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EVALUATION OF STRUCTURAL STABILITY TO THREATS

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Key words: *catastrophe theory, structural stability, threats, "cusp" type catastrophe.*
Abstract: *This paper presents a model for evaluation of the structural stability of the organization to its bearers of threats. The model is based on the catastrophe theory and the theory of parties concerned. This paper is worked out in two sections. Concept of the model is presented in the first section. Procedure for evaluation of structural (in)stability of the organization in respect to its licensing institutions (bearers of threats) is worked out in the second section. The procedure refers to particular fourth degree functions of threat representing "cusp" type catastrophe.*

INTRODUCTION

The aim of this **paper** is to present a model for evaluation of structural stability of the organization in respect to its bearers of threats. The model suggested here is 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 in parameters of that system [1].

The model suggested **is based on the conception** [2; 36] that as a system the organization has many attractor basins whereas in their capacity of attractors are viewed its holders of interests (threats), called licensing institutions. All persons/subjects that have relationships with the organization are in the circle of its holders of interests no matter whether they are external to it or its members [3; 121].

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

This paper is elaborated in **two sections**. Concept about structural stability of the organization is clarified in the first section of the paper. Procedure for evaluation of structural stability of the organization is worked out in the second section. Application of the procedure is also illustrated in this section. The illustration is made by a specific fourth degree threat function of a given licensing institution to the organization, where the function represents "cusp" type catastrophe. In this case, the organization is University of National and World Economy (UNWE) in Sofia and the licensing institution is "Media". Data are taken from the scientific research project "Theoretical fundamentals of an internal standard of measuring and evaluating threats to organizations", financed by the National Science Fund to the Ministry of Education and Science of the Republic of Bulgaria.

1. CONCEPTION FOR EVALUATION OF STRUCTURAL STABILITY TO THREATS

The concept suggested here is based on two theories - catastrophe theory and theory of parties concerned.

The theory of parties concerned 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 [3; 121]. The interaction between the organization and its licensing institutions are described by licenses. By license is meant formalized or non-formalized attitude of agreement to interact with the organization under certain conditions [3; 121]. License conditions are associated with specific operation indicators of the organization, called license indicators. License conditions are described by values of license indicators. Reaching critical values of the license indicators changes magnitude of the licensing institutions aggression and as a result changes values of threats to the organization [2; 42].

In the context of the theory of parties concerned [4], [5; 48], the model suggested here requires defining in advance the following:

- Licensing institutions of the organization;
- License indicators for each licensing institution;
- Functions of threat to the organization from licensing institutions by license indicators.

The catastrophe theory is defined as part of the chaos theory which studies structural (in)stability of the systems [6; 120]. The catastrophe theory examines uneven transitions, disruptions and any qualitative changes in the states of the systems [1]. Catastrophes are associated with destructions of attractor basins for the previous (old) asymptotic stability and in this context, with destructions of attractor basins of the organization's licensing institutions. Asymptotic stability of the system in respect to a certain attractor refers to belonging to its attractor basin under slight changes of the system parameters [1]. When asymptotic stability of the system is sustained even if changes in the meanings of parameters are significant, **structural stability** exists [2; 36].

The application of catastrophe theory in this model aims to examine distance of the points of current aggression from licensing institutions (viewed as 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 here could be described most precisely by this aim. From a mathematical perspective, the model could be described by a homonymous **procedure**, consisting of two activities:

- Structural (in)stability study of parametric families of the organization's threat functions; and
- Subsequent analysis of both specific analytic functions and current states of the organization's structural (in)stability by licensing institutions.

Tools for the structural in(stability) analysis used in this model are bifurcation diagrams of the functions of threat from licensing institutions (see Fig. 1a), graphical presentation of the current states of these functions (see Fig. 1b) and uneven points (catastrophes) (see Fig. 1 and Fig. 2).

Bifurcation (forking of the evolution paths) is a process of a qualitative transition from a state of equilibrium to chaos through very little changes, carried out successively [2; 38]. *Bifurcation diagrams* reflect mathematical relations between parameters in front of the independent unknown variables of the functions examined (in this case, the aggression of licensing institutions from the functions of threat). They are defined by a system of equations formed by derivatives of the non-linear continuous one-dimension functions of threat [7; 45-48], 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 function power.

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”.

2. PROCEDURE FOR EVALUATING STRUCTURAL (IN)STABILITY OF THE ORGANIZATION

The evaluation in this procedure refers to the fourth degree function, which comprises one independent variable and two managing parameters, representing “cusp” type catastrophe of the type $y = x^4 - Ax^2 + Bx$. Mathematical expression of the operations for structural stability study concerning non-linear continuous one-dimension functions in this section of the paper is developed by the author in analogy with numerical examples from sources [1] and [7].

