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METHODOLOGICAL APPROACH TO CONSTRUCTION OF A SYSTEM FOR DETECTION AND PREVENTION OF DESTRUCTION OF THE ACTIVITIES OF CONSTRUCTION PARTICIPANTS

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Abstract. The increasing complexity and risk exposure inherent in the implementation of construction projects underscores the critical need to develop a methodological framework aimed at detecting and preventing disruptive actions that threaten the performance of construction participants. The present study is dedicated to establishing a systematic approach to safeguard the activities of developers, contractors, and project stakeholders against destructive impacts, including reputational, financial, and operational disruptions. The objective of the research is to conceptualise and construct a preventive diagnostic system that integrates analytical models, digital monitoring platforms, and real-time communication protocols. The aim is to identify potential threats before they escalate into critical failures. The focal point of this study is the interaction environment of construction participants, wherein trust, information integrity, and process synchronization are identified as pivotal in ensuring project sustainability. The methodological foundation of the research combines system analysis, risk-oriented modelling, and process mapping techniques. The proposed framework incorporates the utilisation of behavioural indicators, deviation tracking algorithms, and early warning dashboards, which collectively facilitate proactive responses to disruption risks. Consequently, a modular architecture of a digital protection platform was developed, which facilitates real-time assessment of project vulnerabilities and supports adaptive decision-making across all stages of construction. The practical significance of this approach lies in its potential to reduce downtime, mitigate coordination failures, and enhance the reliability of project delivery. The results also offer valuable insights for improving communication transparency, automating compliance controls, and reinforcing institutional resilience within construction enterprises. The study makes a significant contribution to the development of intelligent support systems, which have the capacity to enhance the stability of construction actors in conditions of uncertainty, external shocks or deliberate interference.

Keywords: reliability, economic security, destruction, construction management and organisation, digital transformation, TAM, SAM, SOM model.

JEL Classification: C11, C45, L23, L74

1. Introduction

Due to the scale, complexity and branched structure of construction projects, as well as the dynamism of the construction environment and the actions of numerous interrelated risks and threats, identifying and overcoming the destruction of organisational systems and project structures can have serious negative consequences for another construction project. At best, this will result in budget overruns and delays to design deadlines; at worst, it will lead to disruption to project implementation. In the period preceding the war, the number of unfulfilled projects in the construction industry remained high for a variety of reasons. Data from 2021 to early 2022 indicate delays

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in the delivery of construction projects for a period of at least 12 months. Following the commencement of the war, the phenomenon of widowhood has practically ceased, and the present situation is such that approximately 30% of the facilities in Kyiv have never undergone restoration (Shatrova, Demydova, Tuhai, Savenko & Vornichesku, 2022). The situation is particularly acute in the eastern and southern regions.

The destruction of organisational and administrative systems in the context of construction projects poses a significant threat to the successful execution of these projects, often resulting in delayed completion or even the complete cessation of construction activities. Consequently, the identification of negative trends and factors with the potential to disrupt the investment and construction process is a key aspect of effective system development for construction organisation, monitoring and control. The creation of a single methodology for assessing destructions should meet the current needs of the construction system, which is based on digital transformation and should shape the current life cycle of the organisation of construction objects. Nevertheless, despite the significance of this problem for the field of construction organisation, many scientists have conducted a mostly fragmentary analysis, focusing mostly on individual studies of this problem.

