Primljen / Received: 29.4.2025.
Ispravljen / Corrected: 26.6.2025.
Prihvaćen / Accepted: 30.6.2025.
Dostupno online / Available online: 10.8.2025.

Impact of elements of complexity on project success

Authors:

Assist.Prof. **Marin Nikolić**, MCE
University of Zenica, Bosnia and Herzegovina
Faculty of Polytechnics
marin.nikolic@unze.ba
Corresponding author

Prof. **Anita Cerić**, PhD. CE
University of Zagreb
Faculty of Civil Engineering
anita.ceric@grad.unizg.hr

Original research paper

Marin Nikolić, Anita Cerić

Impact of elements of complexity on project success

Research on the elements of complexity as some of the key factors influencing project success has become important among researchers and practitioners in the construction industry. Considering the most common contracting methods today, and because most resources of a project rely on contractors, the control of many indicators that affect project success is transferred to the contractor. This paper presents an analysis of the impact of elements of complexity on project success during the construction phase. Through a survey with project managers, we analyzed the impact of elements of complexity on the success of a project through five phases of construction. The results of the analysis are presented through different graphs showing changes in the intensity of the impact of complexity on project success. The research showed that elements of complexity have the most significant impact on the success of a project in the execution phase. The results can assist contractors to pay more attention in certain phases of the projects to specific elements of complexity and thus impact the success of the project.

Key words:
construction project, project complexity, construction project complexity, complexity elements, project success

Izvorni znanstveni rad

Marin Nikolić, Anita Cerić

Utjecaj elemenata kompleksnosti na uspjeh građevinskog projekta

Istraživanje elemenata kompleksnosti kao jednog od ključnih čimbenika koji utječu na uspjeh projekta važna je tema među istraživačima i praktičarima u građevinskoj industriji. S obzirom na načine ugovaranja i na to da većinu resursa na projektu zapošljava izvođač, danas je stanje u građevinarstvu takvo da investitor kontrolu velikog broja pokazatelja koji utječu na uspjeh građevinskog projekta uglavnom prebacuje na izvođača radova. U radu je prikazana analiza utjecaja elemenata kompleksnosti na uspjeh projekta kroz faze izvođenja radova. Istraživanjem provedenim među voditeljima građevinskih projekata kod izvođača radova analiziran je utjecaj elemenata kompleksnosti na uspjeh projekta kroz pet faza izvođenja radova. Rezultati provedene analize prikazani su kroz različite grafove koji prikazuju promjene intenziteta utjecaja kompleksnosti na uspjeh projekta. Očigledno je da najveći utjecaj na uspjeh projekta elementi kompleksnosti imaju u fazi izvedbe radova. Rezultati istraživanja mogu pomoći izvođaču radova da u pojedinim fazama projekata veću pozornost posveti pojedinim elementima kompleksnosti te da tako utječe na uspjeh projekta.

Ključne riječi:
građevinski projekt, kompleksnost projekta, kompleksnost građevinskog projekta, elementi kompleksnosti, uspjeh projekta

1. Introduction

Complexity and project success have been linked because the beginning of project complexity analysis as a scientific discipline. The goal of all parties involved in a construction project (investors, supervising engineers, contractors, suppliers and subcontractors), regardless of the degree of complexity, is to complete the project on time, on budget, and with the highest possible quality and work safety. In the search for project delivery to the satisfaction of all project stakeholders, understanding the factors that impact project success has become a major preoccupation of construction practitioners, professionals, and stakeholders [1]. Cost overruns and time delays are common project problems that have been researched for years [2]. One of the reasons for project failure is increasing complexity [3] or underestimating the complexity of the project in the schedule phase [4]. In practice, in the schedule phase, stakeholders tend to consider projects as linear and predictable processes when setting the budget and time for the implementation of a project. However, a closer analysis of real-life examples shows that the construction project is essentially a nonlinear and dynamic, i.e., complex, process. Thus, the project should be considered as a complex and unpredictable process when developing the project plan to influence its results and success [5].

The effects of project complexity on project success have been studied. References [6-8] discussed the negative effects of increased complexity on execution results, i.e., project success. Bosch-Rekveldt et al. [9] stated that when project complexity is properly defined, the improvement of project outcomes in the project scheduling phase is affected by the type of complexity of the project should be investigated. Existing research has not analyzed the impact of different degrees of complexity on different project results [8]. Furthermore, existing research has not addressed the variation in the intensity of the impact of complexity on project results and success at different phases.

