http://www.ijmp.jor.br v. 10, n. 5, September-October 2019
ISSN: 2236-269X
DOI: 10.14807/ijmp.v10i5.900

ENTERPRISE DEVELOPMENT MANAGEMENT THROUGH MANAGED CHAOS

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Submission: 11/09/2018
Revision: 11/23/2018
Accept: 12/09/2018

ABSTRACT

The purpose of the study is to substantiate the feasibility of using the theory of chaos in the process of managing the industrial enterprises. One of the tools for managing chaos is proposed to be chaos engineering – a method of conducting planned experiments that give an idea of how the system can behave as a result of disturbances. The introduction of chaos engineering will allow for prediction of possible perturbations and prepare the system for a new attractor at an optimal time with minimal losses. The chaos management model of the economic system, which allows either a radical change in the status of the enterprise, its ability to influence demand and supply while maintaining the subjectivity of the development, or to promote antifragility of the enterprise, allows strengthening the stability of the economic system.

Keywords: microeconomic system, antifragility, chaos management model

ISSN: 2236-269X
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1. INTRODUCTION

The current situation in the world is characterized by the expansion of the global systemic crisis, increased competition, the growth of uncertainty, risks and instability in all spheres and at all levels of the economy. Among the new, dynamic scientific disciplines of the twenty-first century, the concept of "controlled chaos", the theory of "entropy logic" and "entropy economy" occupy a leading place. A new interdisciplinary field of research is actively developing, which can be generally called the "science of chaos", whose subject matter is systems with nonlinear dynamics, unstable behavior, self-organization effects, the presence of chaotic regimes and bifurcation.

In the modern world, it is particularly important to study the possibility of controlling the generation of chaos, the behavior of complex nonlinear systems and the manifestation of instability, as well as the possibility of a partial determination of the behavior of the system in a turbulent world. The theory of controlled chaos began to develop in the 80 years of the last century. In this theory, the means of creating a controlled chaos of systems are determined. In the application of this theory, the system is artificially transformed into a state of chaos. Managed chaos – the main element of the construction of chaos point of the new attractor, the transition to a new state of order.

According to Mann (1992), “Chaos can change the method by which we view the entire spectrum of human interactions ... We can learn a lot if we consider chaos and regrouping as opportunities, and not rush to stability”. A definite contribution to the development of the theory of critical complexity (chaos) was made by Waldrop (1992), who published the work “Complexity: A New Science at the Turn of Order and Chaos”.

According to Kiel and Elliott (1996), “the theory of chaos today represents the main area of the exact sciences, the achievements of which representatives of the social sciences integrate into their theory and methodology”. However, in their opinion, it is more significant that chaos theory is perceived as a means to explain and identify many aspects of uncertainty, nonlinearity, unpredictability in the behavior of socio-economic systems. We can also mention the work of the French scientist Ramonet (1998) “The geopolitics of chaos”, in which the concepts of the geopolitical theory of chaos are developed.

ISSN: 2236-269X
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PhD and financial investor Williams (2004) applies chaos theory when developing strategies and algorithms for financial transactions. the activity of raiders and investors. His work “Trading Chaos” is best known. According to B. Williams, in accordance with the theory of chaos, an investor who starts from a linear perspective will never see the real market, thereby risking sustained losses. For the success of the financial market, you need to use the tools of chaos theory - nonlinear, fractal analysis.

It is also necessary to cite the work of the American researcher Peters (1994) "Fractal analysis of financial markets. The application of chaos theory in investments and the economy”, which are devoted to the analysis of the modern problem of nonlinear economic dynamics (economic synergetics), proposes long-term forecast methods for stock markets, bonds, currencies, as well as fractal analysis of stock markets , bonds and currencies.

The problems of managing complex systems in terms of entropy engaged in such scholars as Hacken (1985), Prigogine and Stengers (1986), Lepsky (2009), Malinetsky (1998), Akhromeeva and Kurdyumov (2007). These scientists have developed the foundations of the theory of chaos. But the question of using the elements of dynamic chaos to the management of microeconomic systems in modern science has practically not been considered.

