value, social or energy E, is similar to the energy in its physical sense. However, it gives us a certain freedom in the interpretation of "has not lost energy" and not fulfilled job, in assessing the possibility of human work, not yet extracted resources, etc. This moment is very important to build the model. It is necessary to take into account all the factors for the evaluation of the social system which can influence on it. For instance, such parameter as a human work is often decisive in the system, at the same time it is also very hard classified in terms of standard physical concepts.

This view makes it possible to consider intra-and extra-systemic processes as modification or redistribution of energy within the system and between systems. What is more, the basic principles of the systematic approach are used. [4].

Thus, the total social energy of the system is written as:

$$\sum_{i=1}^{n} E_i - E_\Sigma \tag{1}$$

From this, we obtain a system model based on differential equations:

$$\vec{P}_\Sigma = \sum_{i=1}^{n} \vec{P}_\Sigma^i \tag{2}$$

where,

$$\vec{P}_\Sigma = \vec{\chi} \frac{dE_\Sigma}{dt} \tag{3}$$

It is the flow of energy per unit of time in the system, or a change of energy which is used, submitted to intra-laws. In fact, we use the concept of power, which considers the work (energy change), but in our case, since we are interested in the change in energy it is all the same.

$\vec{\chi}$ - single vector in the direction of energy flow.

We believe that in a complex social system, there are two main types of energy (as introduced above the notion of social power), which include all others:

$$E_м = f(E_м^{sc}, E_м^{\Sigma h}, K_d, K_{si}) \tag{4}$$

The material energy of system, where

E_M^{sc} - Energy of resources of the social system and its physical property.

$E_M^{\Sigma h}$ - Energy of material savings and property living (existing) in the social system of people. K_d - factor of leader, determines the effectiveness of the system of social control.

$K_{si} = f(\vec{a}, I_l, K_d, K_s)$ - rate of scientific and technological progress and development of the system. $\vec{\alpha} = (\alpha_1, ..., a_m)$ - set of parameters, determining the scientific and technical progress in the system. I_l- transfer function of the inter-system information exchange.

$K_s = f(\vec{\beta}, I_l, K_d, N)$ - Coefficient of social activity and moral development, moral state of society.

The coefficients K_s and K_{si} exist for each individual in the system separately and total coefficients of the whole system is obtained by fractional conversion of all the values of individuals and clusters of the system.

N - Number of individuals in the social system.

$\vec{\beta} = (\beta_1, ..., \beta_k)$ - A set of parameters defining the spiritual and moral development and moral state of society.

The energy of human labor into the social system:

$$E_h = f\left(K_o, E_h^\Sigma, K_d, K_{sc}\right) \tag{5}$$

E_h^Σ - the total energy of the work of members of the system depends on the N.

Thus, using (2) we wright:

$$\vec{P}_\Sigma = \vec{P}_\Sigma^{\,м} + \vec{P}_\Sigma^{\,h} + \vec{P}_\Sigma^{\,out} \tag{6}$$

Hence using (3)

$$\vec{j}\frac{dE_{м}}{dt}+\vec{k}\frac{dE_{h}}{dt}+\vec{\gamma}\frac{dE_{out}}{dt} \quad (7)$$

Wright through (4) and (5)

$$\vec{P}_{\Sigma}=\vec{j}\left(\frac{dE_{м}^{\Sigma h}}{dt}K_dK_{sc}+\frac{dE_{м}^{sc}}{dt}K_dK_{sc}\right)+\vec{k}\left(\frac{dE_{h}^{\Sigma}}{dt}K_dK_{sc}K_s\right)+\vec{\gamma}\left(\frac{dE^{\Sigma}_{out}}{dt}\xi(K_dK_{sc}K_sI_l)\right) \quad (8)$$

For closed type systems the result will be without the last term:

$$\vec{P}_{\Sigma}=\vec{j}\left(\frac{dE_{м}^{\Sigma h}}{dt}K_dK_{sc}+\frac{dE_{м}^{sc}}{dt}K_dK_{sc}\right)+\vec{k}\left(\frac{dE_{h}^{\Sigma}}{dt}K_dK_{sc}K_s\right) \quad (9)$$

This formula is the basic equation of SEA, which expresses the flow of social energy passing through the system. Methods of calculating the coefficients are given in the early work on the social power approach [5-6].

