

Development of reflex-adaptive organizational structure of high robustness

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Abstract. One of the modern problems of business is the robustness of daily operations of company. Real productive industries permanently face the dramatic changes in the characteristics of the external environment which causes the explosive growth of risk situations that can lead to considerable damages and losses. That is why in modern management a significant place is occupied by methods called "risk management" designed to predict the emergence of negative situations and develop on this basis the protective measures.

The purpose of the article is to equip developers of organizational structures, managers and participants of the construction process with not a complex but with the effective methodology of developing of organizational structures with high resistance qualities to the impact of external and internal environment based on the analysis of the reflex-adaptive qualities of the organizational structure of the investment and construction project. Overall, such method allows to express quantitatively the characteristics of the project structure's elements for scoping the resistance qualities of the organizational structure of the investment and construction project.

This article offers another method for improving robustness of the operating of the business structures based on modern concepts of informatics and the management of information flows. In work, the factors of robustness, sustainability and persistence of organizational structures of the investment and construction project are revealed and systematized. The life cycle of the investment and construction project is considered as a sequence of changes in the organizational structure which consists of a set of functional production-oriented units linked by technological, logistical and other processes synchronized in time. The article also offers the use of a mathematical model of the sustainability of the organizational structure under single impact of an external disturbance which allows us to determine the most loaded element of the system.

The article provides a clear concept of the resistance qualities: robustness, sustainability and persistence of organizational structures based on the specific features of interaction of external and internal factors of the organizational structure as a system with elements of the organizational structure. Thus, for providing the maximum robustness of the structure is necessary to ensure the permanence of the internal environment of the system, that is, in any change in pragmatic information about the state of the internal environment an appropriate action is taken to counter negative impacts. For providing the robustness of the organizational structure, the reaction time of the system should not be less than the time of the disturbing effect change. Persistence is determined by the numerical value of factors affecting on the elements of the system.

Overall, this article could be interesting to a wide range of specialists engaged in system design and allows us to consider solutions of system resistance from the modern positions of informatics.



1. Introduction

The urgent tasks of developing and implementing highly effective organizational production structures are determined by ever increasing demands for obtaining additional competitive advantages in the commodity and production markets of various economic systems. The solution of this problem accompanies the progress of industrial production at all stages of the productive forces. Along with the improvement of technology, the introduction of modern production machines and the enhancement of personnel internal relations which are determined by the organizational structure of company are developing.

The need to provide the designed organizational structures with resisting properties to the negative impacts of the external environment is caused by increasing risks and dramatic changes in the conditions in which the productive activities of enterprises and companies are realized. The intention to protect your business under the economic and social turbulence forces the production managers to solve this problem by thoroughly studying the properties of modern organizational structures in order to reveal the patterns of interaction of the organizational structure with the environment that determine the guaranteed operation of organizational structures throughout the range of changes in the properties of the external environment.

In works [1,5-7,9-12,15] the one of the possible highly effective organizational structures of the investment and construction project possessing high qualities of robustness, sustainability and persistence is shown. This article continues to consider the ways of studying the properties of the reflex-adaptive structure with the purpose of improving the robustness of its operability, sustainability and persistence under the influence of negative environmental factors [3,4,14,16]. Despite some kind of similarity in terms of robustness, sustainability and persistence it is in the interest of analytical work to determine precisely what exactly is meant by these terms. First, by them we will not designate any abstract concepts, but specific properties of the system characterized not only by qualitative but also by numerical values. So under the robustness we will understand the probability of the system to ensure its functioning with a given quality in a static field of influence when the characteristics of the internal environment are changing. This definition (probability of failure-free operation) is written as follows in technology

$$P(t) = \int_t^{\infty} f(t)dt \quad (1)$$

Where: $f(x)$ – MTBF function;

t – operation time of the product.

As indicated the determination of the robustness of a technical product is not very difficult: it is necessary to determine the value of $f(x)$, which is achieved by calculation or empirically. Such approach to determining the robustness of the socio-economic system, which is an industrial organization, is absolutely unacceptable.

As shown in works [3,13,18] the stability of the internal environment of the system is the determining factor of its reliable functioning under the condition of a stationary external environment that does not exceed the calculated values of its parameters.

