European Research Studies Journal
Volume XX, Issue 3B, 2017

pp. 260– 268

Methodology of Structural Stability Management for Industrial Enterprises

A.N. Kuz'minov[1], V.M.Dzhukha[2], O.A. Ternovsky[3]

Abstract:

The article looks into the formation of a new methodology to provide company stability under growing influence of the external factors which raise the level of management uncertainty. Modern approach to management based on intellectualization which increases requirements to tools for assessment and forecasting all systems of the industrial enterprise, containing the methodological drawbacks statistic and mathematical nature which cause the information loss. Equilibrium state of the enterprise as a system is proposed to be used as a target objective and it means application of cenology theory tools

Cenological approach to assessment and to management of equilibrium of systems of an industrial enterprise which allows solving problems of complexity and stochasticity of systems using relevant mathematical research apparatus and system of constraints is grounded in the article. The significant part of the enterprise systems belongs to cenotic type because they are a complex structure of its elements where classical statistic assessment to describe the system "as a whole" is not applicable.

The results of economic and technical structures of a number of industrial enterprises which demonstrate the high results of coenoses theory application in company stability management are given in the conclusion.

Keywords *Stability of industrial enterprises, self-organization of systems, coenoses, financial resources, general equilibrium dynamics, equilibrium of systems.*

JEL Classification codes: *O10, M21*

[1] *Kuz'minov A.N., Professor, Faculty of Management and Entrepreneurship, Rostov State University of Economics, Rostov-on-Don, Russian Federation, corresponding author, mr.azs@mail.ru*
[2] *Dzhuha V.M., Professor, Faculty of Management and Entrepreneurship, Rostov State University of Economics, Rostov-on-Don, Russian Federation.*
[3] *Ternovsky O.A., assistant Professor, Department of Economics, Platov South-Russian State Polytechnic University (NPI), Rostov-on-Don, Russian Federation.*

1. Introduction

The disproportion in the development of enterprise structural elements due to different velocity of their growth and significant complexity of management objects because of their increasing diversity is nowadays one of the important problems of competition growth and industrial enterprises growth. The stated problem does not only decrease the company manageability as a system but increases costs connected with servicing and repair of technical objects as well. There are known researches in this field: BSC - Balanced Score Card, «3S» - Smart-Safe-Sustainable systems (Trentesaux, 2009) and others to intellectualize of management process, to take into account all possible management system components which is provided by modern advances in the computer technology. Management intellectualization is performed on production and infrastructure levels, among which the exogenous subsystems are the most complex: assortment, production program, costs, labor rationing, innovative dynamics, ecological requirements and globalization of national economies indirectly decreasing enterprise stability have a special impact on the process of efficiency and stability support of the industrial enterprise in the period of continuous changes of the environment. Under such conditions it is important to consider the question of enterprise loss of some stability, which in terms of self-organized and interdisciplinary models reflects necessary economic, financial and technical stability, in the logic assessment system.

Enumerated management models do not solve the tasks at full extend, as because they have limitations of cybernetic nature (a big number of changing objects), of statistic nature (it is not always possible to use average values for assessments) and of information nature (asymmetric information).

Thus, the goal of the research is to justify of the possibility of using alternative tools to analyze the enterprise systems that remove the mentioned above limitations and allow assessing its structures in a whole on the basis of the criteria of local stability.

2. Theoretical and empirical research methods

Our research is based on the ideas of self-organization, which attach great importance to structural formation of subsystems and elements of an industrial enterprise resulted from the competition between them for a resource. In terms of entropy approach and information theory there is nonlinear (exponential) dependence of an industrial enterprise on quality use of the limited resource which is difficult to watch due to the conditions of the industrial process and the development of a new methodological apparatus is required (Borangiu, 2012), and as we suppose it is to be performed in the frame of three spaces.

