Available online at www.CivileJournal.org

Civil Engineering Journal

Vol. 5, No. 1, January, 2019

Modeling of Management Processes of Construction Company Business for Increase in its Competitive Stability

Vladimir Evgenievich Bazanov [a*]

[a] *Candidate of Technical Sciences, Associate Professor, Moscow State University of Civil Engineering, Moscow, 129337, Russia.*

Received 10 October 2018; Accepted 11 January 2019

Abstract

The construction organizations lack adaptive infrastructure. It is required to use more intensively SMART-technologies of design and construction. Purposes of this article: a) the system analysis of categories "competitiveness", "stability", "rating of the company" for the construction organizations; b) to construct and investigate economic and mathematical model of competitiveness of the construction organization; c) to determine parameters of self-organization of construction company; d) to construct an identification algorithm for model. These new tasks also answer the purposes of modern construction business, problems of forecasting of its development. Using methods of the system analysis and modeling, in work three levels of the analysis of construction business are considered: macrolevel (level of the state), mesolevel (level of the region) and microlevel (level of the company). For example, 10 various classes of competitiveness of construction companies are offered. It improves the classification used traditionally. The new economic and mathematical model on the basis of production functions of type of Cobb-Douglas is constructed. The algorithm of its identification on the basis of situational scenarios is also developed. The algorithm finds parameters which will allow to define competitiveness of construction company a priori. The offered research has a development, for example, is possible to use for the forecast of adaptation of the enterprise.

Keywords: Construction Company; Competitiveness; Stability; Adaptability; Modeling; Identification; Production Function.

1. Introduction

Management of construction – multilateral process. Modern technologies of construction are not only technology of design, but also and management, marketing, advertising, accounting of consumer preferences [1, 2]. Introduction of innovations (in sphere of events, technologies, materials) in construction is necessary for effective transformation of business processes, production technology solutions.

Construction – a part of production of goods, therefore innovation has to increase efficiency, competitiveness of the construction organization. Innovative solutions have adaptive ability to be applied to the available or expected demand. Factors of quality, innovations, competitiveness need to be considered. For example, construction modular, where self-controllability – not only in sense of the self-organizing organizations, but also in system sense, as a complex system.

Many construction organizations, the companies adapt the infrastructure, processes of management of business, are looking for effective management of the company [3]. For this purpose they use IT, operate SMART-technologies of design and construction. Such approach provides evolutionary ability of the company, its competitiveness [4].

It will save from bankruptcy (on figure 1 – dynamics of the insolvent enterprises in the Russian Federation, 2010-

* Corresponding author: bazanov_kim@mail.ru

http://dx.doi.org/10.28991/cej-2019-03091241

2017).