The condition for reliable operation of the system is the ratio:

$$\frac{dI}{dt} = \frac{dR}{dt} \quad (2)$$

Where: I – pragmatic information about the state of the internal environment of the system. R - resource designed to reflect the changes in the internal environment.

Let's analyze this ratio in details. In this ratio “ I ” is the pragmatic information, the concept of which was introduced by the Russian scientist A. Kharkevich. The value of pragmatic information determines as the difference in the probability of achieving the goal by the system before receiving information and after receiving it:

$$I = \log_2 P_1 - \log_2 P_0 = \log_2 \frac{P_1}{P_0} \quad (3)$$

Where: P_1 - the probability of achieving the goal by the system after receiving information;

P_0 - the probability of achieving the goal by the system before receiving information.

The question may arise, what kind of resource “ R ” should be used to parry negative environmental impacts on the organizational system. Generally, organization’s management system recommends using that kind of resource which caused the negative impact. But the main universal resource is funds.

To fulfill this condition a mechanism for analyzing the current information should be created and on the basis of its conclusions appropriate solutions should be made. Organizational structure of the reflex-adaptive type easily copes with this task.

Sustainability will determine as the property of the system to maintain its efficiency in conditions of constancy of the internal environment under external influence the rate of change of which is commensurate with the speed of the system's response to this impact.

Persistence determines the probability of the system to ensure its operability in conditions of exceeding the calculated values of the environmental impact while the internal environment is constant.

Such a gradation of resistive properties of the organizational structure based on the assessment of the state of the properties of the external and internal environment of the system is most objective and universal and allows the detailed characterization of the structure properties.

In the system of interaction of objects "organizational structure of the project" and "external environment" the main features of interacting systems are highlighted. First, we consider the life cycle of an investment and construction project as a set of its functional, production-oriented blocks connected by technological, logistical and other processes synchronized in time. Using the adopted project life cycle into stages and guided by the order of the works caused by the project matrix we see that each stage of the project life cycle has its own organizational structure inherent only in this project for this stage. We draw attention to the fact that depending on the task of the study a greater detail of the functional blocks of the project is possible. Also, a more detailed decomposition of the organizational structure over time is possible which allow us to speak of scaling the organizational structure as a convenient method of research. Considering the life cycle of the investment and construction project as a sequence of changes in the organizational structure we come to the conclusion that this is the main feature of the reflex-adaptive organizational structure. This gives us an understanding that under the same external influences the reaction of the organizational structure of the project will be different and the degree of its efficiency will correlate with the current changes in the structure. Mathematical model of persistence of organizational structure [2] assumes exact knowledge and an estimation of robustness of elements of system at influence of external indignation. The definition of the digital expression of the robustness of the element of the system which is an integral part of the investment and construction project is a very difficult task: this element is not a machine, mechanism or a combination of them. Elements of the project are its participants: individuals, work communities of various complexity and composition, companies and organizations associated with the external and internal environment with incalculable connections. Nevertheless, it is highly desirable to express quantitatively the qualitative characteristics of the elements of the project structure for carrying out an analytical study of the persistence of the organizational structure as a whole.

Many researches are subordinated to this task today not only in the construction complex, but primarily in the financial and banking business - wherever a partner wants to assess the robustness of his partner [8,11,17,19,20]. Today there are various methods for assessing the financial, payment, organizational and technological robustness of companies which adequately reflect the real quality of the activities of companies. These methods are based on expert assessments of various aspects of a

company. A systematic approach to solve this problem involves identifying the factors that affect to these systems. The table below shows the main robustness factors.

Table 1. Systemic (internal) robustness factors of operating of the organizational structure of the investment and construction project

Systemic (internal) robustness factors of operating of the organizational structure of the investment and construction project			
Organizational factors	Technological factors	Financial and economic factors	Social factors
1. Competence of top management 2. Modern organizational structure of company 3. Flexibility of organizational structure of company 4. Existence of a standardized management and decision-making system 5. Existence of a system for monitoring the implementation 6. Flexibility of horizontal system-forming links of the organizational structure of company 7. Specialization of links of organizational structure elements	1. Technical resource of the main production equipment 2. Existence of a modern production technologies 3. Flexibility of the production process 4. Using of modern materials 5. Modern structure of energy sources 6. State of the production infrastructure 7. Using of R & D results, renovation of fixed assets 8. Existence of production laboratories and research units	1. Share of own funds in the total amount of company funds 2. Debt to equity ratio of the company 3. The ratio of the amount of fixed assets to the value of the company's property 4. The share of accounts payable to the total amount of liabilities of company 5. Share of own working capital to the total amount of all company funds 6. Existence of financial management system	1. System of material interest in the results of work for employees 2. Connection between remuneration with the quality of labor 3. Systematic training and skills development 4. Development of innovation and invention 5. Material and moral incentives promoters of production 6. Existence of creative competitions by profession