The traditional approach considers chaos solely as a negative category, that is, the main purpose of any directed intervention in natural, social or economic processes is to minimize chaos. However, synergetics reveals the positive role of chaos. In reality, all processes occur unevenly: quiet periods are replaced by tense critical states, when it is necessary to decide on the further development of the system.

At such moments the decisive role is played not by order, but by chaos. Without this disordered, uncontrolled, random component, no qualitative changes are possible, the system transition to a qualitatively new state. The theory of chaos says that complex systems are extremely dependent on the initial conditions and small changes in the environment lead to unpredictable consequences.

Chaos gives more opportunities to jump to increase the potential of the system, and most importantly – to sharply change the trajectory and the very logic of its development. The chaos initially provides the possibility of an ascent of the system with the former trajectory in case of loss of stability in the zone of crisis, and then helps to connect to the new attractor, causing obstacles along the way. It is in this that the constructive role of chaos manifests itself. The synergetic economy shows that chaos lies in the nature of any economic system.

Most scientists consider the problems of managing chaotic systems at the level of macroeconomic systems. At the same time, similar chaotic processes are characteristic of microeconomic systems. Thus, an industrial enterprise can be considered as an open microeconomic system, the behavior of which is described by trajectories in a certain space.

Changing the trajectory is a change in the system evolution program. In this sense, the transition from stability to chaos can give a new impetus to the development of the system, contributes to the transition to a fundamentally new level of organization and management. In the case of a successful overcoming of chaos, the efficiency of microeconomic management is significantly enhanced.

Based on the above, under the control of the chaos of the microeconomic system, we will understand the process of changing the evolutionary vector of development into a revolutionary to achieve the global goal of the existence of the system. When managing the development of a company as a microeconomic system, two complex tasks can be solved, namely: elimination of imbalances, deviations from planned system behavior and creation of contradictions as the source for its further development.

2. THEORY

One of the possible tools for controlling chaos, in our opinion, is chaos engineering (shaos engineering) – it is actually "injection" of external and internal influences, the ability to check the system's ability to react to disturbance. This is an effective method for practicing, preparing and preventing / minimizing losses before they occur in reality. Incorrectly consider chaos engineering as a chaotic process. In fact, chaos technology includes planned experiments that show how the system can behave as a result of disturbances. These are experiments in which a hypothesis about the behavior of the system is formed, impacts that improve the system are evaluated. The time and power of the control effects are determined to prevent negative pressure on the system.

ISSN: 2236-269X
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An important principle of technology of chaos engineering is minimization of the radius of an explosion – negative changes, which increases the confidence in the system and understanding the extent of potential risk.

The concept of chaos engineering is based on the category of "antifragility" introduced by Taleb (2014). Antifragility is the ability to benefit from failures, losses, errors; the ability to harden, develop and become stronger when faced with chaos (TALEB, 2014). The concept of antifragility is widely used in living organisms (ecology, physiology, psychology, etc.) and relates to the ability of the system to actively overcome problems and adapt to the new situation.

Antifragiliting systems are amplified under the influence of stress factors, and the gain is due to prediction and hypercompensation:

- the system receives signals about the change of the environment;
- the system predicts that now this will always be, and is rebuilt with a stock;
- being prepared for a certain level of stress, the system is ready to move to a higher level.

There are two important points in this picture. First, we are talking about acute stressors (acute stressors). Chronic, monotonous stresses lead to fatigue and deterioration of the system, not to its development. Second, the system must respond with hyper compensation, and not an equal response to the stressor. In this case, the system will be antifragility in relation to these influences.

Taleb claims: accidental shocks are beneficial for the enterprise to a certain extent. This limit is determined by how much the company has excessive stocks. The form of redundancy for a company is the availability of potential reserves. The presence of excessive resources allows for the implementation of antifragility and invulnerability. True, those who are regularly engaged in material provisioning or regularly insure all their risks, not so much. In addition, the material stock in itself is not antifragility.

Antifragility goes beyond the limits of stability, because it implies the evolution of a system capable of developing as a result of the stress it was subjected to to adapt to new possible "failures." Stability is defined as the ability to "absorb" destabilizing factors that can be caused by stress factors. Antifragilition company is not afraid of

ISSN: 2236-269X
DOI: 10.14807/ijmp.v10i5.900

changes in the external environment and more often comes out of them with additional profits than with losses.

