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CALS-MODEL FOR FORMING THE ANTI-CRISIS POTENTIAL OF CONSTRUCTION ENTERPRISES

Abstract: This paper considers the pecularities of the formation of econmic immunity of construction companies. A system has been proposed to improve the mechanisms of preventive protection and securement of enterprises from loss of viability and subsequent self-liquidation or bankruptcy, which allows effectively identifying existing risks and threats from micro-, meso- and macro-environments and responding to them with the preventive means through economic immunity. A new definition for the term «economic immunity» of the enterprise is proposed, which includes subsystems of monitoring, early detection of internal and external threats, assessment of the degree of danger (risks), defusion, elimination or neutralization, and formation of «memory» of the threat through a system of indicators.

The differences of economic indicators of construction enterprises, which are characterized by different levels of the anti-crisis potential use, are studied, the five most significant indicators of the use of the anti-crisis potential are identified. The rules-conditions for determining the level of activation of anti-crisis opportunities and vulnerability of enterprises to threats for economic security are formulated. Methods of identification and control of the level of anti-crisis potential use of the construction enterprise in the context of digital transformation which allows estimating quality and expediency of administrative actions are developed.

The formation mechanism of the anti-crisis potential of the construction enterprise is developed. Its structure is defined, conceptual foundations of the integrated information system creation of the construction enterprise that should provide the possibility of interaction of various subsystems within the enterprise and the analysis of threats from interaction with various stakeholders are substantiated.

Keywords: economic security, anti-crisis potential, digitalization, financial indicators, construction enterprise, economic immunity, CALS-technologies

Introduction

Instability of economic development of enterprises, a significant level of vulnerability to various threats and dangers, cases of unfair competition, fictitious entrepreneurship, raider attacks make it necessary to solve a set of problems for the further development of the construction industry, to create a reliable and effective mechanism for crisis management of construction companies.

The purpose of forming the mechanism of anti-crisis management of a construction company is to protect its activities from external and internal threats ensuring stable operation of the enterprise and financial and economic growth.

A unique feature of the modern development of economic systems in most countries is the total digital transformation of all administrative and production processes. It is carried out in order to strengthen the internal and external information interaction of all parts of the economic system, especially enterprises as follows: the internal environment of the enterprise is gradually transformed from a number of separate departments, centers of responsibility, and decision-making into single information space.

The introduction of digital technologies for the management of construction companies should take into account the production and economic specifics of this type of activity.

The current stage of organization and management is marked by the transition to paperless technologies that provide fast, and error-free processing of documents of various types. One such technology is the CALS concept.

Greater openness, interdependence, and business processes speed, the need for paperless information exchange at the micro, meso, and macro levels lead to the fact that construction companies need to adapt to new development models, introducing information technology and systems of interaction with other participants. At the same time the key task is to form a system of economic security of the enterprise, in the context of the economic digitalization with high accuracy to detect and neutralize threats to development and operation, which determines the relevance of the study.

Literature Review

The problem of forming and maintaining a sufficient level of economic security of construction companies in economics is not new. At different times, a number of tasks to solve this problem were solved in the works of Stetsenko S.P. [3,14], Sorokina L.V. [18,21], Ryzhakova G. [22], Fedosova O.V. and Molodid O.O. [4,16,21]., Bielienkova, O.Yu. [1,2,16,21], Chupryna Y. [23,24], Tsyfra T. Yu. [14,24], Migus I.P. [6], Fisunenko P.A. [7,8], Shevchenko K.I. [8], Lazhe M.V. [7], Pushkar T.A. [10], Dyachenko K.S. [10], Cherevko O.V. [9], Dmitrenko V.I. [9].

Tasks for the formation of economic security at the national level were solved by O.I. Amosha, S.S. Aptekar, M.G. Bilopolsky, S.I. Yuri, I.I. Podik, at the regional and sectoral levels by Stetsenko S.P. [16,17,18,21], at the level of individual enterprises by Ya. D. Krupka, M.S. Pushkar, P. Ya. Khomin, etc., theoretical approaches to the definition of «economic security», «Risks» and «threats» are given in the works of Shtangret A.M. [11], Prikhodko S.V. [13], Vitlinsky V.V[12].

