# Formation of the model of the open production-and-economic system at the construction enterprise

*Nelli* Volkova[1,*]

[1]Moscow State University of Civil Engineering, 26 Yaroslavskoye Shosse, 109377, Moscow, Russia

**Abstract.** The research is dedicated to the multi-structural model of the complex system at the construction enterprise as well as the model of structurally functional open production-and-economic system at the construction enterprise. The models are created for the acceptance of the justified managerial decisions and carrying out the applied research aimed at the efficiency of the construction enterprises functioning in the conditions of uncertainty, instability of the internal and external environment and heterogeneity of the indicators, which characterize the enterprise's activity. The offered models are developed on the basis of the probability theory and the information theory; they are based on the principles of self-organization, openness of the complex systems, synergy and information-and-statistical approach. The concept of the open productive-and-economic system at the construction enterprise is considered, the content of the functions of the complex system at the construction enterprise is described, their stochastic and quasi-determined communications in the uniform information-and-statistical field of functioning are presented. Bit measurement for the whole set of functions, allowing to receive an adequate assessment of the complex open system behavior, is offered for further scientific and applied research, including the development of more exact forecasts and improvement of statistical heterogeneity of indicators.

## 1 Introduction

Defining the purposes and problems of this research, the author analyzed that "system" is the term characterizing the perception of the research subject as a difficult thing, coordinating all the elements in complete representation by the means of graphic and/or mathematical modeling.

Complex systems can be found everywhere and studied almost in all the fields of science from physics (through chemistry and biology) to economics. It is impossible to give the theoretically properties of complex systems, knowing properties of their separate parts, because of the complexity of such systems. According to the traditional approach complex systems can be described as the systems consisting of great number of parts,

* Corresponding author : angela-1309.m@yandex.ru

elements, components which can be similar or different. Components or parts can be connected to each other in a more or less complex way [1].

Nowadays there are several dozens of definitions of this concept which changed during the development of the theory of systems both in form and in the contents. Systems can be: technical, physical, economic, social, biological and of other nature.

The author's approach, presented in the work [2] on forming of structure and the description of properties, on the determination of the essence of the production-and-economic systems is interesting. But at the same time, it is necessary to establish the fact that trying to learn and control the behavior of any system, we are forced to deal with empirical data, such as the numerous quantitative parameters estimating production business activities of the enterprises including investment-and-construction complex. In modern conditions that demands new innovation approaches, applying mathematical modeling.

There are some questions:

- how deeply is it possible to investigate the essence of the mechanism, managing the processes of interaction of all elements of the systems?
- how will the time and space domain affect the system behavior in the conditions of uncertainty and instability of the parameters, forming the system?
- is it possible to learn how to control the system behavior?
- is it possible in our case to create the new qualitative and/or quantitative parameters, estimating the efficiency of functioning of the productive-and-economic system of the construction enterprise and its self-development?

Such questions are appropriate in many areas of theoretical and applied knowledge, including the justification of effective managerial decisions in construction for which it is required to create a model of the open productive-and-economic system of the construction enterprise within the uniform information and static field.

The approach to the research of complex systems, consisting in the transition from studying of the condition of the system itself to studying of the processes happening in it, evolved in the modern science during the last decade, thanks to works by some authors [1, 3, 4, 5].

## 2 Materials and Methods

There are systems in various spheres of scientific and applied activity, which belong to the concept "complex systems". In practice some of them have simple contents and functioning, while others are to be considered as complex, for example, the systems in the construction industry.

A complex system is called self-organizing if it gets its space, temporary or functional structure without specific influence from the outside.

The specific influence is understood as such an influence which imposes structure and functioning to the system [1].

Self-organization is understood as the capability of active organizational system to reconsider or form its purposes and methods of their achievement independently due to radical reorganization of the internal structure of the system, aa well as to change the methods of interaction with the environment [6].

The aforesaid consideration also belongs the system of the construction enterprise. Self-organization characterizes the capability of open and complex economic systems to reach the new level of their development, to prove such properties as capability to resist to the entropy processes (resulting system in balance stagnation) and to develop anti-entropy (not-entropy) trends to a large extent; to adapt to the changing conditions, transforming its structure if necessary, keeping certain stability at the same time. It is necessary to consider

some regularities and features, based on dialectics laws [7] during economic-mathematical modeling of the complex developing systems: construction complex, the construction enterprises and their parameters (subsystems).

