Ensuring and assessing the sustainability of a management system of the investment and construction complex at the meso-level

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Abstract. In this paper the author suggests a methodological toolkit for assessing the sustainability of the investment and construction complex at the meso-level of management. To ensure the sustainable development of the investment and construction complex, it is necessary to maintain the effective industrial structure that ensures the achievement of social effects, assists to preserving the trend of long-term economic growth and contributes to the increase in competitiveness of domestic construction enterprises. The methodological toolkit is based on the methods of the pricing theory and is necessary for the scientific substantiation of the accepted managerial decisions at the level of industrial management, for the formation of the optimal industrial structure, and for the development of effective methods of a tax policy. Practical implementation of methodological developments, conducted through the example of the regional investment and construction complex of the Voronezh region, allowed empirically to confirm the formulated principles of planning and implementing the organizational and economic changes in the management system of the investment and construction complex to ensure its sustainable development.

1 Introduction

In order to ensure the sustainable development of the investment and construction complex, along with the observance of the principle of regional differentiation, it is necessary to maintain an effective industrial structure that ensures the achievement of social effect, assists to preserving the trend of long-term economic growth and contributes to the competitiveness of domestic construction enterprises.

The issues of structural reorganization of the construction industry are becoming relevant in the light of Russia's membership in the World Trade Organization. We deem it expedient to use the toolkit of the pricing theory as a mechanism for structural analysis of the construction industry by types of activity, namely, structural and topological analysis. The pricing methods of investigation are related to one of the directions of the theory of probability [1]. We agree with V.K. Lozenko that the variety of types of activities and the range of dispersion of the parameters of enterprises make the use of methods of

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mathematical statistics inexpedient. The analysis of the structural and topological dynamics of economic cenosis is aimed at considering the dynamics of species and changing the parameters of the N -distribution [2]. The dynamics is caused by a constant impact on the structure of the cenosis of a number of internal and external factors that contribute to the growth, stabilization or reduction in the number of enterprises of a certain type of activity. Intraspecific and interspecific selections determine the vector of development of the cenosis, setting the dynamics of the structure and ensuring its sustainability [3].

It can be concluded that among the enterprises of the construction industry of the regional investment and construction complex (hereinafter referred to as the ICC), there are economic subjects of various types of activities (in accordance with the Rosstat classification), competing both within each type of activity (the sign of intraspecific selection) and between different types due to the change in processes and technology of work (the sign of interspecific competition), interconnected by different types of links (taking into account the trend of globalization), using similar resources and market outlets. Based on the above, we consider it possible and expedient to use elements of the pricing theory when analyzing the industrial structure of the regional investment and construction complex.

2 Materials and Methods

For the unit of economic cenosis of regional construction enterprises should be taken a construction enterprise characterized by the necessary for the purpose of research indicator - the number of employees and affiliation with certain types of activities. A stable pattern of the cenosis structure is the species distribution, i.e. the distribution of enterprises by the type of activity [4]. According to the laws of pricing [5], the species distribution of elements in the cenosis tends to a hyperbolic N -distribution. That is, the stable industrial structure of the regional investment and construction complex should strive for the hyperbolic N -distribution. In this case, the processes of intraspecific and interspecific competition occurring in the economic cenosis of building organizations are optimized.

The optimization mechanism is as follows. Differentiation of the number of organizations engaged in certain types of construction activities is determined by the need for this particular type of activity, as well as the limitations of this type (resource limitations, institutional limitations, etc.). The dynamics of the needs and limitations caused by the technological, organizational, economic, institutional changes, leads to the different (positive or negative) dynamics of the number of organizations in certain types of activities. Gradually, the organizations move to another (numerous or small) types of activities. This is how interspecific competition is carried out. Using the terminology of evolutionary economic theory, interspecies selection occurs. Interspecific competition and, consequently, intraspecific selection take place between organizations of one type of activity [5]. It is easy to notice that intraspecific competition will be stronger in the numerous types of activities.

Based on the principle of fractality, it is possible to conclude that the direction of increasing the dynamic sustainability of the regional investment and construction complex industry is to increase a variety of businesses. It can be achieved through organizational and economic changes aimed at synchronizing the structural and topological dynamics of the economic cenosis of the regional construction enterprises. In addition, changes aimed at synchronization of structural and topological dynamics increase the competitiveness of the cenosis of construction enterprises, which is especially relevant for the construction industry in the conditions of membership in the World Trade Organization.

Thus, the sustainable development of the investment and construction complex is achieved only with preservation of a variety of structural elements, i.e. when planning and implementing the organizational and economic changes, it is necessary to provide a variety

of structural elements of the controlled subsystem that obey the law of hyperbolic N -distribution, which allows formulating the principle of requisite variety.