Thus, a range of studies has examined various factors affecting the construction sector. The impact of multiple factors on construction timelines was investigated by Yemelianova and Tytok (2019), Zeltser, Kolot, and Panasiuk (2021), Zeltser, Pohorel'tsev, Zeltser, and Tuhai (2019), as well as Tuhai, Pokolenko, Yesipenko, and Dubinka (2020). The influence of labor intensity and cost was analyzed in the works of Hoiko, Sorokina, and Skakun (2018), and Yao, She, and Zhou (2024). The effects of digitalization and robotization on organizational changes in construction were addressed in the articles by Livinskyi, Kliuiev, Savenko et al. (2018), and Ukrinform (2022). Several studies, such as Tuhai and Chupryna (2011), focused on the transition to the European regulatory and legal framework in the context of organizational and technological transformations. Tuhai (2008) examined the influence of seasonal and environmental factors on key construction parameters. The issue of construction quality was studied by Tuhai, Hryhorovskyi, Khyzhniak et al. (2019), Abbasianjahromi and Aghakarimi (2023), Zeltser and Dubinin (2016b), Yemelianova and Tytok (2020), Zeltser (2018), and Pokolenko and Chupryna (2011). Nevertheless, despite a thorough examination of specific elements of the problem, unresolved issues related to destructive changes in organisational structural projects and construction environments persist.

In order to reduce the number of unfulfilled projects, it is imperative to employ scientific methods and undertake a comprehensive risk assessment, as well as a thorough examination of factors that have the potential to compromise the integrity of construction organisation and administration systems.

The development of separate systems of models aimed at the occurrence and overcoming of destruction allows decision-makers to understand the perceived probability of events that affect irreversible changes in the construction organisation system. This, in turn, allows them to implement preventive and control measures to reduce the likelihood of such incidents.

2. Methodology

To identify the causes of organisational destruction, the study employed a content analysis alongside a survey of experts from the professional administrative community in the field of construction organisation. These experts included chief project engineers, technical supervision engineers, project specialistsand project managers. A total of 150 surveys were distributed and 132 were returned (88% of the total), enabling the study to determine the causes and main causes of destruction of the construction system of the organisation. As a result, 42 factors were identified that could be crucial in dismantling the organisational system of construction projects.

Widely branched network systems, such as complex networks (complex networks) (Jacomy, Venturini, Heymann, & Bastian, 2014), neural networks (artificial neural network, neural networks or neural networks) (Yao, She, Zhou, 2024) and Bayesian networks (Ayes networks, Bayesian networks, belief networks, Bayesian model, probabilistic directed acyclic graphic model) (JaHu, 2006) provide support for effective mechanisms for solving problems related to the study of risks and disruptions in the functioning of the development of complex systems.

Bayesian networks have been shown to be particularly effective in addressing the challenges of risk identification and uncertainty assessment in the development of complex systems (including the organisational structure of a construction project and the development of construction participants and their economic security), especially in cases where there are causal mechanisms between the causes of change. The advent of networks has rendered the process of tracing the path of probability propagation from the causal factors that are detected to the result a possibility. This, in turn, facilitates the calculation of the probability of a positive or negative development process. It is therefore evident that Bayesian networks are a valuable tool that improves understanding of the process and scale of causal factors in the destruction of construction organisation systems.

The present study employs an evaluation of the risks associated with the destruction of construction organisation systems of the information network.

The assessment of destructive changes in the construction organisation system includes several key stages, namely: the identification of negative changes, the identification of causal factors, correlation analysis, network topology construction, the study of network parameters, and inversion of reasoning. As demonstrated in Figure 1, the initial stage of the research process involves the pre-processing of the collected data on deviations of construction parameters from the stipulated design requirements. The data is collected through two principal means: text analysis and questionnaire processing. In the former, keywords pertaining to the causes of destruction are highlighted, cleaned, sorted, and combined into similar groups so as to isolate elements of key functions that contribute to destruction. Subsequently, correlation analysis is performed to ascertain the relationships between these key characteristics. Based on the results of the analysis and the experience of experts, the topology of the original network is built. Conditional probabilities should be obtained in a similar manner, utilising a model for evaluating the risk of destruction based on Bayesian networks. The parametric self-learning process is then initiated, and the results are analysed. This approach, founded upon the utilisation of Bayesian networks, facilitates the identification of the trajectory of destruction and the most sensitive factors that precipitate such occurrences.

The initial step in the process entailed the examination and categorisation of the experts' responses into text sets.

