Sustainability of Construction Companies under Construction Uncertainty and Risks

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Abstract. Modern competitive conditions, economic crisis phenomena and an overall decline in business activity significantly influence the self-regulation of a construction company. This paper is aimed at the following: an author’s definition of the building system stability as the ability to function effectively under changing competitive market environment conditions and the construction volume (load) uncertainty (production and technology, supply and sales, financial sustainability, etc.) The paper presents a simulation of the construction company stability by choosing mutually related rational indicator prediction values - construction indicators regarding the risks of achieving its activity goals meeting the requirements to acceptable process variability. To assess and manage the construction company stability, a classification of risks is given. An algorithm was developed for a set of management decisions to minimize the consequences of external risks. The author’s research findings suggest the following conclusions:

- Various types of external risks are the most likely and significant possible damage on construction companies.
- At the construction planning stage, to minimize the possible consequences of external risks and uncertainty, organizational and technical measures should be developed.
- The main organizational and technical measures to quickly respond to reducing (losing) the stability of construction companies, minimizing the consequences of external risks and construction production uncertainty with regard to the Pareto principle should consist in the practical implementation of a set of measures to align the changed production load with the parameters of the construction company's production potential - first of all, the specialization level and production capacity.

1. Introduction

After analyzing works of several researchers [1-5], it was possible to conclude that the main risks affecting the work of construction companies are production destabilizing factors and construction uncertainty [6].

The concept of "a construction company sustainability" can be defined as the ability of a company to work effectively and fulfill its obligations under changing competitive market environment conditions and the construction volume (load) uncertainty [7].

Construction management is the basis on which a company functions.

Modeling such an emergent feature of a construction company as sustainability is a qualitative assessment of the risks of homeostasis non-preservation in the construction process [8].
The construction company’s permissible sustainability level is determined by a statistical evaluation of the construction results described by a specific set of quantitative indicators, including construction indicators of facilities, the fulfillment of established construction and installation volumes, etc [9,10].

2. Methods
Modeling the building company's sustainability is performed by choosing mutually related rational indicator prediction values - construction indicators regarding the risks of achieving its activity goals meeting the requirements for acceptable process variability. Setting the process goals is considered in terms of fulfilling the construction company's obligations to customers, subcontractors and allied companies, the state, the staff and owners under construction uncertainty and risks.

The construction company sustainability's conceptual model can be represented as a set of requirements for the variability of the construction process goals set (\(\bar{x}\)) formulated according to the estimated construction, organization and construction management result indicators (\(\bar{x}_i\)):

\[
\bar{x} = \{\bar{x}_1, \bar{x}_2, \ldots, \bar{x}_i, \ldots, \bar{x}_n\} \tag{1}
\]

\[
\bar{x}_i = \{ x_i \mid \begin{array}{l}
X_i \leq \bar{x}_i \pm 2\sigma \\
X_i > \bar{x}_i \pm 2\sigma
\end{array} \} \tag{2}
\]

The main simulated construction company production load indicators are as follows:
- the level of compliance with the construction company's production load potential (\(K_{pl}\)):

\[
K_{pl} = \frac{Q_{cc}}{Q_{gc}}, \tag{3}
\]

where \(Q_{cc}\) is the simulated process goal, the planned or estimated construction company production load value - the volume of construction and installation work performed in-house, thousand rubles;

\(Q_{gc}\) is a construction company’s potential - the average value of construction and installation work performed by a construction company under general contracting, thousand rubles;
- the estimated value (\(K_1\)) of the planned volume of construction and installation work performed in-house per 1 construction company's employee, thousand rubles per 1 employee;
- the estimated value (\(K_2\)) of the planned volume of construction and installation work performed under general contracting per 1 construction company's employee, thousand rubles per 1 employee;
- the estimated level of compliance with the regulatory (contractual) facility construction (work) terms according to the process goal (\(K_4\)), a dimensionless quantity.

After modeling the construction process goal - the main construction company's production load indicators, rational parameters of the construction company's basic production asset, mechanical construction and labor, construction organization indicators and the construction company's management system's technical condition are set. Allowable variability of indicators determines the construction company's internal stability reserve.