In economics, the state of anti-frailness means that, following a certain decline, loads, a rapid upward movement begins that compensates for losses. It is necessary for the company to constantly endure certain stresses, failures, overcome difficulties. Awakening the system using random noise to improve its performance is used in many areas. Chaotic systems can be stabilized by adding randomness. Chaos turns into order, not because there is less chaos in the system, but because random, absolutely random fluctuations of low intensity have been added to it. This implies an important practical principle: in order to increase the stability of the system, it is sometimes necessary to add random perturbations to it.

Thus, the implementation of chaos-based controlled chaos strategy implies a certain "chaosification" of the system in a controlled manner, which will allow for prediction of possible disturbances and prepare the system for the transition to a new development trajectory at the optimal time with minimal losses. Thanks to chaos engineering, you can achieve a deeper vision of the effects of chaos in order to improve the stability of the system. This, ultimately, is the basis for creating more mature and reliable systems that can recover and reduce harm in the event of a serious security incident.

Thus, the purpose of the study is to construct an economic and mathematical model of chaos management of a microeconomic system that allows one to determine: crisis points of system operation, the impact on which can lead the system to chaos; controlling influence of chaos management, which are formed in accordance with the chosen attractor.

3. RESEARCH METHODOLOGY.

Linear and narrow-disciplinary approaches within the limits of modern classical economic theory are not able to explain and predict contemporary problem parts of socio-economic development caused by nonlinear laws of entropy economy and chaos. In this regard, it is relevant and promising to consider the regularities of the transformation of the functioning of economic systems on the basis of the synergetic paradigm.

INDEPENDENT JOURNAL OF MANAGEMENT & PRODUCTION (IJM&P)
http://www.ijmp.jor.br v. 10, n. 5, September-October 2019
ISSN: 2236-269X
DOI: 10.14807/ijmp.v10i5.900

The model of chaos management, like any other model, in a constructive way can be fully described using four system elements: function, input, output, processor. When constructing a model for managing the chaos of a particular microeconomic system, it is important to fix the zones of intersection of the interests of the existing actors of the economy – "power centers" (shareholders and managers of the company). At the same time, such an effect may be destabilizing, requiring fixation in the model of contradictions (crisis) points by type, group and level, and possible options for their solution.

Schematically, a model for controlling the chaos of a microeconomic system can be represented as follows (Figure 1).

The function performs a system-forming role and characterizes the purpose of the model. The function defines what should be achieved as a result of the operation of the chaos management model, but does not indicate how this should be done. The objective function of the model involves the formation of control effects aimed at the purposeful transformation of the status or complete change of the microeconomic system as the main object of influence of the model. The system components of the company are subject to influence, determining its role and place on the market, the ability to sustainable development: administrative bodies, socio-economic and financial potential, infrastructure, territory and labor resources. The task is to radically change the status of an enterprise, which is determined by its position in the global and regional system, its ability to influence demand and supply while maintaining the inherent subjectivity of its development, or to promote its antifragility, which implies the ability to protect and strengthen its interests, to provide economic security.