The complexity of the projects, as well as the degree of uncertainty in the project, is a characteristic most often associated with large-scale projects, particularly for construction projects. When discussing the complexity of the construction project, project stakeholders often justify their failure with the high degree of complexity of the project. Their claims are often based on subjective assessments without clear analyses that would determine the actual scenario in terms of the impact of the level of complexity on the success of the project. The degree of complexity represents the degree of probability of risk occurrence depending on the characteristics of the project.

Current conditions in the construction market significantly affect the complexity of a project. Today's construction market is characterized by workforce shortages, high workforce fluctuation, high demands on speed and quality of construction, and politically unstable environments. Therefore, construction projects are characterized by a high degree of uncertainty and complexity, which can represent crucial factors related to the success of the project. Therefore, all parties involved in the construction project should determine the intensity, as well as the change in intensity, of the impact of certain elements of complexity on the success of the project during the construction phase.

This paper is primarily concerned with determining the nature and intensity of the impact of a project's degree of complexity on its results and success at each stage of the execution. The main objective of this paper is to determine the change in the degree of impact of complexity and individual elements of complexity on the success of a project through parts of the project construction phase. By determining this impact, project stakeholders can focus on the elements of complexity with a greater impact on project success in the project construction phase and thus manage project success.

2. Literature review

The construction industry, like many other industries, requires significant progress in terms of more successful project management in today's increasingly competitive marketplace. Project success in terms of cost and time, as well as quality and safety at work, has always been considered poor in the construction industry [10, 11]. The reason for poor results in construction is considered to be because the design and construction process itself has a high degree of complexity [12]. The ability to measure the impact of complexity on project success in the early stages of the project can result in a better understanding of the project, creating additional benefits for successful project management and reducing the risks associated with project complexity [12].

The relationship between complexity and project success has been the focus of extensive complexity research over the past twenty years. Researchers generally recognize that project complexity impacts project execution and possibly project success [13-16]. Project managers agree that a lack of understanding of project complexity often causes project failure or ruin [17]. Many studies have shown that project success depends on complexity, and traditional project management methods are not sufficient to adequately address complexity [18].

Large construction projects are generally high-visibility, public sector works, such as stadiums, capital improvement projects, and transportation corridors. They often last longer than one year, require cooperation between hundreds of stakeholders, and cost more than $50 million to complete [19]. The success of these projects depends largely on how well the complexity and risks of the project are determined in the decision-making phase [20, 21]. This relationship means that by planning and analyzing the degree of the impact at different stages of the construction project, stakeholders can effectively manage the complexity of the project and the consequences of their impact on its success. A further step in this management is to consider the different impacts of individual elements of complexity at different stages of the construction work, with the aim of monitoring and managing the project as comprehensively as possible.

2.1. Project complexity

The notion of complexity is often used when discussing construction projects. Construction projects consist of many elements, and their implementation requires many participants and resources and various techniques for their management. With these characteristics, construction projects match our general understanding of something that is significantly complex.

Table 1. Classification of groups with associated key complexity elements from a contractor's perspective

Operational and technological complexity group	Scope complexity group	Organizational complexity group	Complexity group related to resources on the project	Legal and Sociopolitical complexity group	Economic complexity group	Communication complexity group	Environment complexity group
Change in technology intended for the execution of works during the execution of works	Changes in the scope of the project over the course of execution	The importance of the project for the investor	Diversity and availability of workforce	Political impact on the project	Financial conditions of the contractor	Communication with the supervising engineer and investor	Incorrectly planned geological conditions
Incomplete and inaccurate project documentation	Number and overlap of Critical Activities	The influence of the supervising engineer	The expirience of the project manager which is acquired on similar projects	Local legislation	Economic stability of the investor	Concealment of information between participants	Geological conditions
Technology intended for the execution of works	Number and overlap of activities on the project	Significance of the project for the company	Workforce fluctuation	Local experience	Project financing	Relationship between the project manager and the parent organization	Construction site in traffic
Inadequate bill of quantities	Quantity of additional works	Subcontractor works on the critical path	Experience of the project team acquired on similar projects	Holding elections in the course of project execution	Payment deadlines	Communication with subcontractors and suppliers	Local climatic conditions
Presence of transport system near the construction site	Variety of project scope	Coordination of participants	Oscillations in the number of resources required for the project	Local community	Number of variations on the project	Procedures on the project	Interaction between the technological system and the environment
Requirements of preparatory works	Number of Cost Significant Items and Cost Significant Items on a Critical Path	Multiple contractors on the project	Change in the project manager over the course of execution	Changes in legislation during the execution of the project	Change in prices over the course of the project	Communications within the project team	Construction site in a public environment
Technology unknown to the Investor	Project value	Number of subcontractors and suppliers	Diversity and availability of material resources	Contract type	Changes in the global economy	Large amount of information about the project	Hydrological and hydrotechnical conditions
Energy Requirements	Size of the project in terms of funds	Number of hierarchical levels in the project team	Diversity and availability of equipment	Culture of claims	Availability of cost data for specific activities	Capacity of the project team to transfer the infromations	Construction site in the historical core
Quality Control and Quality Requirements	Duration of the project	Number of construction site locations	Resource delivery	Number of contracts	The existence of advance payment	Meetings	Construction site in contaminated environment
Function of the structure being built	Overlap of project phases and the interconnectedness of activities from different project phases	Number of investors	Resource quantity	Cultural diversity of participants	Currency of cost calculation	Diversity of participants communication cultures	Groundwater protection zone