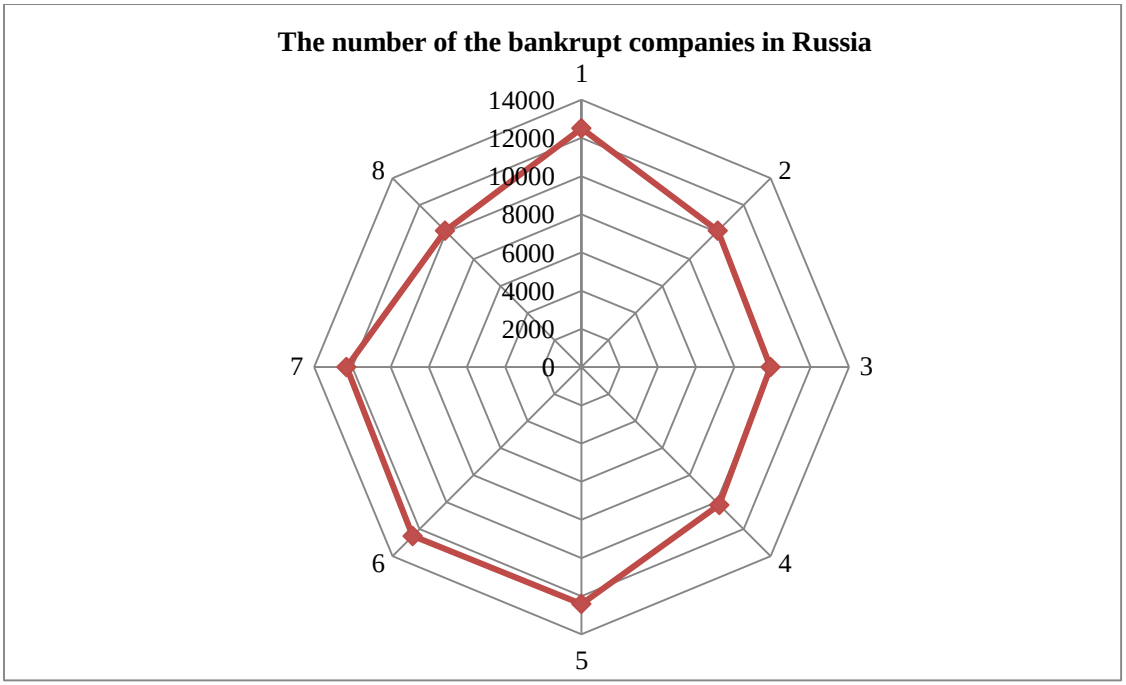

Figure 1. Number of the bankrupt companies in Russia (2010-2017)

There are a deepening and expansion of the market relations between contractors, clients, consumers, construction, architecture, bank, insurance, the companies of control.

2. Category "Competitiveness" and Its Levels for the Construction Organization

The category "competitiveness" in relation to the construction organization in scientific and practical literature (for example, [5-7]) takes into account rating and taxonomy of the companies. The objective rating of the construction organization is based on index values, and competitiveness – on integration of organization, planning, motivation, analytics, account and control. All of them together – on modeling, forecasting, relevance of decision-making, situational imitation and using the system analysis, on multilevel representation of criteria and processes.

At the macrolevel (level of the state, large business) major factors are considered:

- Economic, market;
- Social, political;
- Technological, innovative;
- Financial support of the state, business, investor.

At the meso-level (regional) factors are considered:

- Investment;
- Ecological;
- Raw (deliveries);
- Income of the population;
- Demographic;
- Mentality.

At the microlevel (level of the company, business processes) major factors are considered:

- Pricing;
- Quality;
- Productivities;
- Organizational;
- Marketing;
- Crowd funding.

At identification of degree of a competitiveness of the company, its rating, the methodology which is based on modeling and the systems of decision-making [8, 9] is necessary.

Management in construction business is insufficiently systemically the studied process. Situational modeling in construction is used also insufficiently, adaptive infrastructure is undeveloped. In the conditions of transition to digital technologies of design and construction it slows down development of the company. To become competitive, the construction company has to address innovations, SMART-technologies, models of processes. Therefore in work the economic and mathematical model of competitiveness of the construction organization is constructed and investigated. The adaptive identification algorithm is also developed. Three levels of the analysis of construction business consider: macrolevel, mesolevel and microlevel.

New classification of the companies their competitiveness is offered.

3. Problem of diagnostics of Construction Company Competitiveness and Methods of Formation of Rating Groups

For diagnostics of competitiveness of construction company, it is necessary to use the evolutionary criteria, which are coordinated with the principles specified in [10]:

- Relevance (compliance to the purposes, resources, laws of development and functioning of a system);
- Reliability and stability (ability to function with the set characteristics, parameters during the set time period, without deviating from a trajectory of development or returning to it quickly enough);
- Integrativeness (ability of accounting of joint influence on separate factors, system parameters);
- Autonomy (each factor, parameter is considered individually, irrespective of others);
- Flexibility (ability to dynamically reflect communications with an environment at each stage of development of a system);
- Sensitivity (ability to react dynamically to admissible changes of factors, parameters in allowable limits of a response of a system);
- Dynamism and efficiency (ability to change a trajectory of development of a system in dynamics);
- Efficiency (ability to result in results, decisions at limited resources, admissible expenses).

