A MODEL FOR EVALUATION OF STRUCTURAL STABILITY IN RESPECT TO THREATS

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ABSTRACT

The paper presents a model for evaluation of the structural (inherent) stability of the organization in respect to the bearers of threats to it. The model is based on the catastrophe theory and the theory of parties concerned. The paper is worked out in two sections. The concept of the model is presented in first section. Second section of the paper covers procedure for evaluation of the structural stability of the organization in respect to its licensing institutions (bearers of threats). The procedure refers to particular fourth degree functions of threat to the organization, where each function comprises one independent variable and two managerial parameters and represents "cusp" type catastrophe.

Key words: catastrophe theory, structural stability, threats, "cusp" type catastrophe.

INTRODUCTION

The paper is aimed at presenting a possible model for evaluation of the structural stability of the organization in respect to its bearers of threats, based on the catastrophe theory and the theory of parties concerned.

Structural (inherent) stability refers to the feature of a given system to keep its belonging to the attractor basin (area of belonging) of a certain attractor even under substantial changes of the managerial parameters of the system [3]. The model suggested *is based on the idea from [5]* that the system "organization" has many attractor basins, whereas in their capacity of attractors are viewed its bearers of interests (threats), called licensing institutions[1].

As *a starting point* of the model, it is assumed that current aggressions and threats to the organization from its licensing institutions are previously evaluated in quantitative respect.

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[1] "…in the circle of holders of interests are all persons that have relationships with the organization, no matter whether they are external to it … or its members …" [2].

The evaluation of structural stability of the organization in respect to a given licensing institution (in this instance, "Mediae") is demonstrated in second section of the paper for particular fourth degree function of threat to the organization, where the function represents "cusp" type catastrophe. Data concern University of National and World Economy (UNWE) in the city of Sofia and are taken from the scientific research project "Theoretical fundamentals of an internal standard of measuring and evaluating of threats to the organizations", financed by the National Science Fund to the Bulgarian Ministry of Education, Youth and Science of Republic of Bulgaria.

1 CONCEPT OF THE MODEL FOR EVALUATION OF STRUCTURAL STABILITY OF THE ORGANIZATION

The model is formed at the basis of two theories: theory of parties concerned and catastrophe theory.

Theory of parties concerned (see [2]) is used in this context for defining relations between the organization and subjects from its environment. Holders of interests in respect to operations of the organization are defined as licensing institutions. The interaction between the organization and its licensing institutions are described by so-called "license". By license is meant the formalized or non-formalized attitude of agreement to interact with the organization under certain conditions [5]. Conditions of the license are associated with specific operation indicators of the organization, called license indicators, and are described by values of these indicators. Reaching to the critical values of license indicators changes the magnitude of the aggression of licensing institutions and as a result values of threats to the organization.

In the context of the theory of parties concerned, the starting point of the paper, that values of current aggressions and threats to the organizations are known, requires defining in advance of: licensing institutions of the organization, license indicators of each licensing institution and functions of threat to the organization from licensing institutions according to license indicators.

The catastrophe theory (see [1) is defined as part of the chaos theory which studies the structural in(stability) of the systems. The theory examines uneven transitions, disruptions and any qualitative changes in the states of the systems [3]. Catastrophes are associated with destruction of attractor basins for the old asymptotic stability[2] and in this context, with destruction of the attractor basins of licensing institutions.

Application of the catastrophe theory in the model aims to examine the distance of the points of current aggression from licensing institutions (current states) to the catastrophe points of their attractor basins as a basis for making suitable managerial decisions about the organization. The **concept of the model suggested** could be described most precisely by this aim. From a mathematical point of view, the model could be carried out by a homonymous *procedure*, consisting of two activities: 1) study of the structural (in)stability of the parametric families of the functions of threat from licensing institutions and 2) subsequent analysis of the specific analytic functions and of the current states of structural (in)stability of the organization in respect to its

[2] Asymptotic stability of the system in respect to a certain attractor refers to belonging to its attractor basin under slight changes of the managerial parameters of the system [3], [5].

licensing institutions.