The systems of the construction enterprise are complex, not because their structure is formed of significant amount of elements; first of all it is necessary to speak about their complex behavior.

The investment-and-construction complex in general, regional construction complex in particular and separate construction enterprises are complex systems with their numerous participants of the construction process, cash flows (investments, credits, etc.), production of construction products, consumption of these products (demand), traffic flows, etc.

Let us consider the concept of system in relation to the construction enterprise activity. System (including economic systems of the construction enterprise, investment and construction complex) is the set of included elements, which interaction and/or interdependence has the nature of mutual assistance on obtaining the focused useful result, which is the main backbone factor, the volume of construction products, profit, innovation, financial and economic stability.

The author of the article is guided by the probabilistic logic of functioning of social-and-economic systems in the research works in the field of construction. That assumes the systems' way of evolutionary self-development and self-organization in the conditions of market economy. This way provides the movement and transformation of energy (material, financial, information) from the external environment; more exact calculation of probabilities and reduction of uncertainty at adoption of tactical and strategic decisions.

The main instrument of the scientific approach is the probability theory and the information theory, connected with the economic, theory as well as technical-and-economic and production modeling of complex open systems in the investment-and-construction complex. In particular, the principles of self-organization, the principles of openness of complex systems, synergetic and information-statistical approaches were used for this research.

It is supposed to recognize that the complex system of the construction enterprise is divided into two subsystems: financial and production-and-economic. Both of them are complex in turn. Each subsystem is provided by indicators and criteria for the evaluation of the construction enterprise activity [8, 9].

The research subject is the multi-structural model of the construction enterprise system, including production-and-economic and financial subsystems as well as the open production-and-economic system of the construction enterprise operating in cycles of dynamic unstable equilibrium and adapting in the sphere of the functioning.

The production-and-economic subsystem allocated from the system of the construction enterprise is in turn the open and complex system having the structure and performing certain functions.

It is offered to describe the functions of the production-and-economic system on the basis of the law of normal probability distribution for the further scientific and applied research aimed at the development of the forecast for planning of production business activities of the enterprise.

The description has the form of the following equation:

$$f(d_x, c_x, \sigma_x) \tag{1}$$

where

- x is a random variable value, in our case this is the value of any economic parameter of the function of production-and-economic system of the construction enterprise;
- σx is the mean square deviation of parameter x;
- cx is the quantity of σx values in case of normal distribution;

– dx is the integrated probability depending on quantity of cx.

It is important to note that both the system of the construction enterprise in general, and the open production-and-economic system function in "the uniform information-and-statistical field" which can be divided into internal and external environments conditionally. At the same time production-and-economic control is carried out in case of observance of cycles of dynamic unstable equilibrium of the open production-and-economic system functions.

## 3 Results

Proceeding from the statement that the construction enterprise is a complex system, the models developed by the author and provided in fig. 1, fig. 2 became the result of the conducted research

The research of complex systems of the joint venture and their subsystems is offered to be aimed at the following approaches:

1. Development of the formalized models of systems (subsystems) on the basis of self-organization.

2. The second approach is based on the principle of openness of complex systems.

3. The third approach applied to the complex systems is synergy.

4. The fourth approach is the information-and-statistical one (interrelation communication of entropy and information).

Thus, the provided model, which displays self-development of these systems and also allows to count the trajectory of nonlinear dynamics of the construction processes in them, was developed on the basis of the aforesaid approaches for the research of complex production-and-economic systems of the construction enterprises.

The structure of open production-and-economic system consists of nineteen subsystems, among them eleven subsystems (1-11) are internal subsystems, and eight subsystems (a, b, c … h) come from the environment.

The productive system in this system (construction production) is connected with the external factors through two previous subsystems. Stocks of construction materials, designs, and details are formed in the entrance subsystem, and it serves as the buffer, protecting from the external subsystem of supply influence. Dotted lines in the drawing define the communication of the production-and-economic system with the subsystems of the construction enterprise: supply subsystem → subsystem of output stocks → … → consumption subsystem (market). At the same timeб they also reflect the internal communication of the production-and-economic system with the financial system, i.e. they have dual character. Firm lines display the communications within the financial system and the communication with some elements of the production-and-economic subsystem and the subsystem of market consumption, and the duality is shown again. Such a provision reflects the fact that the financial-and-economic subsystem, which is characterized by immanent (internal) interaction, functions in the construction enterprise system.