Diagnostics of competitiveness can to classify on various groups and categories of construction companies. For example, by volume of contract works:

- Group A is amount of works at the level from 0.9V – 1.0V where V – the greatest possible volume (in natural or cost indexes);
- Group B – from 0.8 V to 0.9 V;
- Group C – from 0.7 V to 0.8 V;
- Group D – from 0.6V to 0.7 of V;

- Group E – from 0.5 V to 0.6 V;
- Group F – from 0.4 V to 0.5 V;
- Group G – from 0.3 V to 0.4 V;
- Group H – from 0.2 V to 0.3 V;
- Group I – from 0.1 V to 0.2 V;
- Group J – from 0.0 V to 0.1V.

Size V is set by experts or in statistical data of the construction organizations. Customers estimate construction company from the consumer's positions, but comparative analysis in construction it's impossible to full estimate.

4. Model, Method and Algorithm of Identification of Competitiveness of Construction Company

At identification of competitiveness of construction company it's necessary to know deviations of indicators from reference values and also a proximity assessment measure. On such deviations it's possible to plan the actions increasing competitiveness of the company taking into account resource limitation of its activity.

It's possible to estimate competitiveness (competitiveness coefficient) in various ways:

- The number (volume) of the won tenders, we will carry to total number of participation (or in general competitive situations) [11];
- Integrally, using various groups of indicators (economic, technological, etc.) [12];
- Ratio of the average offer prices and domestic price of the enterprise [13];
- In percent of implementation of contractual obligations on construction terms (statistically) [14];
- Expert estimation, poll [15].

Every way have "minuses", for example, at the first method has no accounting of problems of the organizational plan, the second way has no accounting of availability of the prices, consumer demand of construction products and flexibility of financing.

The major factors affecting competitiveness of construction companies:

- Providing with own current assets;
- Profitability;
- Competence of management and experience, productivity of workers;
- Product cost;
- Profitability of production;
- Duration of design and construction;
- Quality and innovative saturation of building materials and construction;
- Capacities of production and professionalism of contractors;
- Solvency and stability.

All these factors can be grouped in classes (taxons) in components of evolutionary potential:

- Activity durations in the market;

- Financial (cost);
- Technological;
- Material (security);
- Stability (reliability);
- Profitability;
- Level of innovation;
- Investment;
- Advertising and marketing;
- Marketing;
- Anti-recessionary.

For each component, each class have the operating parameters, the set of indicators, standard values. For example, for a class investment – diversification of a portfolio, for financial – coefficients of security with own means, coverings, intensity, turnover of the advanced capital, profitability of equity, the profit relation to proceeds from sales of products, etc.

In the system analysis it is necessary to consider also a type of activity of the company (housing construction, production construction, etc.) and also features of the region, power (degree inequality of the company), distribution, concentration of the companies in the market [16, 17].

For example, the level of concentration of m of the company in the market (in the industry) may be identified the following procedures:

1) The Herfindalya index –

$R_H = \sum_{i=1}^{m} a_i^2$,

Yielding reliable results if shares of the market small are unknown to the company $a_i,\ i = 1,2, \dots, m$;

2) Entropy (according to Shannon) the index –

$R_I = \sum_{i=1}^{m} a_i I$;

3) Linearly - the uniform index, on shares in the market (in the industry of construction productions, services) –

$R_L = \sum_{i=1}^{m} a_i$.

It is difficult to solve problems of the forecast of sustainable development of the construction enterprise – the unstable price dynamics in the markets complicates assessment of resources, investment potential [18]. The institutional mechanism with the negatives creating the corresponding (negative) conditions of rates of development, especially in the short term influences also [19].

According to analysts, indicators of construction production in times of crisis are falling, in contrast to final consumption, that grow due to the rapid development of demand.