The construction industry has shown much difficulty in dealing with the increased complexity of large construction projects [22]. Bertelsen [23] explained that the general view of construction projects is such that they are considered to be a regulated and linear phenomenon that can be organized, planned, and managed properly. Frequent examples of failure to complete construction projects on time and within the established plans have resulted in a reconsideration of how accurate such a general view of construction is and have forced us to consider whether construction projects are as predictable as we consider them to be.

Continuous requirements related to the speed of construction; cost and quality control; workplace safety and dispute avoidance, and technological progress; economic liberalization and globalization; environmental issues; and fragmentation of the construction industry have resulted in a significant increase in the complexity of construction processes. Regardless of how their relationship is conceptualized in the literature, complexity and uncertainty have significant impacts on project performance. Today, complexity has reached a level where construction project managers must carefully consider its impact on the success of a project [24]. A common opinion is that poor results result from the planning and construction processes are significantly more complex for several reasons [25-27].

Certain characteristics of a project form the basis of determining the appropriate management actions required for the successful completion of the project. Complexity is one such critical characteristic [28]. However, understanding project complexity for better project management is not automatically focused on reducing project complexity [12]. The degree of complexity of projects is increasing; therefore, project complexity requires better understanding and measurement to make better decisions [29].

An important step when measuring the degree of complexity, i.e., its impact on project success, is to determine the key elements of complexity with the greatest influence on the project. In their paper in 2022, Nikolić and Cerić [5] determined the classification of groups of complexity elements with the associated key forms of complexity from a contractor's perspective (Table 1). This classification was also used in this study. The impact of the overall complexity, as well as each group and individual element of complexity, on the success of a project in the construction phase was analyzed.

Many researchers have emphasized the relative importance of complexity in the project management process. Analysis of project complexity helps project managers to clearly determine the requirements in the phases of project planning, coordination, and control. Moreover, complexity makes clearly identifying and defining objectives difficult; it plays a major role in selecting the appropriate organizational structure of the project, project inputs, and the appropriate procurement modalities for the project. Finally, it affects project objectives in terms of time, cost, and quality [25]. The combination of complexity science and project management created a new way of measuring project success and a modern way of recognizing the dynamic nature of a project [30].

2.2. Relationship between complexity and project success

Although project complexity is not clearly defined [3, 8, 23, 31, 32], it is recognized as one of the critical characteristics of a project that determines the appropriate actions that will result in its success [25]. The complexity of a project is widely considered to affect the results of execution and possibly results in the success of the project [13, 14, 16]. Baccarini [25] stated that project complexity helps to determine the requirements in terms of planning, coordination, and control; this makes clearly identifying and defining the project objectives difficult. Additionally, complexity plays a major role in selecting the appropriate organizational structure, project inputs, and appropriate procurement arrangement. As a determinant of the project, complexity significantly affects the project objectives related to time, costs, and quality [5].

The concept of what constitutes a successful project is highly controversial in the field of project management [33]. Project success is traditionally defined as the degree to which project goals have been met [34]. For different researchers, project success means different things. Although project success has been analyzed in many studies over the years, no consensus exists on the definition of project success today [35-38]. Project success is an abstract, subjective, and extremely complex concept that evaluates the state of the project [39, 40].