We will use this technology slightly modifying it in terms of accounting for the largest number of factors (Table 1.) affecting the robustness of company. Then the company robustness assessment will be:

$$N = \prod_{k=1}^n \Phi_k \quad (4)$$

$$\Phi_k = T_k * t_k$$

Where: N – company robustness in numerical expression;

ϕ_k – factor determines the robustness of k -element of operation of company;

T_k – weighting factor of importance of k -element is the function of operation of company;

t_k – expert coefficient of robustness of k -element of company.

Despite some subjectivity of the presented method of assessing the robustness of companies as an element of the organizational structure of the investment and construction project, its accuracy is

sufficient for carrying out analytical studies of the persistence of the reflex-adaptive organizational structure of the investment and construction project.

All variety of environmental factors can be classified on the basis of their inherent certain universal characteristics. Abstracting from the explicit and individual characteristics of the types of external influences on the organizational structure as a system it is possible to distinguish such generally valid properties of external influences as: force of influence, duration of impact, rate of impact change. The threat of external influences to the organizational structure and its elements and also effects these interactions will produce are determined and ranked digitally on the basis of expert assessments and statistical observations. This methodology and practice are well known and widely used by risk management specialists. However, in our case this method should be significantly supplemented. The peculiarities are that if risk management techniques consider the impact object as an isolated system then when considering the organizational structure of the investment and construction project, it is necessary to take into account the complex nature of the system consisting of the block elements, which are simultaneously affected by external disturbances (Table 2). These features complicate the process of investigating the organizational structure, but, at the same time, increase the accuracy of research and the behavior of the system under specific operating conditions.

Table 2. Factors and conditions of external environment

Factors and conditions of external environment				
Macroenvironment			Microenvironment	
Components of macroenvironment	Political	1. Political stability 2. Foreign and domestic policy 3. Investment climate 4. National business conditions	Components of microenvironment	1. Consumer preferences 2. The orientation of consumers on the goods 3. Expansion of consumption at the expense of potential consumers 4. Awareness of consumers 5. Consumer sensitivity to price
	Social	1. Society's attitude to social processes 2. Unemployment rate 3. Quality of life 4. Unification or disunity of the population 5. Level of education, demography		1. The level of specialization 2. Cost of materials, components and services 3. Guarantee of delivery time and quality 4. Scope of supply 5. Existence of necessary and available resources

		Economical	1. Level of economic development 2. Inflation, taxes, exchange rates 3. Dynamics of prices for resources and services 4. Norms of the balance of payments and material savings
		Legal	1. Construction laws 2. Licensing 3. Expertise 4. Control
		Technological	1. Development of science and technology 2. Scientific and technological progress 3. Innovation practice 4. Modernization of production 5. Licenses, know-how

		Competitors	1. Competitive environment 2. Existing and potential producers of a similar product 3. Production of a substitute product 4. Analysis of market prospects
		Workforce	1. Existence of personnel for project implementation 2. Cost of labor 3. Professional training

To study the ability of an organizational structure to resist external influences, i.e. determine the persistence of the organizational structure we use the mathematical model [13,18] of the organizational structure of the investment and construction project, which is shown in the form of a digraph, where the vertices are the elements of the structure, and the vectors correspond to the internal connections of the organizational structure. They are characterized by the direction of the impact, the degree of impact and the degree of damping (or amplification) during the passage of the top of the digraph.

If, for example, the organizational structure of the investment and construction project consists of 6 functional blocks, and their activities are carried out in the zero phase of the life cycle (pre-project preparation), the digraph takes the form, where:

- O - the element of the system corresponding to the organizational block;
- F - the element of the system corresponding to the financial block;
- L - the element of the system corresponding to the logistics block;
- T - the element of the system corresponding to the technological block;
- I - the element of the system corresponding to the engineering block;
- P - the element of the system corresponding to the legal block.