In this study, the method of merging words with similar meaning but different linguistic expressions was employed. For instance, phrases such as "violation of work deadlines by contractors", "delays and stops of construction participants", and "delay in the start of work due to the fault of the work performers" were grouped to reduce the semantic redundancy of the data set and combined into the group "delays due to the fault of contracting companies performing previous work". Expressions such as "labour safety violations" and "failure to comply with personal protection requirements", "fines for violation of labour safety requirements", "violation of labour safety rules and requirements", "failure to comply with work performance rules", and "ignorance of safety

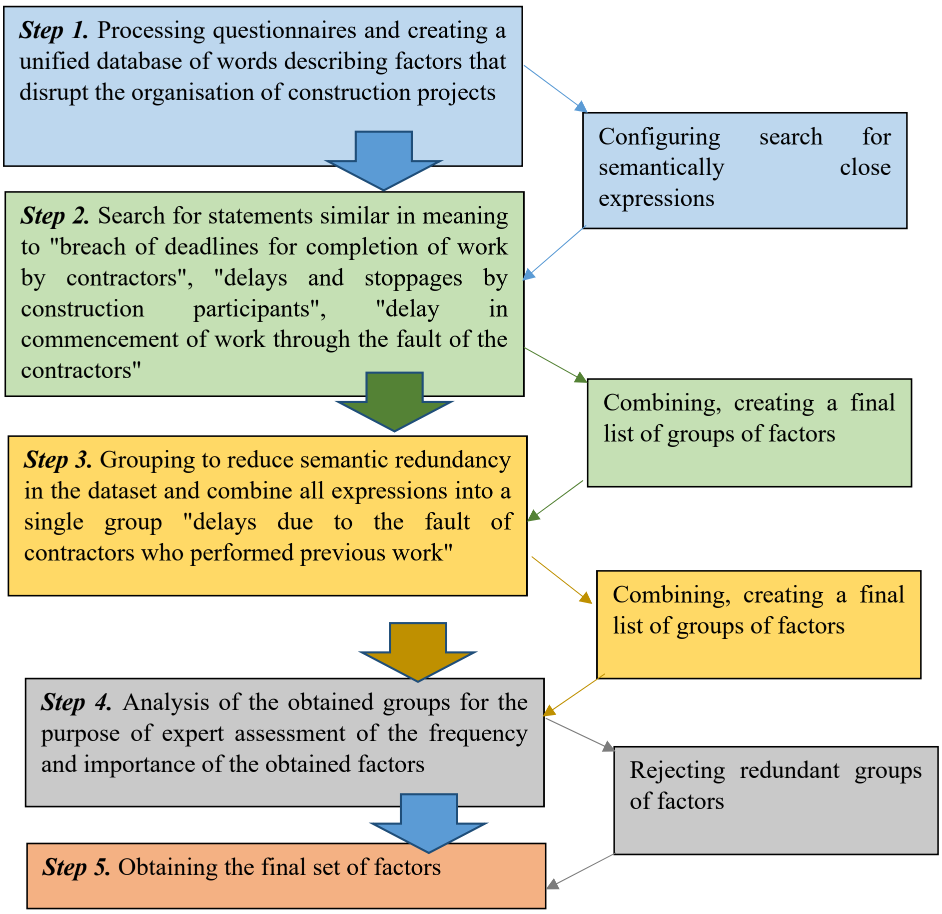

Figure 1. Stages of data preprocessing
Source: developed on the basis of a literature review

precautions" were combined into "violation of work and safety precautions" to facilitate statistical processing of the analysis data. The same procedures were applied to other factors. A comprehensive delineation of this process is provided in Figure 1.

3. Stages of Building a Destruction Management System for Construction Participants

The identification of destruction factors is carried out in the following sequence:

1. Data collection and processing, generalisation of similar answers or synonyms in the experts' answers.
2. Creation of a network of factors of destruction of construction organization systems. The initial model, created in the GEPHI 0.10.1 software product based on the construction of a matrix of common dependencies, will allow to identify the cause-and-effect relationships between factors, their strength and mutual influence.
3. Probabilistic model, created using the GENIE 4.0 software based on the construction of a matrix of common dependencies between factors.
4. Parametric learning and analysis of conclusions, creation of a model that takes into account the path of possibilities for overcoming the destruction of construction organization systems of objects.