The output subsystem contains finished construction goods and provides the external subsystem, e.i. the market of construction products.

The subsystem including the entering stocks of construction materials, designs, details is entered into the making subsystem to get the subsystem of the leaving stocks of finished construction goods.

Communications in the system of the construction enterprise are quasi-determined.
The quantity and quality of the used construction materials, designs and details depends on the made decisions, but they do not define what types of construction products they apply to.

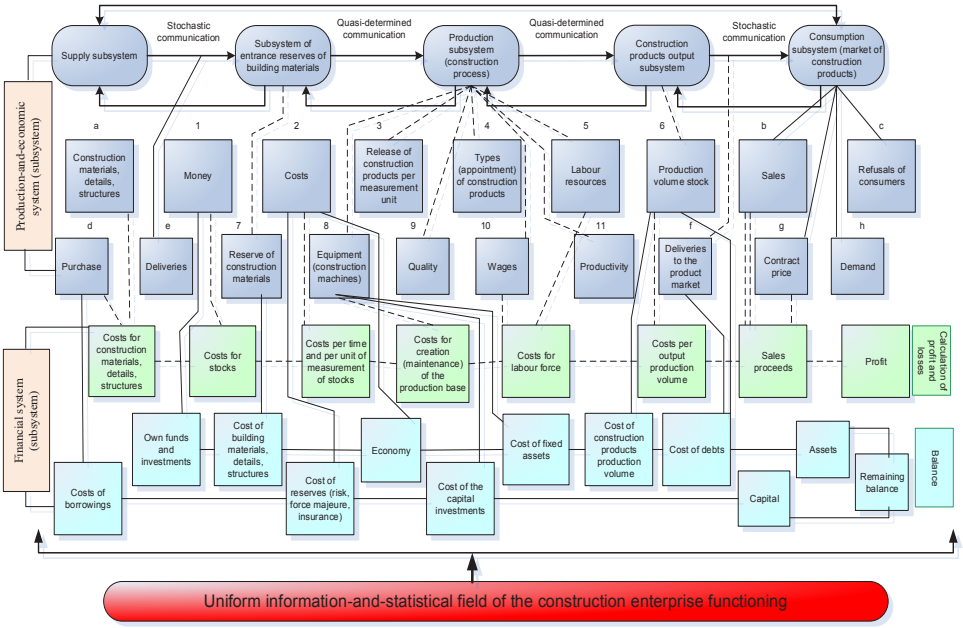


**Fig. 1.** Multi-structure model of the complex construction enterprise system.

Thus, that means, that two communications with the external environment are stochastic: there is no guarantee both concerning the offer from suppliers of building materials, and concerning demand for construction products. These communications are studied with the use of methods of operations research, econometrics and can be effectively described as stochastic processes.

Complex systems are intended for the accomplishment of certain functions, and as the careful analysis proves, these functions can be executed only by complex system consisting of many cooperative parts [1].

The author offers to use twelve functions for the research of open production-and-economic system. Six of these functions [f_1 (d, c, σ)-f_6 (d, c, σ)] are connected with the internal environment, and six other functions [f_7 (d, c, σ (d, c, σ)] are connected with external environment.