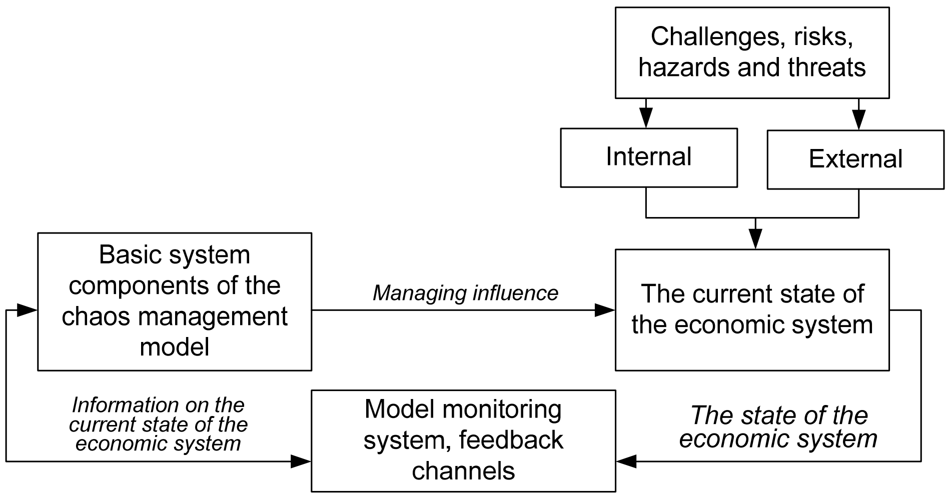

Figure 1: Chaos management model of the microeconomic system

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The model uses a set of tools to create the chaos of the microeconomic system, of which the most common are measures to support existing areas of enterprise development. Along with this, a deliberate introduction of the idea that advancement in this direction will inevitably lead to a decline in the competitiveness of the enterprise, technological lag and loss of positions in the market. The target function of the model reveals the designation of the model and involves the development of managerial actions aimed at increasing the level of conflict in the economic sphere, destabilization of production, distribution, exchange and consumption. The target function determines what should be achieved as a function of the system, but does not indicate how this should be done.

The managerial influences on the input of the chaos management model are formed in accordance with the chosen scenario of the development of the situation within the enterprise and in its environment, as well as situations that arise in the scenario. The input of the model is influenced by various factors – challenges, risks, dangers and threats that are generated in the scenario of controlled chaos and situations that arise when the model operates in accordance with this scenario.

At the exit between the different levels of management of the model implemented tasks of information exchange, control, management and feedback. At the output of the model, solutions are generated that are transmitted to different performance levels acting in the interests of the model within the microeconomic system and beyond.

The processor as an important system characteristic of the model provides a comparison of the current state of economic spheres with a given level. The monitoring system creates a feedback channel that ensures the stability of the model to chaos engineering and allows for continuous operational control and assessment of the impact of the decisions made on the situation within the microeconomic system.

A description of the model of chaos management can be presented as a matrix of system components that can be described by characteristics within the four main dimensions of the model: static, control, dynamic and predictive.

Among the main system components of the model of management of chaos include:

ISSN: 2236-269X
DOI: 10.14807/ijmp.v10i5.900

a) Functions and goals of the model. It should be noted that for the implementation of various purposes, transformation of the model may be required, up to the necessity of creating a new model.

b) The purpose of the model, which is based on the presentation of the interested party in the final results of the functioning of the model, and that the model can really provide for their achievement. The designation of the model is a leading criterion in determining its structure, overall potential and other characteristics, taking into account the expected contribution of the model to the achievement of the final result.

c) The area of responsibility of the model allows to determine the extent to which activities are carried out to form the totality of necessary transformations in order to create a situation of controlled chaos (global or local).

d) Processor model is the most important system characteristic. In general, the processor may include:

- an algorithm that defines the sequence of development and implementation of decisions that ensure the achievement of the goals and objectives of the model;
- basic resources of the model, including material, technical, financial, information, infrastructure for ensuring the activity of the model in its area of responsibility;
- a catalyst, which includes a set of internal factors that ensure the processes of transforming the actions of external factors into managerial influence (competencies of the model and their correspondence to the goals and objectives, the efficiency of the development and decision making procedures, the ability to design financial and industrial influence within the area of responsibility of the model);
- labor resources, which are involved in solving problems of the model at the stages of its implementation.

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e) Strategic stability of the model in different situations. Among the factors that provide strategic stability, one can attribute the presence of a clear strategy; the internal unity of the participants interested in achieving the ultimate goal of the model; the ability of the organizers to ensure the formal compliance of the measures taken with the recognized legal and regulatory framework.

f) Network of model links with other participants in the economic process, interested in transforming the microeconomic system. The network may include individual enterprises, their associations, external organizations, individual influential personalities.

g) Monitoring implies the presence in the model of the developed network of means of observing the situation, systematization and analysis of information and their operational transmission to decision-making centers. The presence of a monitoring system ensures the functioning of the feedback channel, which is a key condition for the stable operation of the model as a whole.

In the architecture of the chaos management model, an important place belongs to the processor, which has a number of significant differences, for example, from the processor model to ensure the economic safety of the system. If the processor of the security model can clearly define hierarchical levels of management: strategic, operational and tactical, then the chaos processor model will look different.