The indicators of the main asset technical condition include physical wear and validity coefficients.

The availability of the construction company's equipment is distinguished by the mechanical construction equipment and labor indicators.

Construction organization level indicators are the levels of specialization for general contracting and the work performed in-house.

The indicators for assessing the management system's condition include the specific weights of the amount and wages of administrative and management staff in the total number of employees and the wage fund (respectively), the staff turnover level.
The overall steady construction company’s condition is determined by internal reserves of the System: main assets, production capacity, production and labor. It is offered to determine the rational value of such reserves according to the two sigma limits of permissible indicator variation.

During modeling the construction company’s sustainability, there are cases, when the indicators for estimating the process goal values exceed the two sigma limits. The excessive process variability can be explained by the activity of both intrasystem and external causes that can be established. The result is a loss of the construction company’s stability or a fundamental change in the construction process (its transition to higher or lower levels) with a change in the organizational and management structures. The failure to take measures to eliminate the influence of excessive construction company’s process indicator variability factors is the main reason for the loss of stability by the construction company.

The target method of system self-organizing is that emergence of new ordered structures (attractors) is due to the influence of some external factors - uncertainty and risks. The construction system organization and the construction management shall ensure the building company’s sustainability. Sustainability is ensured by creating the conditions to achieve the construction process goals formulated according to the estimated construction result indicators.

Studying the intrasystem and external causes of the construction result estimated indicator variability and, as a result, establishing a causation: process goals → risks and uncertainties → excessive indicator dynamics → assessment of the construction company’s sustainability will allow developing effective measures to eliminate the causes and/or consequences of negative impacts and ensure sustainability.

Among the distinctive construction features, the diversity of relations with other economic entities (organizations and enterprises of different industries) can be distinguished; dependence on weather conditions (seasonal work); the duration of preparatory and main stages; the need for arranging temporary infrastructure facilities; specific nature and territorial fixation of building products being created (buildings, structures); high material resources consumption rates; capital intensity and a special calculation (investment) method.

These features are due to the high probability of both losses and profit during economic activity, i.e. uncertainty and risks. The main reasons for the excessive construction company sustainability indicator variability are as follows: construction uncertainty and risks.

Construction uncertainty is the construction company activity conditions, the behavior of construction participants and situations that are not subject to assessment complicating decision-making choices. Let’s imagine an event, of which we are uncertain. Under such conditions, the situation may develop in different ways, i.e., there is uncertainty.

If there is construction uncertainty, any decision-making is risky. The risk can be described as determining the likelihood of an event. Any production activity is subject to the risk of deviations from the estimates and calculations conducted, the risk of a failure or a loss, an unpredictable change of the situation. Construction risks are a combination of the likelihood and consequences of an adverse event.

The issues of assessing the impact of construction uncertainty and risks on the stability of construction companies have not yet been studied. The existing systems for classifying construction risks [etc.] are not fully applicable for solving the problems of assessing sustainability and managing the sustainability of construction companies.

Construction is one of the riskiest types of industrial activity, so the ability to classify types of risks, assess and minimize the consequences of their impact on the stability of construction companies is an important practical result of the study. To facilitate the risk identification process, they must be classified. Furthermore, the classification will allow one to choose the methods to manage risks and consequences thereof correctly.

Scientific literature takes different approaches to risk classification. There is no single point of view on this issue [11]. Depending on the tasks and fields of activity, risks are divided into types, groups and classes according to different features. The main thing is that the classification contributes
to the solution of the tasks and the assessment of the sustainability of construction companies. Therefore, it is important that one chooses from all existing risk classifications a single one that is required for further study of the assessment problem and ensuring the construction company sustainability. The choice of classification criteria is justified by the desirability of forming taxonomic group based on features allowing predictions to be made in order to achieve a goal.

Using the taxonomy principles and understanding the classification of risks as their distribution into groups according to certain features to develop methodologies and practical recommendations for ensuring the sustainability of construction companies, based on effective construction, it is offered to classify the sustainability loss risks, primarily, by their nature: external and internal (construction risks).