Today, systematic research on the organization's economic immunity is being systematically researched by Professor Wang Yihua's scientific school at Tsinghua University and his successor Zhang Jianguang, a researcher at Wuhan Technical University who proposed an enterprise immunity assessment index system [5].

Aims

Given the long-term losses of enterprises in the construction sector of the economy and their low level of financial stability, the formation of an effective system of anti-crisis potential is an urgent need, a necessary element for further development.

Despite the strong theoretical basis of the problems of managing the potential of microeconomic systems, it should be noted the lack of scientific research in the direction of revealing the nature and features of the formation of the anti-crisis potential of construction companies.

The system of threats prevention of the enterprise economic security in the time of digitalization of the economy, and formation of «economic immunity» of the enterprises, development of theoretical approaches and practical recommendations on introduction of this concept needs further consideration.

Results and methods

Economic security, first of all, its financial component, is a necessary condition for conducting economic activity in the medium and long term. However, ensuring this condition is impossible without an effective system of early detection of threats in the short and medium term. The main function of such a system is the ability to identify destabilizing factors, even when their negative impact is weak and has not yet affected the results of economic activity.

The identified patterns proved the need for developing methodological approaches to increase anti-crisis potential and economic immunity, increase viability in a competitive environment of construction companies.

Therefore, it is considered expedient to supplement the conceptual apparatus of economics with the author's definition of the category «economic immunity of the construction company» - a system of preventive protection of construction business, combining monitoring, identification, analytical, protective, neutralizing subsystems, coordinated operation of which eliminates external and internal threats to financial security. In addition, to form a «memory» of them as part of the intellectual capital of the enterprise with continuous updating of the information management unit.

The choice of critical factors for the formation of the anti-crisis potential of construction companies is made. The study is based on data from 26 enterprises for 2004-2019 (a total of 104 observations), all analyzed enterprises belong to group F (41.20). The study examined four-year periods during which companies with low anti-crisis potential left the market, while companies with sufficient anti-crisis potential continued to operate, and therefore were examined the last four years of publishing public financial statements of such companies. The analyzed sample of enterprises was divided into two subgroups: «crisis» and «crisis-free». The first, «crisis», includes companies that left the market at the end of the four-year analysis period. The rest of the companies have been operating in the construction market for more than a year after the end of the four-year analysis period, and many of them are still operating.

In order to improve the control mechanism of the system stability of anti-crisis potential of construction enterprises in the medium term, a cluster analysis was performed not of the entire analyzed sample, but only of its part, which included «crisis-free» enterprises. This study allowed to study, firstly, the observations heterogeneity of relatively stable operation of the construction business, secondly, to identify the most important, prioritised, advanced indicators

of economic security loss, and thirdly, to clarify the threshold values of these indicators and their «blur» in unstable conditions of the external economic environment.

The cluster analysis improvement made it possible to divide the observations of the crisis-free subsample into two subgroups, depending on the level of vulnerability to economic security threats. Cluster analysis was performed using the k-means method, which minimizes the distance between objects belonging to the same cluster group. Usually, the length is determined by Euclid's formula, finding the geometric sum of the deviations of the values of objects representing the cluster from the average cluster value. Computational procedures and the final distribution of observations of cluster subgroups were performed using Statistica 8.0, and numerous experiments have substantiated the sufficiency of only two cluster groups and the five most important leading indicators of the economic security loss. The generalizing criterion for the distribution of observations by groups was the level of use of anti-crisis potential: it is either used at the average level or used minimally. In turn, the level of anti-crisis potential summarizes the results of assessments of partial leading indicators and reflects the sensitivity of enterprises to the destabilizing impact of threats to economic security. Table 1 systematizes the average cluster values, as well as standard deviations for each of the indicators.