How to model, to predict, for example, the average annual rate of gain of construction production? The industry has to be guided by expected values of key parameters of development (demand, expenses, capital investments, etc.) [20]. The forecast in the conditions of credit risks, recession in the market, difficulties of external loans, etc. is especially important.

It will be required to develop and use relevant economic-mathematical models of sustainable development of the enterprises, algorithms of their identification. Models have to be flexible, adaptive, effectively are steady. At the same time, the construction company has to be considered as a stochastic system.

It is difficult to identify such model. The high-quality monitoring not always realized effectively is necessary. Especially, if model difficult. Therefore we consider the mathematical model considering only effective integrated parameters that are parameters of construction company without which it cannot function before achievement of an equilibrium, steady state.

The economic-mathematical model of sustainable development of the enterprise of a look (the generalized production function of type of Cobb-Douglas) is considered:

$$x = \prod_{i=1}^{n} \left(\frac{x_i - x_i^{min}}{x_i^{opt} - x_i^{min}} \right)^{\alpha_i} \left(\frac{x_i^{max} - x_i}{x_i^{max} - x_i^{opt}} \right)^{-\alpha_i \frac{x_i^{max} - x_i^{opt}}{x_i^{opt} - x_i^{min}}}, \quad (1)$$

Where:

x – a vector of production factors of sustainable development of the company;

i – number of a factor ($i=1,2, \ldots, n$);

n – is number of the considered factors;

x – the resulting, integrated indicator of a production system;

α_i – importance of factor number I;

x_i^{max}, x_i^{opt}, x_i^{min}, respectively, the greatest, optimum and smallest i-values of a factor.

Parameters are defined on the basis of technological, financial and economic parameters of competitiveness of the enterprise on the period under review.

For example, in Equation 1, x_1, x_2, x_3 – respectively, specific costs of production, realization and advertizing of products, x_4 – is the ecological parameter, x_5 – is the expenses of the electric power, x_6 – is the logistic expenses, x_7 – is the specific weight of conditional and constant expenses in the total value of expenses.

In particular, for x_7 it is possible to consider conditionally x_7^{max}, x_7^{opt}, x_7^{min} respectively, 0.7, 0.5, 0.3.

Conditionally because they can significantly change depending on a research objective (a modeling hypothesis). We select optimum values by expert or mathematical methods.

It is important to identify parameters α_i for the massif of experimental data as their values reflect the expected scenario of development of the construction enterprise.

For identification of these parameters we introduce the functional:

$$f(\alpha) = \sum_{i=1}^{m} \left(\sum_{k=1}^{n} \alpha_i ln P_{ki} - ln \Delta x_i^2 \right)^2 \rightarrow min \quad (2)$$

Where:

$$P_{ki} = \left(\frac{x_{ki} - x_k^{min}}{x_k^{opt} - x_k^{min}} \right) \left(\frac{x_k^{max} - x_{ki}}{x_k^{max} - x_k^{opt}} \right)^{-\alpha_i \frac{x_k^{max} - x_k^{opt}}{x_k^{opt} - x_k^{min}}}$$

For minimization Equation 2 of f(α) consider a normal system:

$$\begin{cases} \frac{\partial f}{\partial \alpha_1} = 0, \\ \frac{\partial f}{\partial \alpha_2} = 0 \\ \ldots \\ \frac{\partial f}{\partial \alpha_n} = 0 \end{cases} \quad (3)$$

This system Equation 3 after calculations will register in a look:

$$\begin{cases} \sum_{i=1}^{m} (\ln P_{1i} (\alpha_1 ln P_{1i} + \cdots \alpha_n P_{ni} - ln \Delta x_i^2)) = 0 \\ \sum_{i=1}^{m} (\ln P_{2i} (\alpha_1 ln P_{1i} + \cdots \alpha_n P_{ni} - ln \Delta x_i^2)) = 0 \\ \ldots \\ \sum_{i=1}^{m} (\ln P_{ni} (\alpha_1 ln P_{1i} + \cdots \alpha_n P_{ni} - ln \Delta x_i^2)) = 0 \end{cases} \quad (3)$$