Sustainable development of the investment and construction complex is achieved only with the preservation of a variety of structural elements that obey the law of hyperbolic N -distribution.

The methodology of structural and topological analysis of enterprises in the industry is as follows:

1. Ranking of enterprises of the regional investment and construction complex by types of activities.
2. Development of ideal and actual rank distribution.

$$A(r) = W_0/Rb \quad (1)$$

3. Definition of a multitude of activities of intraspecific and interspecific competition.

$$\begin{aligned} Vvk &= (Vt \dots Vn) \\ Vmk &= (Vt \dots Vn) \end{aligned} \quad (2)$$

4. Development of the species distribution of enterprises

$$\Omega(x) = \frac{W_{01}}{x^{1+\alpha}} \quad (3)$$

where, $\gamma = 1 + \alpha$ - a characteristic indicator, W_{01} - number of the first caste presented by unique kinds (each of one individual)

5. Determination of the sustainability of industrial structure of the ICC

$$W = \frac{12D}{m^2(n^3 - n)} \quad (4)$$

where, $S_{med} = \frac{\sum_{k=1}^n \sum_{l=1}^P r_{kl}}{n}$, and $D = \sum_{i=1}^n (\sum_{j=1}^P r_{ij} - S_{med})^2$, m - Quantity of the time periods;

n - quantity of the building enterprises; r - value of an indicator of a rank; P - quantity of the periods; S_{med} - the average sum of ranks of the enterprises for each time period; D - the sum of squares of difference S_{med} and the sums of ranks of each enterprise for each of the periods; W - factor of concordance.

Planning of organizational and economic changes for the improvement of sustainability.

According to this method, a number of indicators of all construction enterprises of the Voronezh Region for 2017 (Figure 1) are analyzed on the basis of the initial data (Table 1).

Fig. 1. Actual ranking of construction enterprises of the Voronezh Region by type of activity, 2017.

Table 1. Data for the analysis of structural and topological dynamics of enterprises of the investment and construction complex of the Voronezh Region (fragment).

		Small enterprise	The Large enterprise	The Average enterprise	The Microenterprise	The Data about enterprise type is absent	The Noncommercial organisation
1	2	3	4	5	6	7	8
1	45 Building	0	1	0	7	6	2
2	45.1 Preparation of a building site	3	11	1	58	113	7
3	45.2 Building of buildings and constructions	14	31	0	159	373	17
4	45.3 Installation of the engineering equipment of buildings and constructions	1	1	0	30	56	0
5	45.4 Manufacture of painting and decorating	6	2	0	66	112	2
6	45.5 Rent of building cars and the equipment	0	0	1	2	4	0
7	45.11 Dismantling and pulling down of buildings, manufacture of excavations	17	2	2	67	29	1
8	45.11.1 Dismantling and pulling down of buildings, clearing of building sites	10	4	0	35	17	0
9	45.11.2 Manufacture of excavations	6	10	3	23	18	0
10	45.11.3 Preparation of a site for mountain works	0	0	0	0	1	0
11	45.12 Prospecting drilling	3	0	0	6	2	0
12	45.21 Manufacture of civil work	108	13	5	405	296	5
13	45.21.1 Manufacture of civil work on erection of buildings.....	102	47	16	210	119	9

The rank distribution allows visually identifying the most numerous and the smallest activities [6].

The rank distribution is the dependence of the value of the parameter on the rank (ordinal number) when ordering the parameter values on a set of objects in descending order.

Non-Gaussian rank distributions are described mathematically by the N-distribution model:

$$A(r) = \frac{W_0}{r^\beta} \tag{5}$$

where, r - a rank (number one after another); W_0 - the maximum value of parameter corresponding to the first rank of community; $\beta > 0$ - a characteristic indicator of hyperbolic approximation rank distributions.

The graph of the distribution of types of activities by the number of enterprises and the theoretical graph of the sustainable distribution is shown in Figure 2.

Fig. 2. The rank distribution of types of activities by the number of enterprises and the theoretical graph of the sustainable distribution.

3 Results

Based on the analysis of the graphs, it is possible to make a conclusion about prevalence of interspecific competition (activities that have ranks 1-33) in the regional investment and construction complex of the Voronezh region. Among enterprises of other types of activities (general construction, installation, finishing work, rental of construction machines), intraspecific competition prevails, i.e. competition between enterprises of the one type of activity. Activities with ranks 1-33 form the potential for growth in the number of enterprises because competition in these segments is small. Intraspecific selection occurs on the basis of competition between enterprises of one type of activity. Thus, when planning the organizational and economic changes, for example, when improving the state procurement system, concessional loans, and developing a tax policy, it is worth at least not to increase tax rates for enterprises belonging to interspecific competition [8, 10]. In the

intraspecific competition zone, it is possible to increase tax rates based on the analysis of enterprises by the number of employees.