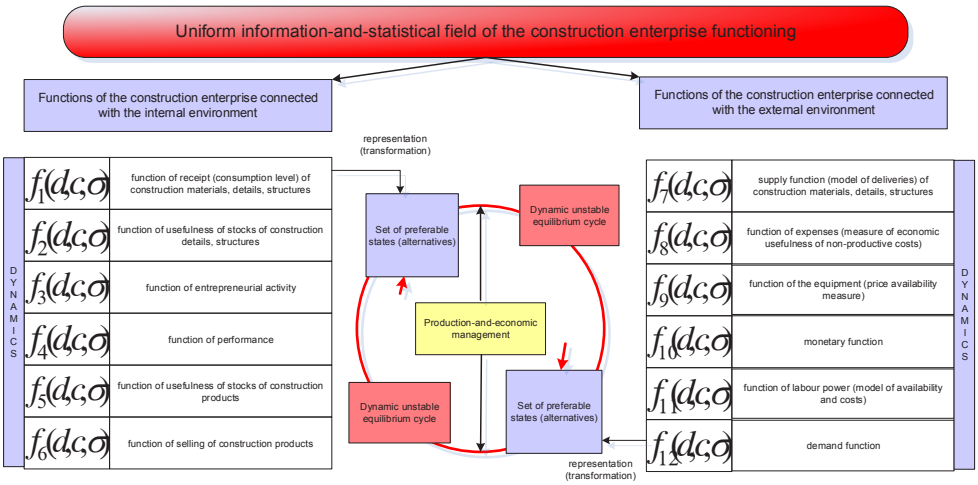


**Fig. 2.** Model of the structurally functional open production-and-economic system of the construction enterprise.

The author offered to consider each specified subsystem (its structure and functionality) not only in total, but also as a system, taken separately, depending on the objective when carrying out further research and the depths of studying of the open production-and-economic system of the construction enterprise.

Let us consider what information one can investigate within the analysis of the functions of the information-and-statistical field which are set quantitatively, by normal probability distribution with parameters d, c, σ to be exact. Six functions (among twelve functions [f (d_i)] performed by this system) are defined analytically according to the influence of internal factors, other six functions are set under the influence of external factors, taking into account positive (negative) feedback.

The functions of the construction enterprise connected with the internal environment are the following:

1. $f_1(d,c,\sigma)$ – the receipt function, optimum level of receipt is defined as the level of the valid consumption of building materials, designs on the basis of mathematical model subsequently, to measure the valid receipt efficiency on the basis of the procedure of the forecast..

2. $f_2(d,c,\sigma)$ - the function of usefulness of the stocks of construction materials, details and designs compares the current valid stocks time with the optimum quantity, calculated on the basis of the operational model, considering the differences between types of construction materials. The usefulness of stocks decreases in case of insufficient or excess providing the construction enterprise for possible interruptions. In each of these cases the function falls below the ideal value (equal to 1): *d=1*.

3) $f_3(d,c,\sigma)$ – the function of entrepreneurial activity is based on the difficult model of construction production and specifies the abstract dimensionless measure of efficiency, taking into consideration all the variable endogenous factors (human resources, investments, prices, etc.).

4) $f_4(d,c,\sigma)$ - the function of performance calculates the optimum level (mathematical expectation) of the construction products, made in each case, considering inevitable losses because of idle times of various character, climatic conditions, etc.; it also compares the level to the valid performance.

5) $f_5(d,c,\sigma)$ - the function of usefulness of the construction products stocks. The stocks of construction products arise because of several reasons: defects, revealed during

commissioning of the project (transfer to the consumer), cancellation of orders by the consumer, the optimum buffer order (products for the future), necessary for agreements performance. The complex stock component, arising because of the delay of the implementation of the programme for release of construction products to demand, can be calculated.

6) $f_6(d, c, \sigma)$ - function of selling of construction products which, in essence, measures the compliance between the entrepreneurial activity and realization. But this function contains the complemented relation between selling costs for order size, paid by the construction enterprise, and the internal profit. Therefore, it provides decisions from the point of view of the construction enterprise concerning he use of the existing market of construction products.

The functions connected with the external environment:

1) $f_7(d, c, \sigma)$ - the supply function (model of deliveries). The complex model of supply measures the supply efficiency from each supplier, considering both average reliability (reliability theory, refusals of deliveries), and fluctuations about average (c, σ), it includes the measure of quality of the delivered construction materials.

2) $f_8(d, c, \sigma)$ - the function of expenses is measured as the measure of economic usefulness of fixed expenses, e.i. non-productive costs.

3) $f_9(d, c, \sigma)$ - the function of the equipment in relation to the construction machines and mechanisms measures the changing availability (rent or payments under agreements of leasing, depreciation) and the new equipment price, construction machines and mechanisms. This function expresses the desirability of implementation of the capital investments connected with the external environment in the new equipment, so-called technical innovations, in any given timepoint.

4) $f_{10}(d, c, \sigma)$ - the function of money is based on the measurement of change of the availability and price of money itself (this time), it reflects the expedient level of the capital investments in construction production and includes the model of local, regional, national, international impacts of the bank interest change during investment, crediting.

5) $f_{11}(d, c, \sigma)$ - the function of labour power, this model is based on the availability and costs; at the same time truancies, idle times because of climatic or technology conditions as well as the level of unemployment are taken into account.