In terms of technical systems we rely on concept of space «Safe», meaning, for example, reliability, accessibility, safety, testability and maintainability of products, processes and industrial systems being assessed in terms of safety (Benard *et al.*, 2008; Salimova and Makolov, 2016; Kormishkin *et al.,* 2016). This aspect is to provide the necessary level of functionality and constant safety of all three types of state of any life cycle of systems. Reliability and stability are also interconnected with the notions of reaction and adaptation to perturbations in the process of their use, no matter of local or global nature (Bergstrom and other, 2015). This concept is not revolutionary as it is originally was used as a tool to analyze and design complex systems, when designers strived to develop efficient systems in terms of functionality including Integrated Logistic Support (ILS) and Providing functional support for production (PFSP) (Kriaa *et al.,* 2015). It seems to be expedient to consider the question of safety providing in general by means of cybernetic model «Up-Down» (Sanislav *et al.,* 2016).

Space «Smart» is an intellectual measurement of product, processes and production systems and refers to the system which comprises computers, service-oriented solutions and means. Production and economic subsystems interact regularly at all stages of industrial enterprise cycles constantly crossing with external factors and personnel which makes the mentioned processes difficult and requires the use of new management tools based on physical and mathematical models.

There are a number of researches in this field such as models: distributed management (Trentesaux, 2009), Holonic manufacturing systems (Giret *et al.,* 2009), multi agent systems (Leitao *et al.,* 2012), service orientations (Borangiu *et al.,* 2012), virtualization and virtual commissioning (Berger *et al.,* 2015), Cloud Production (Xu, 2012), Cyber-physical systems (Lee *et al.,* 2015), intellectual products (McFarlane *et al.,* 2013) and the Internet of things (Atzori *et al.,* 2010), which will promote the development of innovative SMART solutions in industrial theories.

In such context compatibility of the existing information and scientific model systems, for example, presented in Manufacturing Execution Systems (MES) (Kuz'minov, 2016) enterprise resources planning (ERP) are crucial to provide vitality of intellectual solutions, described by the ideas.

However the question of development of different intellectual solutions for industrial enterprises, their integration in the system of models and tools remains unsolved mainly due to stochastic character of typical economic situations.

«Sustainable» means measurement of output, processes and industrial systems, which support balance among economic, financial, social and ecological requirements and restrictions.

The most known and the most often cited definition of "Sustainable Development" from the Brundtland report (UN, 1987): "Sustainable Development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs (United Nations, 1987). In 1993 Graedel and

Allenby proposed Industrial Ecology concept (Graedel and Allenby, 2010; 2002). In 2004 Ehrenfeld presented Sustainable Production concept (Ehrenfeld, 2004), and very recently in 2012 Garetti, and Taisch defined it as an ability to use the raw material effectively, by creating new product through current technology, regulatory measures and coherent social behavior, able to meet economic, ecological and social objectives and thus, preserve environment and continue to perfect human life quality (Garetti and Taisch, 2012; Mihola *et al.*, 2016; Robertie, 2016).

In this formulation of the question, in our view, energy (limited resource) as an ontological phenomenon of all the elements of sustainability is the most prospective direction of research and must include electrical, financial, intellectual, etc. energy (Prabhu *et al.*, 2015).

This dimension for research and optimization of the triad "products-processes-industrial systems" will provide the best balance between the economic, environmental and social fundamentals of sustainable enterprise development.

Besides it should be mentioned that for many years the researchers of sustainable production systems have considered it in terms of paradigms of "limited reliability" of all elements of the enterprise system (Zhu, 2012), without taking into consideration such a generally recognized phenomenon today as the self-organization of systems. Problems of planning and forecasting of sustainability, which being unsolved, possess the largest potential for new decisions forming, are of specific interest. We think, resource (energy) component of the given process will allow to combine SMART solutions and potential of effective resources use to reach economic, and, consequently, general sustainability of industrial enterprises.

Signal theory is an important trend in analyzing of problems of asymmetric information in the research. Nelson's research became the first works to form researching traditions in this field (Nelson, 1974) the research was later expanded and amended by Kihlstrom and Riordan (Kihlstrom and Riordan, 1984), who used dynamic assessment of a set of indirect indicators while assessing the risk of the forthcoming instability.

We proceed from the proposition that company stability is a complex cybernetic characteristic of an economy subject within a certain period of time, which reflects the ability to support the key financial, marketing, production and personnel indicators at the level described by cenological balance under the influence of external and internal disturbances (Kuz'minov, 2009).