The system difference consists in combining the possibilities of hierarchical management structures in it and have already declared themselves phenomena of network structures capable of serving as a powerful tool that has a destabilizing effect on all areas of the microeconomic system. Within the framework of synergistic interaction, these system components complement each other's advantages and mutually compensate for the disadvantages, which ensures the flexibility of their application at various stages of the chaotic operation of the system.

Thus, traditionally rigid hierarchical control system has inherent subordination, stability, restoration, availability of channels of information transmission. However, the hierarchical structure often has a low degree of manageability and a systemic tendency to increase the number of hierarchical stages, lack of efficiency in the

http://www.ijmp.jor.br v. 10, n. 5, September-October 2019
ISSN: 2236-269X
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transmission of information, which leads to delays in decision making and action in real time. Hierarchical structures often die when the central link is destroyed. It is such a hierarchical structure in the form of organizational structure of the enterprise and opposes the model of management of chaos.

Taking into account the specifics of the processor of the model of chaos management, another important feature is the possibility of its timely functional rearrangement. This ensures the mobility and mobility of the use of basic resources, for example, their focus on a strategically important goal.

In general, the presence of high-speed connections and the potential of flexible adaptation facilitates better coordination with sharp and difficult predicted changes in the situation. Variability and manageability of the boundaries of the model allow modifying the composition of the network as a response to such changes. The use of network forms of organization and interaction allows for the survival and effectiveness of chaos management models.

The algorithm for implementing the chaos management model directly with the functions of management and development of solutions and provides the implementation of the scenario through the implementation of a clearly defined sequence of actions.

The task of managing chaos is to obtain the corresponding laws of governance. The laws must maintain the desired levels of stability and chaos, stable development and change of entropy should proceed according to equations that reflect the natural nature of the system's behavior.

If the result of the implementation of the model of chaos engineering should be the transition from one attractor to another with the preservation of the enterprise as an object of management, then the control parameters can only be used to change the current state and, at the final stage of control, connect to the entropy management. The growth of entropy should tend to some limited extent that the microeconomic system is able to control. Such chaos management can only be used in interphase transitions of the system's development. These transitions are very short-lived and sensitive to external influences. When using chaos-engineering in other periods, the system, after getting off the trajectory of development, returns to the old attractor again

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after a certain period of time, increasing its antifragility. In such periods, the transfer to a new attractor will require enormous costs of "managing" chaos resources.

4. RESULTS AND DISCUSSION

The above can make an important conclusion: when managing chaos based on the confrontation between entropy *s* and the current state *x*, it is expedient to select such optimal attractors $u = 0$, the motion of which approximation was determined by the equations describing the stabilization of processes on the asymptotic behavior. The choice of such a manifold $\psi(s, x)$ determines the natural nature of the interaction of entropy and the current state, and corresponds to a self-similar, self-consistent behavior of the processes of self-organization of the system.

A powerful instrument for controlling nonlinear objects, the application of which has been recently devoted to a significant number of publications, is the method of analytical design of aggregate regulators (ADAR) (KOLESNIKOV, 2012).

Let the microeconomic system be described in the state space by a system of equations of the form:

$$\left.\begin{aligned} \frac{ds}{dt} &= f_1(s,x) + u \\ \frac{dx}{dt} &= f_2(s,x) \end{aligned}\right\} \qquad (1)$$

where $f_1(s, x)$ and $f_2(s, x)$ are some functions that depend on the level of chaos *s*, the current state x; *u* – a controlling influence that can be defined as

$$u = \psi(s, x) \qquad (2)$$

ADAR method is a solution of the system of functional equations of the form

$$\frac{d\psi}{dt} + T\psi = 0 \qquad (3)$$

allows to synthesize a state regulator that provides the system not only asymptotic stability but also the main direct indicators of the current state and entropy, as well as the static accuracy provided by the choice of the form and parameters of function (3), where ψ are some aggregated changes in the control influence u, which provide the transition of system (1) from a certain initial state (s_0, x_0) to a small neighborhood of the solutions of the equation $\psi(s, x) = 0$, the transition to the desired state of the

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system. The controlling influence (2) allows maintaining the trajectory of the system's development in the required neighborhood at its motion along the given curve $\psi(s, x) = 0$.