Account of fluctuations in the social and political processes. Social and political processes characterized by the fact that they cannot be strictly specified. They are always subject to small changes and fluctuations. Resorting to analogy, the social process is similar to the Brownian particle - particle moving along a well-defined path, but on closer inspection - much winding, with lots of small breaks. These small changes (just - fluctuations) are explained by the random motion of other molecules. In the social processes fluctuation can be interpreted as a manifestation of the free will of its members [7].

Description of the social process from the point of view of mathematics, it is necessary to use a stochastic process.

The Langevin equation is used in mathematics to describe Brownian motion:

$$s(t) = (s_1(t), s_2(t),...,s_n(t)) \quad (10)$$

– vector field describing social process (in this case, IR).

Langevin equation for s is given by:

$$\frac{ds}{dt}=-ks+\zeta \quad (11)$$

where $\zeta(t)$- the random force acting on the social system. It can be determined by a number of factors, such as, for example, the level of social tension in society (is dtermined by the K_s and K_{si}

We consider that the average value:

$$<\zeta>(t)\equiv M\zeta(t)=\int_{E_{\zeta(t)}}[\zeta(t)](\omega)dP_{\zeta(t)}(\omega)=0$$

$$<\zeta(t)\zeta(t')>=\delta(t-t')$$

where $<E_{\zeta(t)}P_{\zeta(t)}$ - the probability space of the random variable

$\zeta(t),\omega\in E_{\zeta(t)}$- elementary event.

From (11) we have

$$s(t)=s_0e^{-kt}+\int_0^t e^{-k(t-t')}\zeta(t')dt'$$

we can assume that the initial data is a random variable with a probability space $<E_0, P_0>$. In this case $s(t)=[s(t)](\omega,v)$– random variable with a probability space $<E_{\zeta(t)}\times E_0, P_{\zeta(t)}\times P_0>$, where $v\in E_0$

Averaging (13) we get

$$<s>(t)=\int_{E_{\zeta(t)}\times E_0}[s(t)](\omega,v)dP_{\zeta(t)}(\omega)\times P_0(v)=$$

$$=\int_{E_0}s_0(v)e^{-kt}dP_0(v)+\int_0^1 e^{-k(t-t')}(\int_{E_{\zeta(t')}}[\zeta(t')](\omega)\,dP_{\zeta(t')}(\omega)dt'=$$

$$=<s_0>e^{-kt}+\int_0^1 e^{-k(t-t')}<\zeta>(t')dt'=<s_0>e^{-kt}$$

This means

$$<s>(t)=<s_0>e^{-kt} \quad (15)$$

Accordingly, the stochastic process s(t) at $t\to\infty$ becomes quasi-stationary, close to balance s=0.

In general, the Langevin equation can be written as:

$$\frac{ds}{dt}=-ks+F(t)+\zeta \quad (16)$$

where the external force F (t) may be a potential, so that $F=\nabla V$, where V=V(x,t) – vector field. As can be seen in this case s=s(x,t). Consequently, the social process of s depends on other parameters in the phase space [7], which is extremely important to take into account in the modeling process.

Formation of the field of communication in the system. We suppose that we have a social system A, with a given distribution coefficients K_{si} and K_s (i corresponds to each individual factor k_i). As it will be their interaction and how the change will be reflected outside influence on the system?

Holyst J.A., Kacperski K., Schweiter F. A convenient model of public opinion on the basis of the idea of interaction between individuals, in the form of Brownian motion [8]. Applying this model to our case - for the coefficients, it had to make some significant changes. In this process, the individuals involved, field communication by interacting: $h_k(x,t), x \in S \subset \mathbb{R}^2$

This field takes into account the spatial distribution of the coefficients and distributed in the community, modeling the transfer of information. But you should understand that it is a social space that has physical symptoms, but in terms of development of information tools is clear that the impact of one individual to another optional exercise, being physically close. Thus, this space - a multi-dimensional, social, physical, characterizing the possibility of one individual "reach" their communications field to the other, that is, to influence him on the coefficients and the ability to move. It is clear that, in addition, in fact, the physical space coordinates, it will be the social and coordinates (describing the social situation of the individual).