Table 1. The results of cluster analysis of a crisis-free subsample

Indicator	Cluster with an average level of use of anti-crisis potential, 33 observations		Cluster with a low level of use of anti-crisis potential, 11 observations
	Middle cluster value	Cluster standard deviation	Middle cluster value
The level of capital consumption of owners	0,37299	0,43052	0,8790
Profitability of operating sales on retained earnings	0,05501	0,37600	-1,9437
Return on working capital by retained earnings	0,03813	0,77785	-0,7525
Cost intensity of operating costs by personnel costs	14,61119	12,05866	27,3253
Term of turnover of accounts payable	38,29369	48,72517	327,6228

Given that many of the surveyed enterprises from the crisis-free subgroup further still could not stay on the market, we can not characterize any of the cluster groups as such, whose anti-crisis potential is used at a high, and even more so at the maximum level. Partial indicators of the use of anti-crisis potential (Table 1) set the level of consumption of owners' capital, profitability of operating sales on retained earnings, return on working capital on retained earnings, cost intensity of operating costs on personnel costs, as well as the turnover of accounts payable. As a result of cluster analysis, it was found that indicators of the level of use of anti-crisis potential are indicators o the profitability on retained earnings, it is on such modified profitability indicators that differences in cluster groups are more noticeable than on profitability indicators calculated on the basis of «traditional» financial results. Two indicators of the use of anti-crisis potential are determined on the basis of the total amount of operating costs - the level of consumption of capital of the owners and the cost of personnel costs. In our opinion, the cost of personnel costs, which is the ratio of total operating costs to personnel costs, ie. the payroll together with social security contributions, best characterizes the contribution of all categories of employees in ensuring the crisis potential of construction companies. In other words, this indicator reflects the interaction of human, managerial, intellectual, and financial potential. Certainly, the value of this indicator, in any case, will be greater than one, if the company produces material good because then the structure of operating costs will include other elements, including material costs. In construction companies, the usual activity

is not limited to design work, they provide the construction of structural elements of buildings, and therefore the value of this indicator is higher than the three previous financial indicators (Table 1). The latter, the fifth indicator, differs significantly from the others not only in its values but also in its unit of measurement and economic content. As you know, the period of turnover of accounts payable is measured in days and reflects the average period of time the company pays for its current liabilities to counterparties. Given the specifics of construction activities and the long-term period of production and operating cycles, the considerable duration of the accounts payable turnover is natural. However, in a cluster with a low level of use of anti-crisis potential, its values are too large (Table 1) - 327 days, ie. almost a year.

In accordance with the results of cluster analysis, the following discrepancies can be determined between enterprises that use their anti-crisis potential to varying degrees:

- The burden of owners 'capital on operating costs, or the level of consumption of owners' capital as the use of anti-crisis potential decreases: for a typical representative of the cluster with minimum use of the ratio of the main positive components of equity to operating costs is 0.879. While the average use is only 0.373 variable for all analyzed enterprises, regardless of their anti-crisis potential. In both clusters, the standard deviations also differ significantly (Table 1), respectively 2.060 and 0.431. This means that the cluster with the average level of use is more homogeneous in this indicator, ie. its values in the cluster deviate less from the middle cluster, compared to the second cluster;
- Both indicators in the form of profitability in each of the clusters have a different sign (Table 1), and in the case of low use of anti-crisis potential, they are negative. This means that insufficient activation of resources aimed at ensuring economic security is detrimental to construction companies. Because then, due to the accumulation of uncovered losses, equity becomes negative, and therefore the profitability indicators become negative. Of course, under such conditions, viability and even remediation capacity are nullified. If the company is able to use at least part of its anti-crisis potential, it is expected that it will be able to achieve about 5.5% return on sales and 3.8% return on current assets, determined on the basis of retained earnings. In our opinion, these quantitative parameters should be defined as thresholds for achieving economic security. The indicator of return on sales is characterized by a smaller cluster variation for the average level of use of anti-crisis potential, while for the return on working capital a more stable level is found in a cluster with a low level. This conclusion is based on the values of standard deviations by clusters (Table 1): 0.376 and 3.186 for the profitability of operating sales and 0.778 and 0.538 for the current assets profitability, respectively, for medium and low levels.