In terms of synergy, a variable is a generalized order parameter (the main variable when describing the operation of a system, for example, a function that establishes the connection between the growth of entropy and the current state), which reflects the properties of the system. The introduced parameter of order is a kind of "informer", which acts as the transmitter of information about the processes occurring in the economic system. The parameter of order indicates the state of flow of purposeful processes of self-organization in the system. Consideration of the variable as a generalized order parameter, makes it possible to make such an interpretation, optimizes the functional.

According to G. Hacken (1985), the microscopic measure of action for any self-organizing system is the square of the order parameter. The measure of microscopic action can be conventionally called the work performed by the system for the creation of entropy. For these reasons, it is expedient to introduce into the accompanying functional *J* the quadratic components ψ^2, which reflect the degree of microscopic action of the systems obtained. The efficiency of the system in synergetics is the rate of change from the performed measures, which means the introduction of the derivative $\frac{d\psi}{dt}$ in the accompanying functional *J*. The weight coefficient *T* specifies the time of development of the economic system from the moment of the start of management to the entrance to the attractor zone.

Assume that the management of enterprise chaos changes the type of equilibrium functions that can occur when changing the values of system parameters. Parametric method of management correspond to methods of creating chaos and the destruction of the current state of the enterprise. In the initial formulation, the task of managing an enterprise is determined by differential equations, to which are added external forces that consist of the corresponding management influences *u(t)*. For the emergence of the phenomenon of self-organization, it is necessary that the external forces included in the model prove to be internal. To do this, you need to move from the original to the expanded task, taking into account that external forces have become internal interactions of the general system.

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Let *k(s, x)* – the coefficient of stability of the enterprise development, depending on the purpose of development and on the level of available potential, *L(x)* – capacity depreciation coefficient, $f_1(s,x)$ – function describes the behavior of chaos.

Consider the following model:

$$\left.\begin{aligned}\frac{ds}{dt} &= f_1(s,x) + u\\ \frac{dx}{dt} &= k(s,x)x - L(x)x\end{aligned}\right\} \quad (4)$$

Introduce the function that describes the possible variety:

$$\psi(s,x) = \beta x - k(s,x) \quad (5)$$

It is necessary that the function ψ satisfy the characteristic differential equation $T\frac{d\psi}{dt} + \psi = 0$. From equation (5) we find $\frac{d\psi}{dt}$ and obtain the equation

$$u = \frac{k'_x(s,x)+\beta}{k'_s(s,x)}(k(s,x)x - L(x)x) - f_1(s,x) + \frac{\beta x - k(s,x)}{cT} \quad (6)$$

which puts the system $\psi(s,x) = \beta x - k(s,x) = 0$,, where the coefficients $k'_x(s,x)$ and $k'_x(s,x)$ are partial derivatives of the corresponding coefficient.

The system of differential equations (4) is transformed into a system under the influence of the received control influence

$$\left.\begin{aligned}\frac{ds}{dt} &= \frac{k'_x(s,x)+\beta}{k'_s(s,x)}(k(s,x)x - L(x)x) + \frac{\beta x - k(s,x)}{cT}\\ \frac{dx}{dt} &= k(s,x)x - L(x)x\end{aligned}\right\}, \quad (7)$$

which describes the development of the entropy and the gravitation of the current state of the enterprise to the attractor $\psi(s,x) = \beta x - k(s,x)$.

According to official statistics, more than a third of Ukrainian enterprises currently have signs of instability (Table 1). You can see a significant imbalance in the statistics.