The tools for the analysis of the structural in(stability) are the bifurcation diagrams of the functions of threat from licensing institutions (see figure 1 (a), the graphical presentation of the current states for separate threats (see figure 1 (b) and the uneven points (catastrophes) (see figures 1 and 2). *Bifurcation diagrams*[3] reflect the mathematical relation between the parameters in front of the independent unknown variables of the examined functions (in this case the aggression of licensing institutions from the function of threat). They are defined by a system of equations of the derivatives of the non-linear continuous one-dimension functions of threat (see [4]), where each equation equalizes one of the derivatives of a given function to zero. The number of equations is determined by the number of parameters in front of the independent unknown variable and the power of the function. *The catastrophe points*, called "critical degenerate points", concern the analysis of the particular analytic function (in this context, function of threat). They are defined by equalizing the derivatives of these functions to the number "zero".

3 PROCEDURE FOR EVALUATION OF STRUCTURAL (IN)STABILITY OF THE ORGANIZATION

The evaluation in the procedure refers to fourth degree function, which comprises one independent variable and two managerial parameters, representing "cusp" type catastrophe of the type $y = x^4 - Ax^2 + Bx$. Mathematical expression of the operations for study of structural stability for non-linear continuous one-dimension functions in this section of the paper is developed by the author in analogy with numerical examples from [3] and [4].

I.1. Investigation of the structural (in)stability of the parametric family of the function of threat.

I.1.1. Calculation of first, second and third derivative ($th_i^{',f,par}$, $th_i^{'',f,par}$ and $th_i^{''',f,par}$) of the parametric function of threat $y = x^4 - Ax^2 + Bx$.

I.1.2. Defining the solutions to the system from formula (1).

$$\left| \begin{array}{l} th_i^{',f,par} = 0 \\ th_i^{'',f,par} = 0 \end{array} \right. \qquad (1)$$

where:

$th_i^{f,par}$ is the parametric function of threat to the organization from the licensing institution f by license parameter i;

par - the meaning for parametric presentation of function.

The solution (formula (2) to the system from formula (1) reflects the relationship between parameters A and B of function y, whose projection in the plane is associated with the bifurcation diagram of the function (see figure 1).

[3] Bifurcation (forking of the paths of evolution) is a process of a qualitative transition from a state of equilibrium to chaos through very little changes, carried out successively [5].

$B = \pm(2A/3)^{3/2}$ (2)

I.1.3. Setting the second derivative of the parametric function of threat to zero (formula (3).

$th_i^{'',f,par} = 0$ (3)

I.1.4. Defining the double critical degenerate points for the parametric function of threat y (figure 1 and formula (4).

$x_{1,2} = \pm(A/6)^{1/2}$ (4)

I.1.5. Setting the third derivative of the parametric function of threat to zero (formula (5).

$th_i^{''',f,par} = 0$ (5)

I.1.6. Defining the triple critical degenerate point for the parametric function of threat y (figure 1 and formula (6).

$x_3 = 0$ (6)

I.1.7. Plotting the bifurcation diagram of function y (see figure 1).