The average cluster values of the cost of operating costs for personnel costs in a cluster with a low level of use of anti-crisis potential is almost twice as high as in a cluster with an average level: 27.33 vs. 14.61. This means that the staff costs of the typical representatives of each of the clusters are respectively 1/27 and 1/14 of the total operating costs. Thus, the savings incentives for labor and managerial potential have a negative impact on economic security. If we compare the ratio of the standard deviation in the cluster to the average cluster value, ie the coefficients of variation, in the group with a low level of potential use, this coefficient is much lower: 0.578 (= 15.78 / 27.33) against 0.825 (= 12.06 / 14.61). Therefore, this cluster group is more homogeneous in terms of the values of the analyzed indicator.

- As already mentioned, the cluster with a low level of anti-crisis potential use is characterized by a considerable duration of accounts payable turnover, which is 327.6 days and almost 10 times higher than the average cluster value at the average level - 38, 3 days. Such significant differences indicate the presence or loss of economic security. Given the large difference in the mean cluster values, this indicator, like the previous one,

it is advisable to compare not to the standard deviations but the coefficients of variation. In a cluster that does not use the anti-crisis potential, the coefficient of variation is 0.395 (= 129.56 / 327.62), while in another cluster it is 1.272 (= 48.73 / 38.29). That means that the cluster, whose enterprises use the anti-crisis potential at the average level, is characterized by greater variability in the turnover of accounts payable. On the one hand, this indicates better solvency, on the other - the lack of activation of anti-crisis potential does not allow to eliminate the shortage of cash resources in the short and medium term.

- How significant the differences of indicator values in cluster groups determine the results of the analysis of variance. First of all, it is necessary that the variance or the sum of the squares of the deviations of the observation values from the average cluster value in the middle of the cluster would be less than similar indicators calculated on the basis of average cluster values and the total average. That is, the intergroup variance must be greater than the variance in the middle of the groups. Accordingly, the Fisher's criterion (F-criterion) will become larger, while the level of significance p will decrease, which can still be characterized as the probability of classification error in the case of using a certain criterion. Table 2 shows the analysis results of the variance of the cluster distribution.

Table 2. Results of the variance analysis of grouping of the enterprises on a level of use of anti-crisis potential

Indicator	Intergroup sum of squares, number of degrees of freedom 1 (=2clusters-1)	The sum of squares within groups, the number of degrees of freedom 42 (=44 observations-2 clusters)	F-criterion	Reliability of the F-test, p
The level of capital consumption of owners	2,1	48,4	1,8351	0,182767
Profitability of operating sales on retained earnings	33,0	106,0	13,0523	0,000803
Return on working capital by retained earnings	5,2	22,3	9,7327	0,003267
Cost intensity of operating costs by personnel costs	1333,6	7144,7	7,8395	0,007691
Term of turnover of accounts payable	690618,7	243827,3	118,9612	0,000000

*Note. The critical value of the F-criterion F * (0.05; 1; 42) = 4,073*

Table 2 shows that the vast majority of indicators are statistically significant for cluster analysis of construction companies, as their Fisher's test exceeds the critical value not only for reliability of 0.05, but also for 0.01. Only the level of consumption of owners' capital was insignificant for the classification of observations of construction companies, as its reliability reached 0.183. It should also be noted that three indicators, namely: both profitability and cost-effectiveness in terms of personnel costs, despite the statistical significance, provided a cluster distribution in which the intergroup variance was less than the residual. However, the reason for this situation is a significant variation in the values of observations in terms of indicators, in particular, the value of the duration of accounts payable is measured in tens and hundreds of days, while working capital returns do not exceed one.

Given the statistical significance of the cluster distribution, the average cluster values of indicators should be used as a basis for monitoring the stability of the anti-crisis potential system in the medium and short term, when economic management aims to identify threats to economic security and prevent their impact [15].

It is proposed to create the interconnection between these subsystems on the basis of CALS-technologies, which are widely used in product life cycle management in science-intensive industries. CALS-technologies is a modern direction of development of information support of production and business processes, which is aimed at creating a single information space, based on integrated databases that make up a united information space.