Such changes contribute to the growth in the number of organizations in concessional activities. The occurred growth in the number of organizations will lead to the increase in intraspecific competition, the liquidation of a part of non-competitive enterprises, and then to the repetition of the cycle of structural and topological dynamics.

The theorists of the pricing theory [6] proved that the indicator of the sustainability of the structure in dynamics can be considered as the Kendall's concordance coefficient characterizing the preservation of the rank distribution in dynamics:

$$W = \frac{12D}{m^2(n^3 - n)} \quad (6)$$

$$\text{where, } S_{med} = \frac{\sum_{k=1}^n \sum_{l=1}^P r_{kl}}{n}, \text{ and } D = \sum_{i=1}^n \left(\sum_{j=1}^P r_{ij} - S_{med} \right)^2, \text{ m - quantity of the time}$$

periods; n - quantity of the building enterprises; r - value of an indicator of a rank; P - quantity of the periods; Smed - the average sum of ranks of the enterprises for each time period; D - the sum of squares of difference Smed and the sums of ranks of each enterprise for each of the periods; W – factor of concordance.

According to the calculations for the last 3 years (2015-2017), the values of the concordance coefficient for the cenosis of the construction industry enterprises of the Voronezh Region exceed 0.7. This indicates that there are quite strong interrelations in the construction industry in the region. That is, the dynamics of the individual enterprise is largely determined by the dynamics of the full range of enterprises of the regional investment and construction complex, and vice versa. This structure is considered quite sustainable in the pricing.

When characterizing structural and topological dynamics, the species distribution is used along with the ranking. This distribution shows groups of enterprises with the same value of the studied parameter. Then the groups are combined into enlarged castes [6]. Castes are ranked according to the number of groups included in them. As a result, the axis of abscissas indicates the number of objects in the group, and the axis of ordinates indicates the number of groups in the caste [6].

The species distribution is represented as follows:

$$\Omega(x) = \frac{W_{01}}{x^{1+\alpha}} \quad (7)$$

where, $\gamma = 1 + \alpha$ - a characteristic indicator, W01 - number of the first caste presented by unique kinds (each of one individual) [6].

The species distribution of construction enterprises of the Voronezh Region is shown in Figure 3.

Fig. 3. The species distribution of an enterprise in the construction industry of the Voronezh Region, where K is the number in order; i - number of enterprises; $W(i)$ is the number of types of activities.

Despite the compliance with the condition that about half of the enterprises belong to the most numerous group, a larger number of "unique" activities is necessary to ensure the sustainability of the structure of the investment and construction complex of the Voronezh region. These very activities constitute the basis for the redistribution of construction enterprises in the process of structural and topological dynamics. Therefore, the industrial and regional administrating authorities, as well as the regional business community, should expand the list of new types of activities. This will ensure the growth of innovation activity of enterprises. For the groups of activities with a large number of enterprises, it is expedient to introduce a larger tax, which contributes to the growth of intraspecific competition.

The results of the price analysis show that the structure of the investment and construction complex in terms of types of activities is fractal.

4 Discussions

The sustainable economic infrastructure is provided by the set of multi-scaled (according to the principle of fractality) economic entities forming a pyramid [6]. The foundation of the pyramid consists of many small enterprises. The size of enterprises increases and the number of enterprises decreases from bottom to top. This structure is typical, for example, for the US economy. Small businesses are more likely to change and have more innovation activities. Due to this, enterprises either increase in size, or transfer innovation and experience to the larger companies. Therefore, the principle of requisite variety is valid not only for the variety of types of activities, but also for structuring of the industry enterprises by the size (Figure 4).

Fig. 4. The structure of construction enterprises of the Voronezh Region, depending on the number of employees, %.

According to the analysis, the majority of small enterprises belong to the zone of intraspecific competition, which should be taken into account when planning economic changes, as well as when improving the requirements for the accession of organizations into self-regulatory organizations.

5 Conclusion

The result of the analysis shows that the structure of the investment and construction complex is subject to an objective non-Gaussian pattern described by the rank distribution with a characteristic index that is stable on samples of different parameter intervals and different time intervals. The pricing analysis and modeling of the investment and construction complex as a cenosis makes it possible to identify objective patterns. The use of these patterns increases the efficiency of management of the construction enterprises at all levels as a sustainable self-organizing system, contributing to the formation and maintenance of the trend for sustainable development in the investment and construction complex of the region and the country as a whole.

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