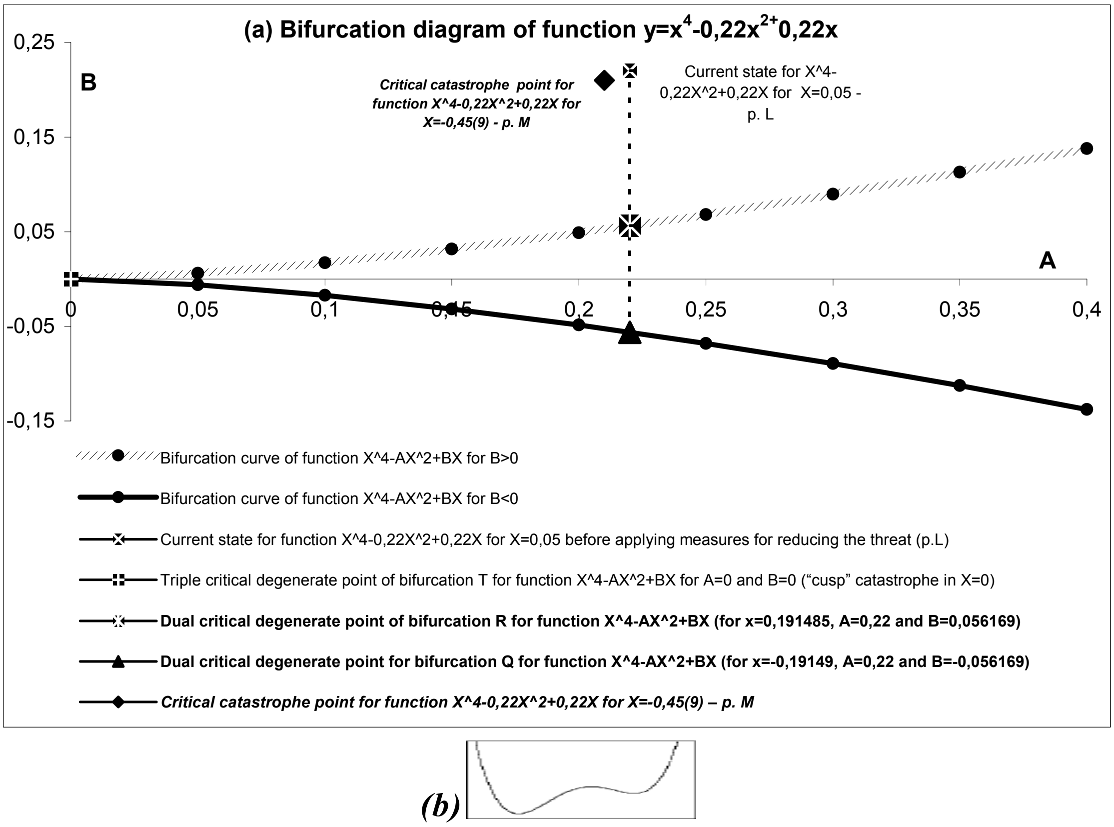

Figure1 Bifurcation diagram (a) and current state (b) of function of threat $y = x^4 - 0,22x^2 + 0,22x$

I.2. Analysis of structural (in)stability of the analytic function of threat y and of the current state of structural (in)stability.

I.2.1. Defining the double critical degenerate points for the analytic function of threat y for a specific A and the required values of B (p. R and p. Q from figure 1).

I.2.2. Setting the first derivative of the analytic function of threat to zero (formula (7).

$th_i^{',f} = 0$ (7)

I.2.3. Defining the critical points of the catastrophe for the analytic function of threat y (p. M from figure 1).

The points of transition from structural stability to instability for the specific analytic function of threat coincide with the solutions to the equation from formula (7).

I.2.4. Defining the point and the type of the current state in respect to the structural stability of the analytic function of threat y (p. L from figure 1).

The activity is realized by substituting the evaluation of current aggression ($ag_{i,pre}^f$) of a specific licensing institution f and license parameter i in the first derivative of the respective analytic function of threat $th_i^{',f}$.

Possible results are:

- Formula (8) is fulfilled. ⇒ The point on the bifurcation diagram of the function is unstable (see figure 1).

$th_i^{',f}\left(ag_{i,pre}^f\right) > 0$ (8)

- Formula (9) is fulfilled. ⇒ The point on the bifurcation diagram of the function is stable (see figure 1).

$th_i^{',f}\left(ag_{i,pre}^f\right) < 0$ (9)

I.2.5. Reflecting the results from I.2. in the three-dimension space (see figure 2).