Spatial and temporal variations in the field of communication is taken into account by the equation:

$$\frac{\partial}{\partial t}h_k(x,t) - \sum_{i=1}^{N} f(k_i, k_n)\delta(x - x_i) + D_h\Delta h_k(x,t) \qquad (17)$$

$\delta(x\text{-}x_i)$- Dirac function - δ

$F(k_i\text{-}k_n)$- Function that determines the power to influence an individual to another concrete individual, dependents on their coefficients.

N = The number of individuals

D_h = Diffusion coefficient characterizing the propagation of the field communication.

Every person at the point x_i, makes his own contribution to the field in accordance with the terms of their coefficients (which also determine the influence and power of the individual to the surrounding individuals and the radius of influence). Field exercises influence on the individual as follows. Being at the point xi, individual falls under the influence of the communication field of another individual (or several). Depending on its difference from its coefficients and ratios of individuals acting on it, it can react in the following ways:

- Changes the value of its coefficients under the influence of other individuals
- Moves in the direction of the area where the difference between the coefficients is relatively minimal in the present

Let - the probability of exposure to the field of communication of individual i communication field of the individual (or a cluster of individuals) j, so that would change its coefficients K_s and K_{si} (individually or together) at time t. Then, the likelihood of displacement of the individual i in the direction of the area where the difference between the coefficients is relatively minimal at the moment

Then the change of this probability:

$$\frac{\partial}{\partial t}p_{ij}(k_i,k_j,t,x_i,x_j) = \\ = \sum_{k'_i} \nu(k_i|k'_j)p_{ij}(k'_i,k'_j,t,x_i,x_j)\vartheta(\Delta x_{ij},\Delta k_{ij}) \\ - p_{ij}(k_i,k_j,t,x_i,x_j)\sum_{k'_i}\nu(k'_i|k_j)\vartheta(\Delta x_{ij},\Delta k'_{ij}) \qquad (18)$$

$(\Delta x_{ij},\Delta k_{ij})$ - Parameter characterizing the inductive effect of the communication field.

Where $\nu(k'_i|k_j)$- Conditional probability of coefficient change per unit time

$$\nu(k'_i|k_j) = \begin{cases} k_i \neq k_i' \to \eta exp\{[h_{k'_i}(x_i,t) - h_{k_i}(x_i,t)]/Q\} \\ k_i = k_i' \to 0 \end{cases} \qquad (19)$$

where Q – social freedom parameter that characterizes the degree of freedom of movement of individuals in social and physical space.

Movements of individuals in social and physical space are described by the Langevin equation:

$$\frac{dx_i}{dt} = k_i\vartheta(\Delta x_{ij},\Delta k_{ij})\nabla_x h_\Sigma(x_i,t)|_{x_i} + \sqrt{2D_n}\zeta_i(x_i,t) \qquad (20)$$

where D_n - Spatial diffusion coefficient of individuals, h_Σ-(x_i, t) the resulting field of communication, acting on the individual i.

Random fluctuations and the impact of simulated stochastic force ζ_i-(x_i, t), so that ζ_i - white noise, which depends also on the location of the individual, (assuming that the effect of random external and internal factors on the social position of the individual in different parts of the system - the other) c

$$< \zeta_i(x_i,t)\zeta_j(x_j,t') >= \delta_{ij}\delta(t-t')$$

Thus, this model allows us to calculate the change in the coefficients in the public system under external influence or change the system itself and its global parameters.

The results of modeling. Computer model was built in mathematical programming environment MatLab 2009a and MatCad14. In particular, it was a case of interaction between the two systems (one system is trying to weaken the other) for two cases:

Case 1: We assume that the system of A with coefficients K_s and K_{si} equal to 0.9 and 0.9 are affected by system B with coefficients 0.80 and 0.30, respectively.