Table 1
Statistical table of key signs of causal influence on the destruction of the construction organization system (fragment)

No.	Code	Key characteristics	Number of cases
		Budgetary and financial factors (Bf)	
1	*Bf1*	Violation of project financing schedules or individual stages	72
2	*Bf2*	Poor project cost management	64
3	*Bf3*	Delays in payment for completed work	53
		Design and planning factors (Hf)	
4	*Hf1*	Errors in project documentation	32
5	*Hf2*	Reworking individual sections of the project to meet customer requirements	19
6	*Hf3*	Using fundamentally new organisational and technological approaches and solutions	8
7	*Hf4*	Low quality of incoming control of project documentation	22
8	*Hf5*	Availability of IT support and software compatibility	36
9	*Hf6*	Delays in obtaining permits and licenses	16
10	*Hf7*	Poor work planning, allocation of specific actions, tasks, duties and responsibilities.	19
		…	
		Resource factors (Rf)	
15	*Rf1*	Inadequate provision of material resources	26
16	*Rf2*	Insufficient level of digitalisation of project implementers	30
17	*Rf3*	Insufficient qualification of personnel	32
18	*Rf4*	Inconsistency of material and technical resources with quality requirements	19
19	*Rf5*	Lack of a flexible adaptive system for digital staff development and advanced training	17
		…	
		Structural-functional (Sf)	
20	*Sf1*	Errors in concluding contracts and selecting contracting organisations	19
21	*Sf2*	Imperfect procurement mechanism	16
22	*Sf3*	Information support system for project participants	44
		…	
		Administrative and managerial factors (Af)	
26	*Af1*	Non-compliance with work procedures and construction plan	20
27	*Af2*	Insufficient level of risk management	32
28	*Af3*	Project manager effectiveness, lack of communication, ability to coordinate and motivate the team	54
29	*Af4*	Delays due to contractors performing previous work	30
		…	
		Other factors (If)	
		…	
42	*If4*	Changing rules and regulations in the construction sector	26
43	*If5*	Changing key members of the project management team	29

Source: developed on the basis of a literature review

As illustrated in Table 1, the paper sets out to explore the key features of the causal influence of a number of factors on the construction organisation system. In addition, it provides statistical data on the number of cases of identifying specific budgetary and financial, design and planning, resource, structural and functional, administrative and managerial and other factors among the experts' responses as the causes of destruction.

A co-occurrence matrix is a set of words that appear together in the same text. The frequency of distribution of these words is determined, and their mutual influence and co-distribution are calculated. These calculations are based on cases when these factors occurred together in the expert questionnaires. The co-occurrence matrix obtained in this study is presented in Table 2.

The generated co-occurrence matrix was imported into Gephi software (BnF, Paris, France) to analyse and visualise the relationships between the data, thereby creating a network of causal relationships in the sphere of influence of factors on the destruction of the construction organisation system, as shown in Fig. 2. The resulting networks encapsulate the synthesis of various key terms that describe the main factors of critical violations of the construction organisation system obtained through content analysis. This clarifies the importance and dispersion of relationships among these terms using two algorithms. The first of these is ForceAtlas2 (Shatrova, Demydova, Tuhai, Savenko, Vornichesku, 2022), and the second is Yufan Hu Proportional (Savenko, Palchyk, Dotsenko, Chertkov, 2018).

As illustrated in Figure 2, the Yifan Hu model incorporates a colour coding system for its vertices, with each vertex assigned a colour based on the group to which the factor belongs, and the intensity of the factor's influence (weight) and its sphere of influence, as previously delineated. The model was created using the following settings:

– Optimal distance is 100.0 (to place nodes further apart);
– relative strength is 0.2;
– initial step size is 20.0;
– step factor is 0.95 (provides better quality compared to speed).