In the literature, the term CALS stands for "Continuous Acquisition and Life Cycle Support" - continuous information support of supplies and life cycle or Ukrainian analogue of ISP - information support of product life cycle processes. In [20] CALS is considered as a concept and ideology of information support of the product life cycle at all stages, based on the use of a single information space (integrated information environment), which provides common ways of all participants interaction in this cycle - customers and suppliers (manufacturers) of products, maintenance and repair personnel, implemented in the form of international standards governing the rules of this interaction, mainly through electronic data interchange.

The concept of CALS has undergone a long evolution since the origin of this concept in the US defense industry due to the natural need to organize a single information space that provides rapid data exchange between customers, manufacturers, and consumers of military equipment [19].

According to historical and comparative analysis [20] there are the following stages of formation of the concept of CALS:

- Origin in the US Department of Defense in the mid-80's as (Computer-Aided of Logistics Support) «Computer Support for Logistics Systems». Initially, they were associated only with large-scale projects of the American military-industrial complex.
- In 1988, in the semantic sense of CALS-technologies, the typical military restrictions were lifted, and they became known (Computer-Aided Acquisition and Support) «Computerized supply and support».
- In 1993, the acronym CALS became known as Computer-Aided Acquisition and Lifecycle Support.
- In 1995, CALS began to be deciphered as (Commerce At Ligth Speed).

Currently, the term is accepted as (Computer Acquisition and Life-cycle Support) «Continuous information support of the product life cycle» The article proposes to use this concept as a basis for developing a system of continuous information support of the enterprise life cycle and economic immunity at each stage of its development. In contrast to the use of technologies, standards, and software and hardware CALS in product design, which provides the possibility of parallel execution of complex projects by several working groups (parallel engineering) at the design and production stages. It significantly reduces development time and costs when using CALS technologies for the formation of economic immunity, the possibility of parallel work of individual departments and specialists with information and threat detection is allowed in parallel, while the decision-making center is appointed only one. The results of the work of each individual group should be accumulated in the center. Based on the accumulated information, a decision is made to neutralize the risks of a particular group or the need to connect to the troubleshooting of the enterprise of other participants.

The variety of processes in the course of operational, financial, and investment enterprise activities and the need to prevent threats require active information interaction of all divisions of the enterprise, as well as key stakeholders who have the greatest impact on economic security.

Due to the fact that every year the amount of information used and transmitted, the need to create an integrated system of economic immunity of the enterprise at different stages of the life cycle, systematization of information interaction of components of the economic immunity system, lead to the need for an integrated information system (IIS).

Such a system should provide the possibility of interaction of different subsystems of the enterprise and analysis of threats from interaction with different stakeholders (suppliers, customers, competitors, state and local authorities, financial institutions, etc.) in order to prevent crisis development. All information in the IIS is stored digitally. All processes of information exchange with the help of IIS have the ultimate goal of the maximum possible exclusion from business practice of paper documents and the transition to direct paperless data exchange (in the practice of construction, an example is the creation of a BIM-model of objects).

The example of the formation of a single information environment to solve the problem of providing the system of economic immunity of the enterprise with the original data on the basis of a single information environment using CALS-technologies is to be considered. The first step is to define the functional responsibilities and interconnection between different users of the information environment, modeling the operational, investment, and financial activities of the enterprise within the life cycle, description of major business processes, description of organizational structure, modelling, and analysis of its operation. The purpose of the analysis is to identify the existing interactions and relationships between individual functional units and stakeholders of the enterprise, to assess their effectiveness, to identify duplication. Using CALS-technologies, an information model is developed that contains a detailed description of functional units, responsible executors, processes, and their relationship. A set of indicators that signal threats to the financial condition of the enterprise within certain activities, projects, stakeholders is determined. Limits are defined within which the decision to neutralize threats is made at the level of a separate functional unit or responsible executor or transferred to a higher level of management. The obtained information model allows solving a number of problems related to risk assessment.

Conclusion

The performed research results allowed to form scientific and methodological tools for identification and control of the level of anti-crisis potential of the construction company in the conditions of digital transformation. The information model of potential-generating resource flows of a construction enterprise, developed on the basis of CALS-ideology, which includes the author's methods of monitoring and controlling the level of economic immunity, allows improving the interaction of individual subsystems of a construction enterprise.

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