Activities of the procedure in this section are the following:

I.1. Investigation of structural (in)stability of the parametric family of the threat function $y = x^4 - Ax^2 + Bx$

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

I.1.2. Finding solutions of the system from Eq. 1

$$\begin{vmatrix} th_i^{',f,par} = 0 \\ th_i^{'',f,par} = 0 \end{vmatrix}, \qquad (1)$$

where:

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

par - meaning for the parametric presentation of any function.

Solution (see Eq. 2) to the system from Eq. 1 reflects the relation between parameters A and B of the function y, whose projection in the plane finds expression in the bifurcation diagram of this function (see Fig 1).

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

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

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

I.1.4. Finding double critical degenerate points for the parametric function of threat y (see Fig. 1 and Eq. 4)

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

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

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

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

$$x_3 = 0, \qquad (6)$$

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

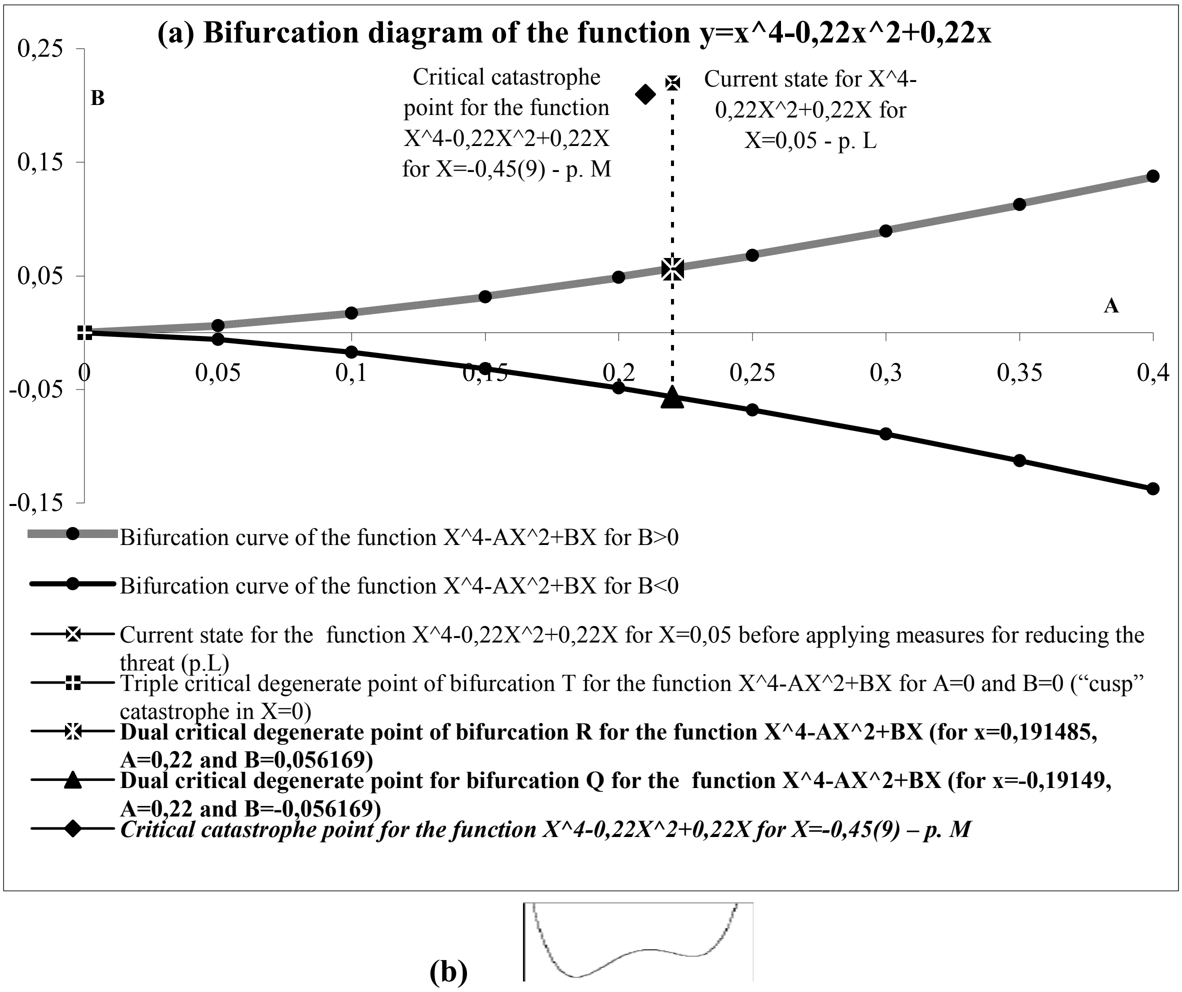

Fig. 1. Bifurcation diagram (a) and current state (b) of the UNWE threat function

$y = x^4 - 0{,}22x^2 + 0{,}22x$

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

I.2.1. Finding double critical degenerate points for the analytic function of threat y for a specific A and the required values of B (see p. R and p. Q in Fig. 1)

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

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

I.2.3. Defining critical points of the catastrophe for the analytic function of threat y (see p. M in Fig. 1)

Points of transition from structural stability to instability for the specific analytic function of threat coincide with solutions to the system in Eq. 7.