It is expedient to assess an enterprise economic stability in terms of quantity, because it will allow controlling its level, where his local optimum of modeling is the calculated boundaries of the so-called cenological restrictions mathematically developing the ideas of Pareto and Zipf.

The considered concept relies on the statement that stability is a certain natural state of systems, which is achieved by virtue of the inherent self-organization of elements in the physical sense of the stability of mechanical systems - L. Euler and cybernetic - A.M. Lyapunov, J. Lagrange, A. Puankare and others.

The statement that the stability can be described by a certain number of possible values that allow a dynamic deviation from equilibrium is quite important for further reasoning. Going beyond these frames can result in destructive consequences or the transformation that is striving to equilibrium, but in the new coordinate system (Kuz'minov, 2007; 2009).

The most important hypothesis of a well-known contingency theory is reduced to the simple statement that the requirement to cope with the high complexity generates higher levels of informality and decentralization of entrepreneurship. "Combating complexity and rapid often stochastic changes, requires focusing on a goal that provides responsibility and circumspection throughout the organization while it is required to understand other communities and their influence, and coping with the dynamics" (Adler and Docherty, 1998).

Lawrence (1981) proposed the main synthesis of an environmentally oriented theory of organization while overcoming this one-sided emphasis on complexity. He argued that all economic businesses have two types of drawbacks which produce rather contradictory adaptation strategies: 1) Lack of information; 2) Deficiency of resources.

Mathematically, the redistribution of any resources can be represented in the form of regularities:

- vector $L \equiv (L^1, L^2, K, L^m)$ the resources available to the system (financial, personnel, raw materials, etc.);

- vector $q_i \equiv \left(q_i^1, q_i^2, \ldots, q_i^m\right)$ Needs of objects of class i in resources L.

For modeling purposes, the task is represented in the formalization of the number of classes n_i, I = $\overline{1, w}$.

The technology of variation modeling involves the identification of the most significant factor constraints:

- determining the resources that limit the functioning of the system, i.e. finding a subset $J \subset \{\overline{1,m}\}$ resources such that resources $L^k(k \in J)$ Consumed by the system completely, and adding them to the system leads to an increase in the numbers n_i;
- determination of the possible and necessary size L_i^k,

the limiting resources of each class i of the system $\left(\sum_{i=1}^{w} L_i^k = L^k\right)$;
- calculation of real consumption $\tilde{L}^k$ и $\tilde{L}_i^k$, $k \notin J$, $i = \overline{1,w}$ (by whole system and each of its classes) recourses which are not limiting (these resources are consumed completely from the environment)
- Optimization of class numbers n_i, i.e. calculation of a combination of task parameters $G_i\left(L^J, q_i^J\right)$, in which the number n_i maximum or minimum.

Cenological approach is the most effective theoretical and methodological construct to solve the problems of this simulation, meeting the requirements of searching for the indicated ecological regularities. This approach allows describing the structure of a number of dissimilar elements (enterprises, subunits, etc.), in a form of a kind of a community – a component family, which is observable and assessable (units, pieces, rubles, etc.) (Kudrin B., 2006). Identifying each object of the observed population by a pair of numbers: $i = \overline{1,U}$ - number of the component in some order, where U - total number of elements (production, costs, technical object, etc.); $j = \overline{1,S}$ - The number of the community, which includes the specific element, where S - The total number of community groups (clusters). The variety of types of elements and the range of variation of the observed parameters (volume of production, size of capital, etc.) is so big that it is impossible to apply habitual classical mathematical statistic to analyze the given ecological totality in a whole.

The required local ordering and structural stability of the observed set of elements can be described by statistical states of the species distribution, that is, the dependence of the number of species on the number of components in it; species and rank distribution received as a result of ranking of kinds on number of elements; distribution of rank by parameter. To model the nonincreasing function of all three distributions, a hyperbola of the form is applied:

$$N(r)=A/r^G, \tag{1}$$

where, in particular, for the rank distribution of species N(r) - Number of individuals in a kind with a rank r, pieces; A, G - Constant distributions. The theory of cenoses explains the mechanism of the formation of hyperbolic species, species and rank, and rank-by-rank distributions by what in biology is called the struggle of species for existence (natural selection of species) (Kudrin, 2006). This selection takes place through the nature of access and use of a limited resource (energy) and is inherent in systems of any nature, preserving their fundamental principles and provisions.