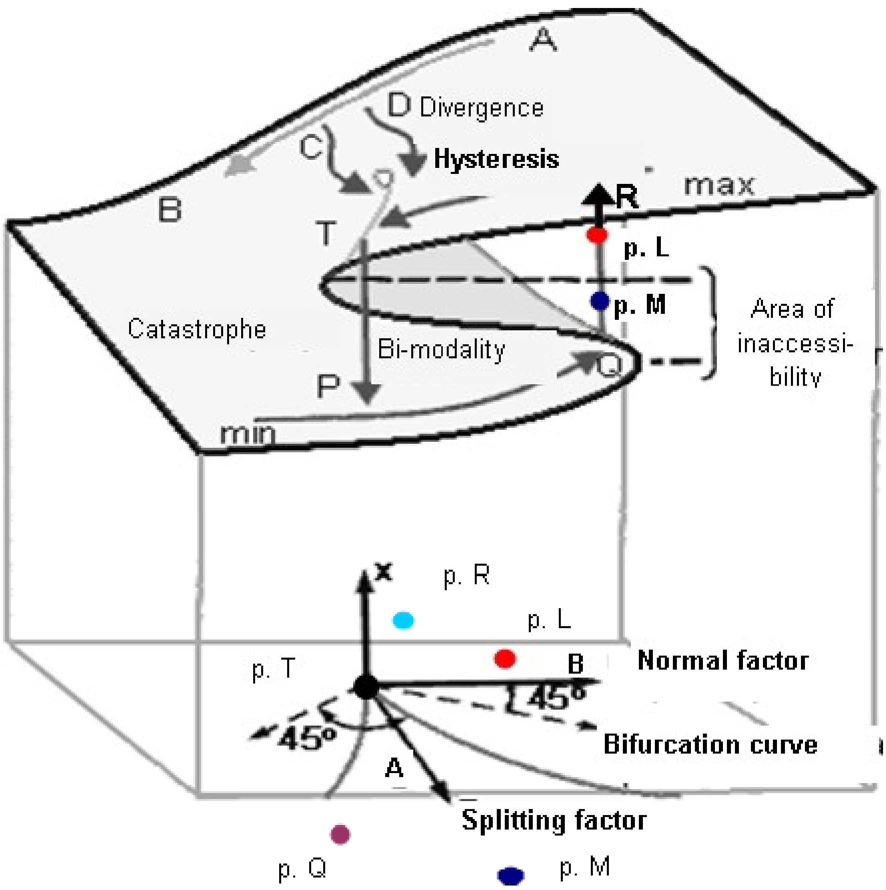

Figure 2. Results for the current state of structural (in)stability of function of threat $y = x^4 - 0{,}22x^2 + 0{,}22x$

I.2.6. Conclusions and evaluations of the structural stability of the analytic function of threat.

Conclusions/evaluations refer to: the character of the current state of structural (in)stability of the organization, the distance of the current state of the analytic function to the points of catastrophe and possible decisions that might be made by the organization.

As to the example shown in figures 1 and 2, the current aggression of the organization (UNWE in the city of Sofia) from its licensing institution (“Mediae”) is described by point L, the current state is structural instability according to formula (8), point L does not coincide with the points of catastrophe T, Q, R and M.

CONCLUSION

The paper presents a model for evaluation of the structural stability of the organization in respect to the bearers of threats to it, based on the catastrophe theory and the theory of parties concerned. The model is explained by its concept, characterization of theories, which are at the root of the model, and of instruments used as well as by description of the procedure for evaluation of the structural (in)stability to bearers of threats. The model is suitable for putting into management practice of organizations of all types.

Possible application of the model is demonstrated for a particular fourth degree function of threat, which comprises one independent variable and two managerial parameters, representing “cusp” type catastrophe.

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článok recenzoval:
prof. Ing. Ladislav Šimák, PhD.