Table 1: Financial results of Ukrainian enterprises

	Indexes	2012	2013	2014	2015	2016	2017
Industry	financial results, mln. UAH	21353,4	13698,3	-166414,0	-181360,9	-7569,6	85429,5
	margin,%	3,4	3,0	1,6	0,9	4,2	6,6
	% of companies that received damage	37,6	36,7	36,7	27,1	27,2	28,4

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Manufacturing	financial results, mln. UAH	-1842,4	5526,9	-135282,9	-121774,3	-25938,2	23592,3
	margin,%	1,8	2,1	-0,6	0,7	3,0	4,4
	% of companies that received damage	35,9	34,8	34,8	24,9	24,8	30,9
Engineering	financial results, mln. UAH	13322,8	5526,9	-20501,5	-12651,6	1696,2	9023,3
	margin,%	9,9	6,6	-2,4	3,4	8,0	9,3
	% of companies that received damage	33,0	34,8	35,3	25,9	22,8	22,6

Source: Financial results of large and medium-sized enterprises before taxation by types of economic activity

Thus, the number of unprofitable enterprises in industry is gradually decreasing, but losses from economic activity are increasing. This can be explained by the loss of economic stability by individual enterprises, especially large-scale businesses, whose loss-making has a significant impact on the industry as a whole.

The negative factor on the way of development of industrial enterprises of Ukraine is the outdated potential – production funds of III-IV technological processes, the maintenance of which is rather costly, and produced products – uncompetitive. However, the experience of the functioning of industrial enterprises, which occupy the leading position in the industry, shows that the imbalance of economic processes that exists both at the macro and micro levels, can entail not only threats, but also be a stimulus to start a new cycle system development.

The simplest program of elementary catastrophe forecasting, which is an indicator of the chaotic state of the economic system, can be built on the basis of data on the relationship of variables that characterize its behavior. If it is established that between the variables characterizing the behavior of the system, the relation is described by the polynomial of the third degree of the species

$$y = x^3 + a * x + b, \quad (8)$$

then it can be argued that the system may display instability. If the parameter *a* is positive, but there is a tendency for its reduction, then we can assume that the system is approaching the disaster. In both cases, it is necessary to continue studying the system and identify the conditions or possible timing of the disaster, assess its likely consequences. If by the level of determination, the level of significance of the

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regression equation of one of the disasters exceeds the regression equation of relations of a stable nature, then a catastrophe should be considered as possible.

Public Company "Motor Sich", which is engaged in development, production, repair and service of aviation gas turbine engines for airplanes and helicopters, was chosen as an object of analysis (KASIANOVA, KAVUN 2018). On the basis of the analysis of economic performance of the enterprise, its stability is assessed (Table 2). The given indicators allow to conclude, about positive tendencies of functioning of the enterprise. Statistical analysis has shown that the most significant factor in assessing the sustainability of an enterprise is the importance of the ratio of current liquidity.

Table 2: Dynamics of development of Public Company "Motor Sich" for 2006-2017.

	Cost of assets, UAH thou.	Sales revenue, UAH thou.	Net profit, UAH thou.	Cost of sales, UAH thou.	EBITDA margin,%	Current liquidity
2006	2267439	1278964	37627	762639	15,70	1,500
2007	2924979	1800852	216263	984263	22,17	1,725
2008	3537314	2131572	3843	1326556	17,14	1,432
2009	4210663	3837706	754646	2137504	31,88	1,977
2010	6141903	5106758	1248028	2666560	34,17	2,043
2011	8182339	5891225	1344161	2927924	38,77	2,294
2012	11712209	7845558	1822865	4628489	42,17	2,805
2013	13196110	8583924	1319191	4974227	36,46	3,262
2014	16584942	10730122	1560367	5514991	53,81	2,784
2015	20756541	13830655	3399842	4907340	69,60	2,786
2016	25251032	10546323	2044097	4137864	41,73	3,197
2017	29243457	15150429	3104174	6687998	42,18	3,531

Source: authors' calculations

According to the initial data of economic indicators for 12 years, the most deterministic model of enterprise development has been obtained, which has the form:

$$y = x^3 - 1{,}612 * x + 14{,}536 \quad (9)$$

For a negative value of the parameter *a*, the function described by the equation is a nonmonotone function. The function of enterprise development will reach the point of extremum (points of unstable equilibrium) at *x=2,201*.