3. Results

Empirical analysis of the results of this cenological methodology use is based on data of a number of industrial enterprises, where the cenotic type systems: assortment structure, of power energy equipment structures; financial costs structure observed in the management accounting system.

Thus, there is a significant discrepancy in the statistical evaluation of the distributions of the elements for all observations, which indicates a significant difference between the empirical and calculated values and the impossibility of applying estimates of the normal distribution.

The selective Kendall rank correlation coefficient, determined for a pair of distribution ranks, showed the high degree of their interconnection, the absolute value of this indicator does not exceed one.

The selective rank correlation coefficients are significant; consequently, rank parametric distributions are interconnected and it is possible to use for cenological processing.

Rank Characteristic Index G (β) is in the cenologic range, and in general reflects the state of relative stability. However, structural disproportions are found in all distributions, for example: disproportional structure of the produced assortment causing surplus in warehouse; the excess of unique power plants in production, which makes them difficult to repair and maintain; in the costs structure, there was an excess in operating expenses.

All obtained regularities in the result of analysis confirm the possibility of cenology theory application, and revealed disproportions influence enterprise stability, but have not been observed while using other assessment tools and it proves practical significance of the proposed approach.

4. Conclusions and Suggestions

We have drawn to a conclusion that each component of stability is an independent object of modeling and planning, have a different impact on the result depending on peculiarities of enterprise internal and external environment. Subsystems of the enterprise, which are found in the 3S space, are the key element that provides the enterprise stability in a whole. The sustainability management process includes the implementation of measures for forecasting, planning, operational management and of cenotic type structures monitoring, where statistical limitations are the criteria. Proposed tools to research and manage complex economic systems will allow and will make it necessary the application of program complexes, comprising enterprise subsystems and intellectual management systems.

References

Adler, N. and Docherty, P. 1998. Bringing Business into sociotechnical theory and practice. Human Relations, 51(3), p. 319

Alsafi, Y. and Vyatkin, V. 2010. Ontology-based reconfiguration agent for intelligent mechatronic systems in flexible manufacturing. Robotics and Computer-Integrated Manufacturing, 26, 381-391.

Atzori, L., lera A. and Morabito, G. 2010. The internet of things: A survey. Computer Networks, 54, 2787-2805.

Benard, V., Cauffriez, L. and Renaux, D. 2008. The Safe-SADT method for aiding designers to choose and improve dependable architectures for complex automated systems. Reliability Engineering & System Safety, 93, 179-196.

Berger, T., Deneux, D., Bonte, T., Cocquebert, E. and Trentesaux, D. 2015. Arezzo-flexible manufacturing system: A generic flexible manufacturing system shop floor emulator approach for high-level control virtual commissioning. Concurrent Engineering, 23, 333-342.

Bergstrom, J., van Winsen, R. and Henriqson, E. 2015. On the rationale of resilience in the domain of safety: A literature review. Reliability Engineering & System Safety, Special Issue on Resilience Engineering, 141, 131-141.

Borangiu, T., Thomas, A. and Trentesaux, D. (Eds.), 2012. Service Orientation in Holonic and Multi-Agent Manufacturing Control//Studies in Computational Intelligence. Springer, 284-296.

Ehrenfeld, J.R. 2004. Can Industrial Ecology be the «Science of Sustainability?» // Journal of Industrial Ecology 8, 1-3.

Garetti, M. and Taisch, M. 2012. Sustainable manufacturing: trends and research challenges. Production Planning & Control, 23, 83-104.

Giret, A. and Botti, V. 2009. Engineering Holonic Manufacturing Systems. Computers in Industry, 60, 428-440.

Graedel, T.E. and Allenby, B.R. 2010. Industrial ecology and sustainable engineering. Prentice Hall, Upper Saddle River, N.J., Graedel, T.E., Allenby, B.R., 2002. Industrial Ecology. Prentice Hall.