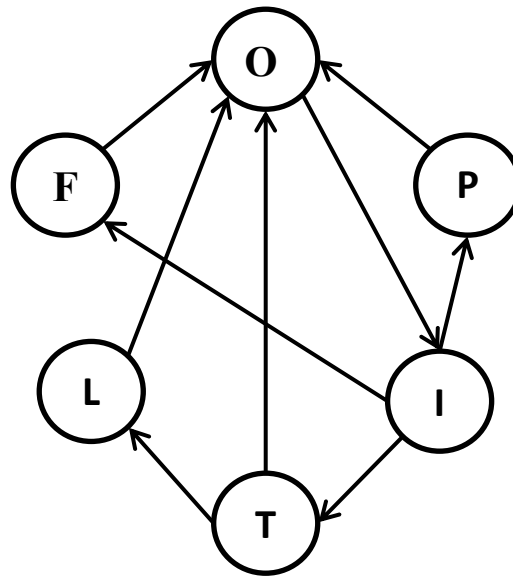


Figure 1. Preparatory phase.

This digraph illustrates the preparatory phase of the life cycle of investment and construction project which is in the fact that the "O" block having formed the concept of investment and construction project entrusts its detailed elaboration to the "I" block, which in turn sends its requirements to the respective blocks in order to develop the design specification.

$$\overline{OI}(\lambda_o\beta_o); \overline{IP}(\lambda_i\beta_i); \overline{PO}(\lambda_p\beta_p); \overline{IF}(\lambda_i\beta_i); \overline{FO}(\lambda_f\beta_f) \quad (5)$$

$$\overline{IT}(\lambda_i\beta_i); \overline{TL}(\lambda_t\beta_t); \overline{LO}(\lambda_l\beta_l) - \text{impact vector;}$$

λ – degree of impact of communication; β – coupling loss degree.

For comparison, we give the digraph in the phase of construction and installation works.

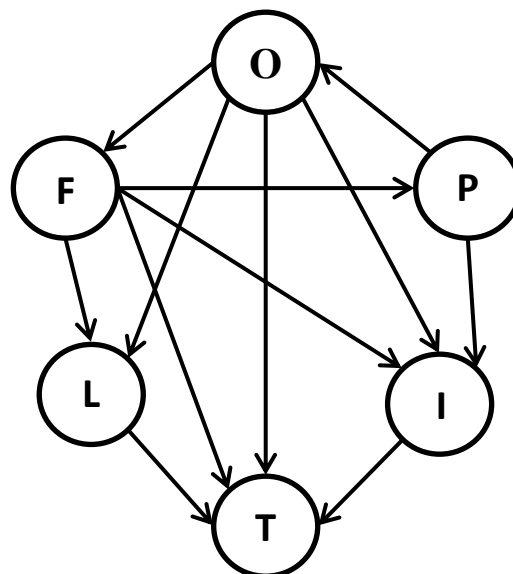


Figure 2. Phase of construction and installation works.

Investigation of the persistence of the organizational structure will be carried out by the method of simulation modeling, acting alternately on each element of the system, determining the propagation of the disturbance along the system and highlighting in each step of the impact a decrease in the robustness of each element.

The simulation modeling of the stability of the organizational structure of the digraph $G = (V, X)$, which describes the interrelation between the elements "O", "F", "L", "T", "I", "P", reduces to calculating the numerical values of the weights of the vertices of the graph $\omega = (\omega_i \omega_j) = \varepsilon_{ij}$, which characterize the robustness of the elements in [2,3], i.e.

$$\omega_i(t+1) = \omega_i(t) \prod_{k=1}^{dbgvi} \varepsilon_{ij} * imp_j(t) \quad (6)$$

When passing through the impulse action, which is given by the ratio:

$$imp(t) = \frac{\omega_j(t)}{\omega_j(t-1)} \text{ where } t \geq 1 \quad (7)$$

These formulas specify the changes in the weights of the vertices of the graph $G = (V, X)$, thereby determining the dynamics of the propagation of the external impact across the system.

Thus, the presented method of recording and forming the properties of the resistivity of the organizational structure to the negative influences of environmental factors makes it possible to predict the response of the system to perturbing environmental influences at the design stage of the reflex-adaptive organizational structure. This makes it possible to take preventive measures to increase the resilience of the organizational structure to external influences, as well as to calculate the necessary resource for parrying possible risk situations.

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