6) $f_{12}(d, c, \sigma)$ - the function of demand for construction products, is the most composite function from all; with its help the construction enterprise to seek to measure the market of construction products and possibility of profit earning on it, using all the entrance factors and parameters relating there. The quantity of preorders on construction products, profitability of each order size or per unit of measurement of construction products, approved with such factors as costs for realization, correction of defects and the optimum size of the formed order portfolio are included into the functional model.

All these functions depend on the relation of some qualitative parameters (criteria) and quantitative indices, that is characteristics of the expected behavior of the studied production-and-economic system of the construction enterprise.

This provision is very important as it enters the general method of "black box" for the identification of unknown values, which are resistant to accounting. As the behavior model can be inadequate to the original in the conditions of dynamically developing uncertainty in the sphere (field) of functioning of the production-and-economic system of the construction enterprise, the forecasts created and estimates based on it are valid only in the case the model is adequate. But no analytical model can be rather adequate in the exclusively complex and probabilistic system, including production-and-economic one.

The way of permission of this contradiction consists in imposing the continuous feedback, measuring efficiency of the model as an expected one on the rough forecasts of any analytical model.

It is also offered to enter the transformation with the purpose to improve statistical uniformity (bit measurement) for all the set of functions, and to receive large-scale transformations.

The values found for each function [f (d_i)] at a given time (on chronology), make up the assessment which can be considered as average value of distribution of probabilities or average value (population mean) of the studied or the formed indicator.

Despite changes in time of average values which can be optimized during functioning of the production-and-economic system [f (d_i)] where inequality of $d_i \leq \sum_{i=1}^{N} p_i \leq 1$ for the complete group of events in the indicator variation is the important component assessment.

Thus, the nature of the production-and-economic system behavior in time and in the information-and-statistical field is defined by two spaces, creating the configuration "productive and economic system – the information and statistical environment" (internal and external). At the same time every internal or external environment, represents the set of preferable states (alternatives) which represent the training transformation or representation during adaptation. The real mechanism of the production-and-economic system behavior assumes recurrence of dynamic unstable equilibrium which is regulated by information-and-economic management of parameters of the evaluation of the construction enterprise activity efficiency.

## 4 Conclusion

The models (including the multi-structural model of the complex system and the model of structurally functional open production-and-economic system of the modern construction enterprise) were developed taking into account the market relations which are characterized by uncertainty and instability of external and internal environment of the enterprise functioning.

The concept of the open production-and-economic system as the complex system performing certain functions, and consisting of many cooperative parts (according to the principle of interaction) in the uniform information-and-statistical field of functioning of the construction enterprise was considered.

Twelve functions of the open production-and-economic system were defined. Six functions are connected with the internal environment, six functions are connected with the external environment. All the functions interact with each other, performing the stochastic and quasi-determined communications among them. Each function has the certain value and focus.

According to the created model the author offers to continue further research on studying of the open production-and-economic system developments at the construction enterprise.

## Reference

1. G. Haken, *Information and self-organization*. *Macroscopic approach to complex systems* (Lenand, Moscow, 2014)
2. T.R. Bechelova, Modern problems of science and education **2** (2012)
3. V.B. Zang, *Synergy economy*. *Time and changes in the nonlinear economic theory: Translated from English* (World, Moscow, 1999)
4. V.P. Milovanov, *Synergetrics and self-organization: Social-and-economic systems* (URSS, Moscow, 2015)

5. N. Grégoire, I. Prigozhin, *Knowledge of difficult things*. *Introduction* (Lenand, Moscow, 2014)
6. L.A. Ismagilova, Economical-and-legal aspects of the strategy implementation of modernization in Russia: search of the model of effective social-and-economicdevelopment, 83-88 (2017)
7. N.A. Bondareva, MGSU Bulletin **11**, 236-241 (2012)
8. N.A. Bondareva, MGSU Bulletin **2(1)**, 181-183 (2009)
9. N.A. Bondareva, Scientific review **7**, 114-119 (2013)
10. E. Ganebnykh, O. Lezhnina, J. Zhukova, V. Kashintseva, E3S Web of Conferences **210**, 10008 (2020)
11. E. Ganebnykh, T. Burtseva, E.Gurova, I. Polyakova, E3S Web of Conferences **33**, 03046 (2018)