Case 2: We assume that the system of A with coefficients K_s and K_{si} equal to 0.95 and 0.95 B acts on the system with coefficients 0.80 and 0.20, respectively.

In contrast to [9-11] simulation was carried out not by looking for changes in public and social structure under the influence of the external system and to change the coefficients of the system, since so much easier to see the threshold effects [12].

In Figures Fig. 1 and Fig. 2 shows the process of changing the basic system coefficients for the two cases described above. The axes $K_t = \Delta k_{si} + K_{si\ early}$, $\Delta K_s = K_{s\ early} - K_s$, $\Delta K_{si} = K_{si\ early} - K_{si}$, where $K_{si\ early}$, $K_{s\ early}$ - The initial value of the coefficient, t - time reports.

It is clear from the graph that there exists a "peak" of K_t for both cases, so that time in which the change in the coefficients is maximum, then it drops sharply at continuing influence of the same force, after that - goes to a certain asymptote, but with a fairly small changes to K_t.

Before this peak there is a certain threshold point, after passing through it, the state of the system begins to change dramatically. It is important to point out that all this time the impact of another system remained invariable. Consequently, we are getting in touch here with a threshold effect, which triggers the transition processes in the system up to the point of bifurcation - the peak.

At this point the change vector of system settings 1changed dramatically and then the system returns to its stable state, demonstrating the reflexivity of the system. Between two stable states of the social system were

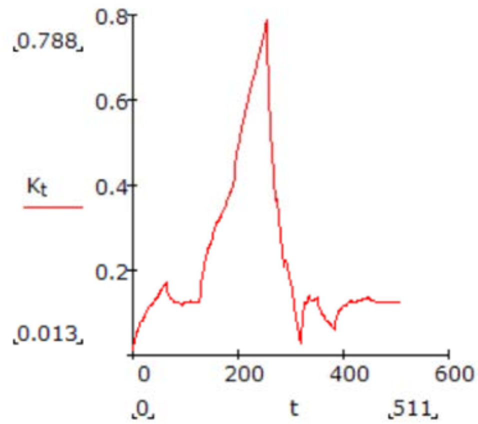

Fig. 1:

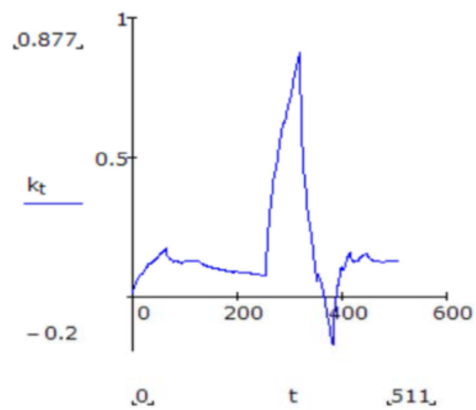

Fig. 2:

processes called - transients. During these processes, the system was unstable, changing coefficients went sharp jerks and the system was in a state of deterministic chaos. In this state, any even relatively little additional impact on the system would lead for a qualitative change in the structure and the energy level of the system. In a society such states correspond to the revolutionary processes, coups and a major public unrest.

Thus, we can establish a pattern of such processes as reflexivity, the presence of characteristic peaks (bifurcation points).

CONCLUSION

Thus, in this article the basis of the mathematical model are offered by which the author plans to develop an approach, to model social system in a whole and research threshold effects in particular. It is shown that it is possible to consider the fluctuations of the factor of "randomness" in the mathematical model using physical analogs in this case - by a Wiener process through the Langevin equation.

Based on this model, specifying the parameters, it is possible to calculate the total energy of the system state during the transients to predict changes of the coefficients K_s and K_{si}. What is more it is feasible to calculate the energy of the outflow or inflow of the social system in it and thus to calculate the energy of the entire system at the desired time. This makes it viable to count the impact from without on a given system and to predict the possible directions of change in its status and structure, moreover taking into account the threshold effects. A pattern of such processes as reflexivity was established, as well as the presence of characteristic peaks (bifurcation points).

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