Internal risks come from the organizational, construction technology level and the level of management strategies. They mean the uncertainty of construction results in the implementation of specific facility construction projects. Internal risks are related to several circumstances:
- decrease in the construction company efficiency due to violation of the construction rhythm under the influence of such factors as damage, aging of main assets (equipment, construction machines, transport, building structures, engineering networks, etc.);
- introduction to the construction of new equipment and technologies;
- probability of property loss due to theft, negligence, accidents, etc.

The following types of external risks are of the greatest interest for the study: natural, environmental, financial. External risks are not affected by construction organization features and the construction company’s activities. They emerged due to uncontrollable external factors (demographic, geographic, economic, social, climatic, etc.).

According to the measurability and predictability degree, internal and external risks are, as a rule, classified into predictable (predictable risks that can be foreseen based on the construction practice, but it is impossible to foresee the moment of their occurrence) and unpredictable (unpredictable risks nothing is known about, therefore it is impossible to assess their impact on the extent of damage).

By the time of occurrence, risks are divided into past, current and future. An analysis of the causes and consequences of negative events occurred is a source of theoretical and practical experience. It certainly helps prevent a recurrence of risk situations in the future.

By severity of possible consequences, construction risks are classified as follows. [11]:
- minimum (losses range from 1 to 10% of profit);
- moderate (profit decreases by 10-50%);
- permissible (profit decreases by 50-100%);
- critical (negative consequences lead to losses);
- catastrophic (lead to the complete loss of construction company sustainability - inability to fulfill obligations, including due to natural disasters). The classification of risks by severity of possible consequences is required for making decisions about recognition of risks as significant and their further consideration during construction management.

Even though the construction risk assessment and management theory has been sufficiently studied, the risk assessment and management system is usually underdeveloped in construction companies.

Risk management aims at developing a classification of construction risks for a certain construction company; analyzing risk using expert methods, rarely using the probability theory apparatus; identifying all types of possible risks, their sources and moments of their occurrence; assessing all possible consequences of a certain event and their probability; determining the most significant risks and severity of possible negative consequences; developing measures to prevent risky events and/or minimize their consequences.

The main risk management methods are as follows: diversification - risk sharing between project participants or the over time by allocating individual project stages; evasion - development of measures, which will reduce or eliminate the negative impact of risky events; compensation - insurance, guaranteeing (buying a bank guarantee) and/or creating reserves of financial and material
resources; localization - allocation of certain activities to eliminate the negative impact of a risky event on construction results.

Most of the internal risks are managed, therefore, it is possible and required to plan and develop organizational and technical measures to avoid such risks and/or reduce their negative impact on construction results. External risks (especially unpredictable) are deemed uncontrollable. As a rule, to reduce the negative impact of this type of risks, compensatory measures are developed. Sometimes the probability of occurrence of such risky events is just ignored (Table 1).

**Table 1. Methods of managing various types of construction company sustainability risks.**

| Sustainability risks management methods                                      | Risk diversification | Risk evasion | Risk compensation | Risk localization |
|----------------------------------------------------------------------------|----------------------|-------------|-------------------|-------------------|
|                                                                           | - risk sharing       | - development of measures to reduce or eliminate the negative impact of risky events | - creation of reserves: financial, material and informational | - identification of types of activities to eliminate the negative impact of a risky event on the results in general |
| Unpredictable Types of external risks                                      | _                    | _           | +                 | _                 |
| Predictable Types of external risks                                       | +                    | _           | +                 | _                 |
| Internal risks                                                             | +                    | +           | +                 | +                 |

External risks emerge due to the adverse influence of the surrounding macroenvironment or facilities that are functionally related to a construction company (banks, investors, suppliers, subcontractors, tax authorities, etc.) [11,12]. Types of external risks that have a significant impact on construction results are presented in Table 2.
Table 2. External risks in construction.