A visual inspection of the model revealed that factors Rf5 (lack of a flexible adaptive system for digital personnel development, advanced training), Hf10 (selection of a site without prior research), Hf4 (low quality of incoming control of project documentation), Rf4 (mismatch of material and technical resources and resource quality control, material specification planning does not take into account compliance factors), If4 (change in rules and regulations in the field of construction), If2 (complicated construction conditions), If3 (disasters (war, fires, earthquakes and landslides, etc.)) are at some distance from other factors that are closely interconnected, which indicates their somewhat external impact on the construction organisation system, which only in a few cases may depend on the actions of construction participants (Rf4, Hf4, Rf5, Hf10), while others, influencing the construction organisation system, changing it, remain macro-factors that have an impact on all other factors, while remaining external and uncontrollable for construction participants, which requires their mandatory consideration, an adaptive approach to changing construction organisation systems.

Table 2
Matrix of sharing factors of destruction of the construction organization and management system (fragment)

	Bf1	Bf2	Bf3	Pf1	Pf2	Pf3	Pf4	Pf5	Pf6
Bf1	72	56	63	0	0	0	0	2	6
Bf2	60	64	50	0	3	0	0	0	0
Bf3	0	0	53	2	4	0	19	0	0
Pf1	0	11	13	26	3	0	0	2	1
Pf2	0	10	0	17	19	14	6	0	0
Pf3	0	0	0	0	4	8	0	0	6
Pf4	0	0	0	18	16	0	22	18	0
Pf5	0	12	0	13	10	0	12	36	0
Pf6	0	0	0	0	0	0	0	0	16
Pf7	0	0	17	3	1	0	0	0	6
Pf8	10	16	8	0	0	0	16	0	12
Pf9	0	2	21	0	15	6	0	0	4
Pf10	0	4	8	20	13	0	0	0	0
Pf11	0	8	4	0	0	6	0	0	0
Rf1	0	26	26	0	0	0	0	0	0
Rf2	12	25	3	3	3	15	6	28	0