Or

$$\begin{cases} \alpha_1 \sum_{i=1}^{m} \ln P_{1i} ln\, P_{1i} + \cdots \alpha_n \sum_{i=1}^{m} \ln P_{1i} ln\, P_{ni} = \sum_{i=1}^{m} ln\Delta x_i^2 lnP_{1i}\,, \\ \alpha_1 \sum_{i=1}^{m} \ln P_{2i} ln\, P_{1i} + \cdots \alpha_n \sum_{i=1}^{m} \ln P_{2i} ln\, P_{ni} = \sum_{i=1}^{m} ln\Delta x_i^2 lnP_{2i}\,, \\ \cdots \\ \alpha_1 \sum_{i=1}^{m} \ln P_{ni} ln\, P_{1i} + \cdots \alpha_n \sum_{i=1}^{m} \ln P_{ni} ln\, P_{ni} = \sum_{i=1}^{m} ln\Delta x_i^2 lnP_{ni} \end{cases}$$

It follows that unknown parameters can be identified from this system of the algebraic equations.

We solve the received system Equation 4 of the algebraic equations, for example, by method of square roots [21] with use of the known mathematical package (MathCAD, MathLab, etc.).

After identification of model (parameters) it's possible to predict adaptation opportunities of the enterprise. For example, to predict the probability of bankruptcy of the enterprise. Dynamically adjusting, unlike the existing Altman models based on the financial analysis of economic activity of the enterprises [22].

The bankrupt company will demand improvement, restructuring of finance, debts, first of all, of receivables of the company.

Its values – the more evolutionary capacity and, therefore, competitiveness, stability of the construction enterprise are higher.

As a result of carrying out researches it's possible to draw a conclusion on need of continuation of researches, in particular, of testing of various models by the offered method, for example, based on indistinct sets and also creation of special models of a research of stability of construction company in the market [23].

5. Results and Discussion

For innovative development of construction, business process automation (especially, management and planning) difficult models are inefficient. Difficult, expensive monitoring is necessary for them. Therefore the offered flexible model and a simple algorithm of situational modeling in construction will be useful. Besides, they allow to determine the parameter of self-organization of a system which is important for assessment of evolutionary potential of a system.

Competitiveness assessment methods also evolve and are structured. They began to consider estimates of projects, the business processes, expected (predicted) results, technologies of realization and construction materials.

The model can be evolutionary. For example, it is possible to execute situational modeling, it's possible to consider a separate subsystem of decision-making on competitiveness of construction company, distribution of projects.

6. Conclusion

The modern technologies which are actively introduced now in construction will allow to reduce cost of construction, to increase its profitability, to increase power and operational efficiency of constructions for implementation non-standard decisions.

The analysis of competitiveness of each company, each enterprise, clarification of their controllability (the operating influences) comes down to the analysis of the coefficients similar above given, in particular, linearly – the uniform index [24], on shares in the industry, in the market.

May be and implicitly, profitability is connected with increase in a share of the market, expansion of the segment. For example, getting rid of restriction of the activity with a market segment. Such fact is observed, in particular, at the state auction, tender competitions. Despite existence of demand in other segments of the market, for example, in this territory.

Applicants at the state auction have to be compared on rating positions, control systems, competitiveness. It allows to identify effective contractors though the purposes of the auction and creation of rating are various. To the auction financial stability is more attractive; power is more attractive to rating (volume indicators are more attractive).

In other words, the current state is more preferable predicted. The predicted has to be informative, allowing to classify the construction organizations for their competitiveness [25].

The system analysis which is carried out in article and the constructed method of rating of the enterprises for competitiveness, also mathematical model and algorithm of its identification will allow to make it is adaptive, considering dynamic and stochastic changes of an environment.

7. Conflicts of Interest

The authors declare no conflict of interest.

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