Kihlstrom R.E. and Riordan M.H. 1984. Advertising as a Signal //Journal of Political Economy., vol.92, pp. 427-450.

Kormishkin, D.E., Sausheva, S.O., Gorin, A.V and Zemskova, S.E. 2016. Innovation and Investment Safety as the Condition for Neo-Industrial Development. European Research Studies Journal, 19(3) Part A, 94-109.

Kriaa, S., Pietre-Cambacedes, L., Bouissou, M. and Halgand ,Y. 2015. A survey of approaches combining safety and security for industrial control systems. Reliability Engineering & System Safety, 139, 156-178.

Kudrin, B. 2006. Classics of technical coenoses. General and Applied Cenology, Issue 31, «Cenological research». Tomsk: TSU - Center for System Studies, 220.
Kuz'minov, A. 2007. Cenological features of modeling of the regional market as a mechanism of resource allocation // Terra Economicus, 5(4-2), 127-130.
Kuz'minov, A. 2009. A conceptual model of coenoses management in socio-economic systems // Terra Economicus, 7(2-2), 28-32.
Kuz'minov, A. 2009. Sustainability management of the region: a coenoses model // Economy of the region, 2, 142-152.
Kuz'minov, A. and Tyaglov, S. 2016. The self-organization management model of import substitution in the region. // Bulletin of the Russian Economic University. GV Plekhanov, 1(85), 122-129.
Lawrence, P.R. 1981. Organization and Environment Perspective. In: Van de Ven, A.H. & Joyce, W.F. Perspectives on Organizat Design and Behavior, John Wiley & Sons New York , 311-345.
Lee, J., Bagheri, B. and Kao, H.A. 2015. A Cyber-Physical Systems architecture for Industry 4.0-based manufacturing systems// Manufacturing Letters # 3, 18-23.
Leitao, P., Colombo, A.W. and Karnouskos, S. 2016. Industrial automation based on cyber-physical systems technologies: Prototype implementations and challenges. Computers in Industry.
McFarlane, D., Giannikas, V., Wong, A.C.Y. and Harrison, M., 2013. Product intelligence in industrial control: Theory and practice. Annual Reviews in Control #37, 69-88.
Mihola, J., Kotěšovcová, J., Wawrosz, P. 2016. Intensity and Extensity of Firm Development and Dynamic Dupont Analysis. European Research Studies Journal, 19(4), 53-63.
Nelson, P. 1974. Advertising and Information //Journal of Political Economy, 84, 427-450.
Prabhu, V.V., Trentesaux, D. and Taisch, M. 2015. Energy-aware manufacturing operations. //International Journal of Production Research, 53, 6994-7004.
Robertie, C. 2016. Top Managers Networking Influence on Competitive Intelligence Practices: The Case of Hi-Tech SMBs. European Research Studies Journal, 19(4), 158-169.
Salimova, A.T., Makolov, I.V. 2016. Unused Potential of Quality Management Systems of the Russian Companies: an Empirical Study. European Research Studies Journal, 19(3) Part A, 150-166.
Sanislav, T., Mois, G. and Miclea, L. 2016. An approach to model dependability of cyber-physical systems. Microprocessors and Microsystems, 41, 67-76.
Trentesaux, D. 2009. Distributed control of production systems.// Engineering Applications of Artificial Intelligence, 22.
Trentesaux, D. and Millot, P. 2016. A human-centered design to break the myth of the « Magic Human » in Intelligent Manufacturing Systems, in: Service Orientation in Holonic and Multi-Agent Manufacturing, Studies in Computational Intelligence. Springer, 103-114.
United Nations. 1987. Report of the World Commission on Environment and Development: Our Common Future.
Xu, X. 2012. From cloud computing to cloud manufacturing. //Robotics and Computer-Integrated Manufacturing, 28(1), 75–86.
Zhu, H. 2012. Reliability and availability analysis for large networking system. Presented at the Reliability and Maintainability Symposium (RAMS), Proceedings - IEEE, 1-6.