Source: calculated by the authors

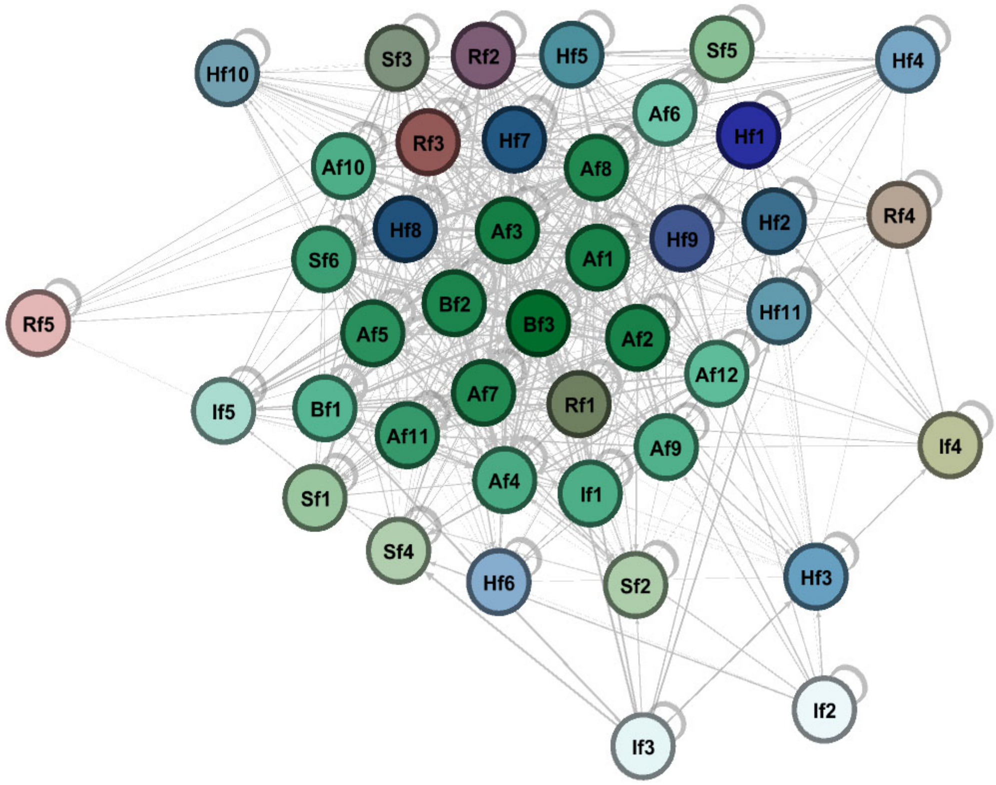

Figure 2. Visualisation of the influence of a number of factors of destruction of organisational systems, created using the Yufan Hu algorithm

Source: calculated by the authors

Construction participants can achieve a high level of economic security by analysing the trends of changes in factors or the relationships between them, thereby preventing the destruction of the construction management and organisation system. An illustration of such management is evident in the assessment of the level of digitalisation of all participants (factor Rf5) and its augmentation via the utilisation of the tools of the TAM, SAM, SOM model adapted to the realities of construction. These tools are proposed for the assessment of the level of digital development of construction participants (Fig. 3).

The tools TAM (Total Addressable Market), SAM (Serviceable Available Market) and SOM (Serviceable Obtainable Market) are traditionally used in business planning to assess the market. However, they can be successfully adapted for the implementation of digital technologies in construction, if the "market" is considered not only in financial terms, but also in terms of its organisational potential for transformation. This can be achieved by considering TAM (Total Addressable Market), defined as the total potential for digitalisation in construction, i.e., the maximum possible scope of digital technology implementation in all subsystems of the industry, if resources are unlimited and there are no barriers, thus enabling an assessment of the strategic potential of digital transformation of the construction industry as a whole. Concurrently, the concept of the SAM (Serviceable Available Market) should address the question of which enterprises and projects possess the capability to transition to digital solutions within a timeframe of 3–5 years. The SOM (Serviceable Obtainable Market) component of the SAM encompasses the present scope of coverage, taking into account the existing implementation experience, team composition, technical resources, extant digital solutions (BIM, digital estimates, planners, CRM, etc.), and the readiness of company management.

The TAM-SAM-SOM model has been adapted to the levels of digitalisation, with "Market" replaced by "Level". This has resulted in a new model, TAL-SAL-SOL (Total Addressable Level, Serviceable Available Level, Serviceable Obtainable Level), which determines the potential, real opportunities and actual level of digitalisation in the construction industry or in an individual company. In lieu of financial or market volumes, consideration is given to the levels of implementation of digital technologies.

TAL is the strategic goal of digitalisation. It determines the best possible processes without restrictions. SOL is the maximum achievable level given the current resources and environment. This is the tactical planning zone. SOL is the current