| Types of risk factors                                      | Kinds of risk                                                                                                                                 |
|-------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------|
| Political - the likelihood of undesirable consequences,    | The internal political situation instability in the country, a subject                                                                      |
| possible political and other decisions related to political | or the municipality of the Russian Federation, a likelihood of regional and local conflicts, tense international relations with         |
| events that can cause damage to their participants during   | major global and regional powers, neighboring countries, conflict of investor interests, management of a conflict with                   |
| implementation of their interests                            | government structures in a construction company, government support of competitors etc.                                                      |
| Legal - potential losses due to the legislation inability   | The regulatory legal base perfection degree, the arbitration                                                                             |
| to take them into account at all or its changes in the      | proceedings perfection degree, the domestic market protection degree, customs policy, licensing policy, etc.                                  |
| legislation during construction                             | Instability, the likelihood of strikes, staff turnover and difficulties in recruiting qualified work force, increasing the costs of         |
| Social - the likelihood of a violation of a certain         | organizing working conditions and other measures for the social protection of workers, etc.                                               |
| population living on a certain territory social status      | Ruble depreciation, devaluation, default, rising inflation, a banking crisis; losses related to increased competition due to improved      |
| caused by reasons arising from the history of a particular  | economic conditions and new players entering the market, etc.                                                                            |
| society                                                      | Natural disasters, accidents and explosions; harmful production, increased radiation background, man-made and transport disasters, etc. |
| Sectoral and economical in general - risks associated with  |                                                                               |
| market factors external to a company                        |                                                                               |
| Climatic and environmental - the likelihood of consequences  |                                                                               |
| arising from the natural process (phenomenon) impact on    |                                                                               |
| people and facilities, negative environmental changes or    |                                                                               |
| their long-term effects arising from the negative impact on |                                                                               |
| the environment                                             |                                                                               |

The algorithm for developing a set of management decisions to minimize the consequences of external risks includes 3 stages:

The 1st stage. Setting goals:
- monitoring of the system "construction company - external environment";
- identification of external risks;
- identification of internal risks;
- development of measures to prevent and/or minimize effects of external risks.

The 2nd stage. Quantitative analysis of each external risk:
- selection of quantitative risk assessment methods;
- assessment of possible losses from effects of risks;
- determination of predictable and acceptable risk levels;
- comparison of certain risk levels;
- prediction of changes in the sustainability level under the influence of risk.

The 3rd stage. Development of a complex of managerial, organizational and technical measures to minimize risk consequences:
- determination of activities;
- development of managerial, organizational and technical measures;
- costing the implementation of measures to restore sustainability;
- assessment of the effectiveness of the measures developed.
3. Conclusions
The implementation of the above algorithm allows one to develop and apply a comprehensive program to ensure the construction company sustainability under construction uncertainty and external risks. Since many of the construction uncertainties can be considered and not all external risks can be mitigated, economic methods (insurance, guaranteeing, hedging and reservation) will develop appropriate organizational and technological measures. To make sound management decisions, costs of measures to restore organizational and technical sustainability shall be comparative with costs of insurance, reservations and other economic measures.

External risks, which are usually not considered when solving organizational and technological construction tasks, can have a significant impact on the sustainability of construction companies. Therefore, they are also considered to minimize the consequences.

After analyzing possible consequences of various types of external risks, as well as similar uncertainties of types of effects caused and ranking them by the likelihood of occurrence and the amount of possible damage, the following conclusions can be drawn:

1. The most likely and significant in terms of the possible damage to construction companies are various types of external risks leading to the breakdown or termination of agreements, construction suspension, violation of facility construction deadlines, the impossibility of implementing projects;
2. The consequences of potential external risks (uncertainties) leading to the breakdown or termination of agreement, construction suspension, violation of facility commissioning deadlines, the impossibility of implementing projects are manifested in the form of a reduction or increase in the production load of construction companies in the planned period (quarter, year);
3. During assessment of the construction company sustainability with critical values of the reduction or increase in production load, excess variability will be shown first by indicators K3, K2, K1 reflecting the production load to production potential ratio and the number of employees;
4. At the planning stage, to minimize possible consequences of external risks and the construction uncertainty, organizational and technical measures shall be developed to quickly respond to the reduction (loss) of the construction company sustainability;
5. - The main organizational and technical measures to quickly respond to reducing (losing) the stability of construction companies, minimizing the consequences of external risks and construction production uncertainty with regard to the Pareto principle should consist in the practical implementation of a set of measures to align the changed production load with the parameters of the construction company's production potential - first of all, the specialization level and production capacity.

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