Since the model disaster Public Company "Motor Sich" is determined in relation to the model of the enterprise, it can be concluded on sustainable development for the period 2006-2017 years. That is the economic condition of Public Company "Motor Sich" can be described as stable. By calculating the corresponding regression equations for other parameters, it is possible to determine the possible changes of the resulting indicator when individual factors change in the direction of increase or decrease. At the same time, it is impossible to assess the changes in the development

http://www.ijmp.jor.br v. 10, n. 5, September-October 2019
ISSN: 2236-269X
DOI: 10.14807/ijmp.v10i5.900

of the enterprise, since the scale of the indicator of development, which is analyzed, varies from catastrophic to excellent within the "one step" (with a change in the ratio of current liquidity by 50% in one direction or the other).

Using the Maple 18 program, two types of model calculations were carried out for Public Company "Motor Sich" without external interference and using chaos management in a particular case presented by the model (7). For each calculation were taken four different initial state of the system. For the first model (Figure 2), the development of an enterprise leads to a stable attractor with coordinates (*x = 1,12; s = 0,73*). Managed chaos shifts the trajectory of enterprise development into another stable attractor (Figure 3) with a lower level of development and approximately the same level of chaos (*x = 0,83; s = 0,42*). In cases of chaos management, approaching a new attractor is faster than with the natural development of the economic system.

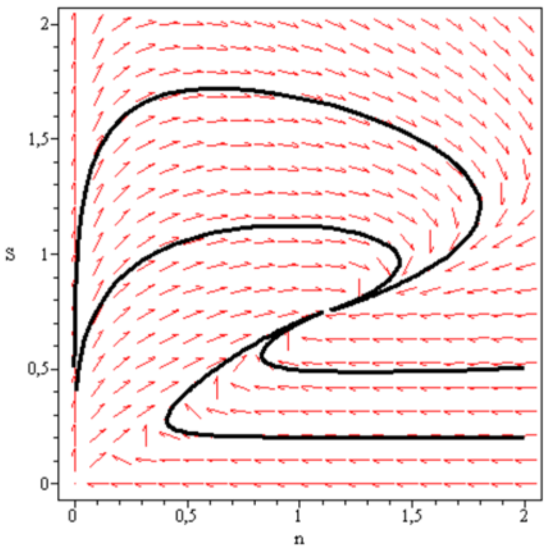

Figure 2. The behavior of the system in natural conditions

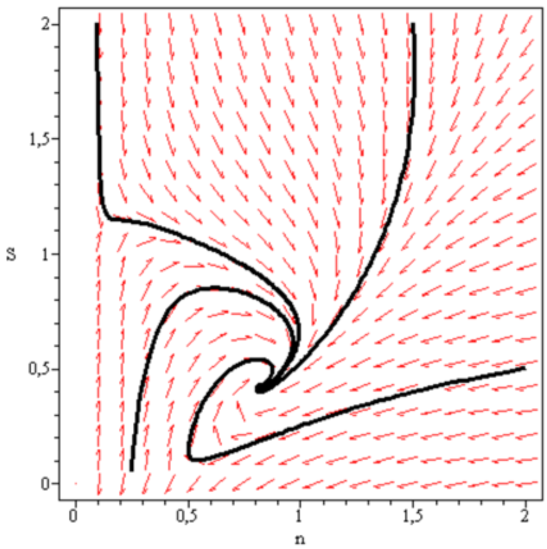

Figure 3. The behavior of the system in a controlled chaos

Thus, in economic systems, including microeconomic ones, which are complex by their nature, chaos management remains a global problem. the problem of forming a complex of management measures requires further research.

5. CONCLUSIONS.

The practical application of the elements of the chaos theory allows us to assess the possible changes in the sustainability of enterprise development by increasing entropy, as well as to identify the main positive trends in the change of indicators to improve the stability of the enterprise in terms of uncertainty. But the

http://www.ijmp.jor.br v. 10, n. 5, September-October 2019
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steady development of the company today can not guarantee the absence of disasters tomorrow. Any insignificant controlling influence can lead to the loss of an enterprise balance.

In turn, the implementation of chaos-based controlled chaos strategy implies a certain "chaosification" of the system in a controlled manner, which will allow for prediction of possible disturbances and prepare the system for the transition to a new development trajectory at the optimal time with minimal losses. Thanks to chaos engineering, you can achieve a deeper vision of the effects of chaos in order to improve the stability of the system. This, ultimately, is the basis for creating more mature and reliable systems that can recover and reduce harm in the event of a serious security incident.

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