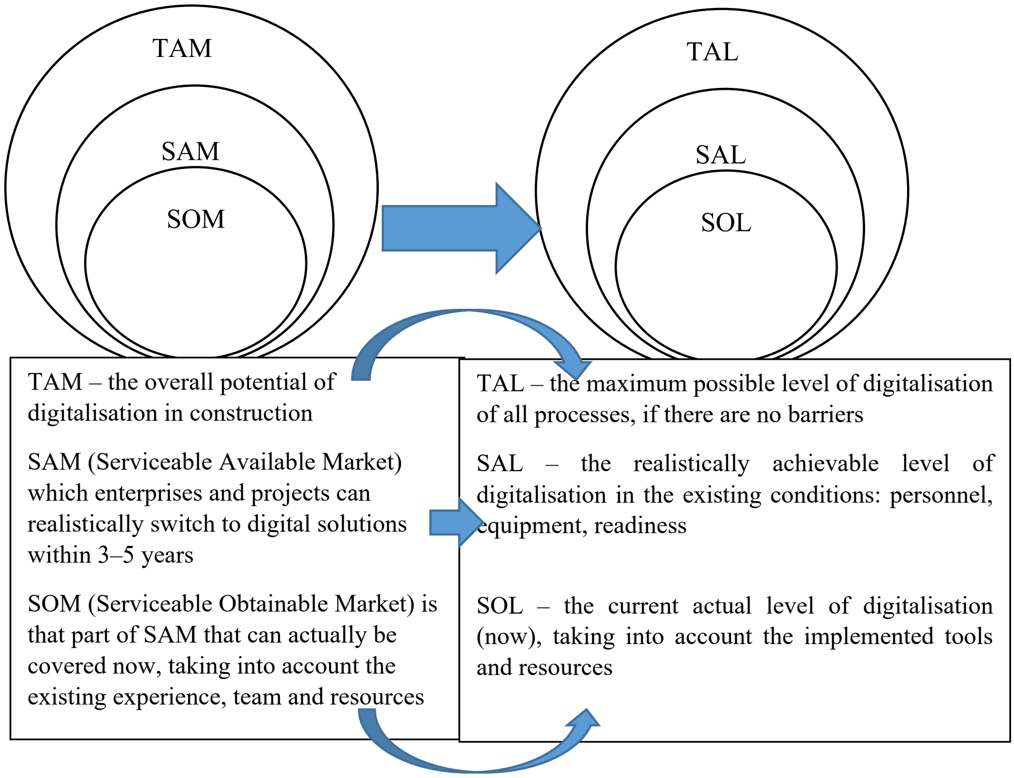

Figure 3. Conceptual transformation of the TAM, SAM, SOM model into the TAL, SAL, SOL model

Source: developed by the authors on the basis of a literature review

reality. It shows where the company or project is now. The TAL-SAL-SOL model offers a new qualitative approach to assessing digital maturity in construction. The process of digitalisation can be quantified and structured, thereby converting the abstract concept of "digitalisation" into specific values, levels and steps. Furthermore, it facilitates adaptive management and evaluation of preventive measures to mitigate destruction.

4. Conclusions

The proposed methodology for assessing the destruction of construction organisation systems is predicated on the simultaneous utilisation of expert assessment methods and Bayesian networks. The implementation of this methodology will engender an enhancement in the level of safety and a reduction in the risks of destruction or critical requests of the construction organisation system of various objects. The findings suggest that the probability, importance and sensitivity of destruction factors remain at average or low levels. However, an increase in risk has been observed due to military actions and changes in the construction sector itself. The dissolution of a construction organisation system typically arises from factors that are of medium or large scale. Such failures can occur for a variety of reasons, including inadequate planning, insufficient risk management, external shocks or systemic inefficiency. In order to reduce these risks and restore the organisational system, a multifaceted approach is required, which includes strategic planning, reliable risk reduction and organisational resilience. The implementation of a preventative management system has been shown to have a number of benefits, including the ability to minimise the risks of failure and to create measures that can improve or rebuild the construction organisation system.

The study found that the risks of project disruptions are multidimensional, encompassing financial, logistical, technical and human factors. In order to mitigate the aforementioned risks, a proactive and comprehensive approach is required.

A fundamental step in the mitigation of disruptions is to conduct a comprehensive risk assessment during the planning phase. This process entails the identification of potential risks, the assessment of their likelihood and impact, and the development of strategies to address them. It is evident that tools such as risk matrices, simulation models and contingency planning can assist project managers in preparing for uncertainty. For instance, the anticipation of supply chain delays by securing multiple suppliers or stockpiling critical materials can prevent project downtime.

One of the most common causes of disruption is poor communication between stakeholders. Clear communication protocols and modern project management tools, such as Building Information Modelling (BIM) and cloud-based collaboration platforms, can improve coordination between contractors, subcontractors, developers, designers and clients. Regular meetings and briefings throughout the construction process ensure that all parties are aligned and can respond quickly to new challenges.

It is widely acknowledged that financial instability represents a significant risk with regard to construction projects. The establishment of a robust financial management system, incorporating contingency funds and performance bonds, can serve as a safeguard against unanticipated expenses. Transparent budgeting and regular financial audits further ensure efficient resource allocation and minimise the risk of insolvency.

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