I.2.4. Defining the point and type of the current state concerning structural stability of the analytic function of threat y (see p. L in Fig. 1)

This 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 the following:

- Eq. 8 is fulfilled. ⇒ The point on the bifurcation diagram of the function is unstable (see Fig. 1);

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

- Eq. 9 is fulfilled. ⇒ The point on the bifurcation diagram of the function is stable (see Fig. 1);

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

I.2.5. Presentation of the results in three-dimension space (see Fig. 2)

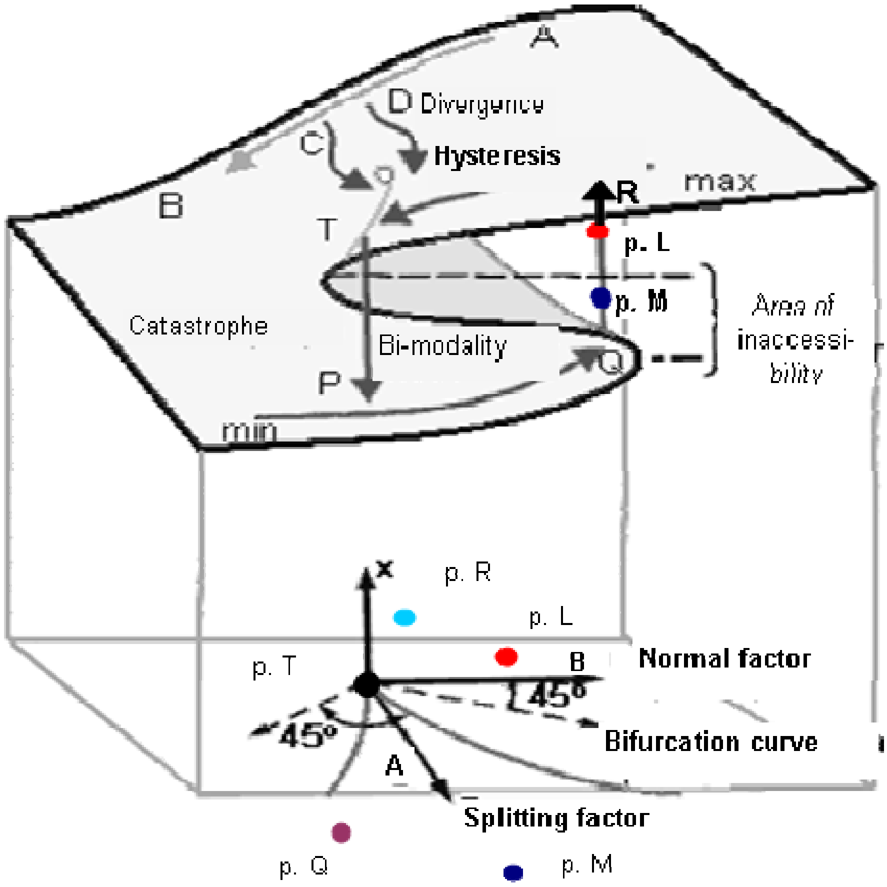

Fig. 2. Results for the current state of UNWE structural (in)stability of the threat function $y = x^4 - 0{,}22\,x^2 + 0{,}22\,x$

I.2.6. Evaluations of structural (in)stability of the analytic function of threat y and conclusions

Conclusions/ evaluations from this activity refer to:

- The character of the current state of structural (in)stability of the organization;
- Distance of the current state of the analytic function to the catastrophe points;
- Possible decisions that might be made by management of the organization.

As to the example, shown in Fig. 1 and Fig. 2:

- The UNWE current aggression from its licensing institution "Media" is described by point L;
- The UNWE current state is structural instability according to Eq. 8; and
- Point L does not coincide with the points of catastrophe T, Q, R and M.

CONCLUSION

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

An 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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ОЦЕНЯВАНЕ НА СТРУКТУРНАТА УСТОЙЧИВОСТ КЪМ ЗАПЛАХИТЕ

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Ключови думи: *теория на катастрофите, структурна устойчивост, заплахи, катастрофа тип "витло".*

Резюме: *Статията представя един модел за оценяване на структурната устойчивост на организацията към носителите на заплахи за нея. Моделът е разработен на основата на теорията на катастрафите и теорията на заинтересованите страни. Статията е разработена в две части. В първата част е представена концепцията на модела. Във втората част е разработена процедура по оценяване на структурната (не)устойчивост на организацията по отношение на нейните лицензиращи институции (носители на заплахи). Процедурата се отнася за определена функция на заплаха от четвърта степен, представяща катастрофа тип "витло".*