Project success is a complex and often illusory concept, yet it is critical to the effective implementation of the project [34]. Researchers such as de Wit [41] stated that a project can be considered successful if its participants generally achieved project success and if the technical requirements defined by the project task were met. Muller and Turner [42] found that projects differ in terms of size, uniqueness, and complexity. This led researchers such as Westerveld [43] to conclude that the factors used to measure project success can vary by project, and identifying a clear set of factors that affect all projects in all industries is difficult. To summarize, most researchers, investors, and project managers today view project success as a measure of the following criteria: budget, plan, customer satisfaction, and performance results.

Almost all industries are dynamic by nature, and the construction industry is no exception [40]. As mentioned earlier, the construction industry, like many others, has a significant need for advancements in effectiveness and efficiency to advance in today's increasingly competitive marketplace. New methods and techniques should be developed to better implement quality management and minimize losses [44]. Generally, the reasons for cost and time overruns lie in the poor level of knowledge regarding the management of construction projects [45]. Some of the criticism of this is correct. However, as with everything, such criticisms are not entirely justified. A major problem for the construction industry is that to properly manage a project, the scope of the project and its characteristics must be defined. This primarily refers to the project characteristics related to uncertainties, which we consider to be an essential part of project complexity. A generally accepted opinion is that

poor results in construction are caused by the high degree of complexity of the construction process [12].

The environment of construction projects and their characteristics are becoming more dynamic owing to the increasing uncertainty in the technologies used, the budget, and the development processes [45]. Construction projects are completed from a combination of many events and their interactions, planned and unplanned, throughout their life, including the change in stakeholders and the development of the project in an ever-changing environment [46].

Different types of projects have different contingencies that require different management approaches [47]. Although complexity is not clearly defined [48-51], it is nevertheless recognized as one of the crucial characteristics of a project that determines the appropriate actions that result in the success of the project [25].

As a conclusion of their research, Tatikonda and Rosenthal [52] found that different elements of technological innovation, as well as project complexity, have different effects on individual project objectives at different stages. They considered that by applying their research findings, they could help organizations improve their effectiveness by better predicting results for different types of projects and help them utilize the management practices required for a particular project. Therefore, they have already linked the achievement of project goals, i.e., the success of the projects, with the complexity of the projects; they have created a framework showing that the achievement of project goals depends on technology innovations and project complexity. Therefore, the way organizations anticipate, understand, and manage complexity determines their success or failure [53]. Many researchers, such as Baccarini [25], take the position that project success is directly dependent on project complexity and that this has a direct impact on the overall results of the project [9, 14]. Often, certain projects are overestimated in terms of their complexity, whereas others are significantly underestimated [54]. Experienced companies and experienced project managers will consider certain projects to be less complex than companies and project managers with less experience [54]. Wood and Ashton [55] indicated that the importance of identifying the impact of project complexity lies in the project phases before construction begins. If the contractor can measure complexity in the early stages of the project, they would have a better understanding of the project and, accordingly, a significant benefit in successfully managing the project and reducing the risks associated with complexity [55].

As the construction phase of a construction project encompasses the highest concentration of resource utilization and financial expenditure, it is clearly pivotal in influencing the success of the project. Therefore, this paper presents an analysis of the impact of project complexity over the entire construction phase, as well as individual parts of this phase. The success of large construction projects depends largely on how well the complexity and risks of the project are determined in the decision-making phase [21, 22]. Because most decisions are made in the construction phase, considering its dynamics, each of these decisions should be based on certain input parameters. A facilitating circumstance in managing a project at its execution stage can be that a project participant is aware of the intensity of the influence of complexity, i.e., certain characteristics of the project, on its success.

As mentioned earlier, several studies have been conducted on the relationship between project complexity and success and models that attempt to quantify this relationship. However, none of these models define the relationship between complexity and success in the project construction phase. This relationship in this phase can be crucial to the overall success of the project. In this paper, the direct dependency of project success on the degree of project complexity in the project construction phase has been identified without a more detailed analysis of the role of complexity and how this measure consequently affects the results and success of a project. Therefore, the change in the degree of complexity's impact on project success is analyzed without much detail about how exactly this is achieved. This analysis should be the subject of a future study.

Because the intensity of the impact of the elements of complexity varies at different times during the execution of the project, the individual phases of the project and the phase of execution of the work should be separated. In these phases, the different intensity of the influence of the individual elements of complexity on the project is determined. The review of the literature shows that the project can generally be divided into five phases:

- Conceptualizing
- Planning
- Construction
- Monitoring
- Project cost control and project completion

Because the paper addresses the influence of complex elements on the success of the project in the construction phase, the phases of project execution must be defined to achieve better results. For the contractor, this phase begins with the signing of the contract for the execution of the work. The project construction phase is also divided into five parts:

- **Schedule phase:** includes planning with basic activities and determining the requirements of the construction site and technical planning
- **Selection of key stakeholders and procurement:** includes the selection of project stakeholders and the review of the procurement plan, as well as the execution of key procurements that ensure the smooth implementation of the project
- **Preparation phase:** includes site preparation, clarification of local community issues, establishing local contacts, clarification of construction liaison, and arrival on site
- **Execution of works:** includes the execution of the works in the form of civil works and the control of costs and monitoring of the progress of the works, as well as quality control of the works done
- **Taking over phase:** includes the taking over of the construction works with the most important activities in the form of identification and preparation for the takeover of the building, acceptance of the product, and takeover of the technical certificates, and all other legally and contractually stipulated documents

Therefore, this research determined the change in the intensity of the impact of complexity and individual groups and key elements of complexity through these five phases of the construction phase.

3. Methodology

The research presented in this paper was based on the necessity to determine the impact of individual elements of complexity, as well as overall complexity, on the success of a construction project during the construction phase. Not all forms of complexity can and have the same impact on success in general or on partial phases of project execution. Therefore, changes in the intensity of the impact of complexity and individual elements of complexity on project success must be identified and understood. The theoretical basis for this investigation is presented in the literature review. In addition, input data on complexity elements, groups of complexity elements, and phases of project execution are presented, in which their impact on project success is analyzed. To increase project success, the changes in the intensity of the impact of project complexity on success should be promptly determined in terms of its characteristics. Such an analysis helps to create an appropriate plan and facilitates the monitoring of the execution of the construction project. The study on the changing intensity of the impact of complexity on the success of the project was conducted from the perspective of the contractor project managers, and the application of the results also has limitations in relation to other participants. The questionnaire prepared for recording the results was sent to the address of the contractor's representative.

Note that the survey was sent to 59 addresses and that the answers came from 41 addresses. Therefore, the questionnaire was not provided by 18 respondents. Out of those eighteen, nine of them stated that the research submitted to them was a complex task that would require a significant amount of time, and they could not send an answer. Three respondents declared that they were unsure if they could provide adequate answers to the questions; thus, they could not submit their answers. No reply was received from the six addresses to which the questionnaires were sent. Nevertheless, the 41 responses submitted represented a significant sample that could be used to adequately define the results from the answers. All the results obtained in these 41 responses were analyzed to define the influence of complexity on project success in the construction phase. Note that the surveyed experts in the field of construction project management had sufficient knowledge and experience in this phase of construction works to provide the necessary answers (Table 2). The questionnaire given to the respondents contained all the necessary explanations. Based on the answers collected, we could obtain the necessary data to monitor the changes in the intensity of the impact of the elements of complexity on the success of the project during the construction phase.

Table 2. General information about respondents

Characteristics		Number of respondents
Sex	Female	4
	Male	37
Age	< 30	0
	30 - 40	28
	41 - 50	10
	51 - 60	2
	> 60	1
Qualifications	NSS	0
	Secondary school	0
	University degree	28
	Master's degree in Science	12
	Doctor of Science	1
Years of experience in managing execution of construction works	5 - 10	21
	11 - 20	13
	21 - 30	4
	more of 30	3
Number of countries in which the respondent worked	1	20
	2	12
	3	4
	4	2
	5 and more	3
Number of the construction companies where the respondent worked	1	8
	2	11
	3	9
	4	4
	5 and more	9

4. Results

In the conducted research, the levels of importance of the individual elements of complexity for construction projects were defined from the perspectives of the contractors for each of the complexity groups based on the submitted answers. For the previously defined lists of complexity elements for each complexity group, the degree of importance of their impact on each group of complexity elements and the overall complexity of the project was offered. During the period in which the replies to the questionnaire were being sent back, no significant questions or ambiguities regarding the nature of the project occurred, which represents a particular element of complexity that is part of the present research. The degree of impact was determined by the respondents using a Likert scale of impact of elements on project success that ranged from 5 to 1, where 5 represents the largest possible impact and 1 the smallest possible impact. The impact with an intensity of 4 on the Likert scale

represents a large impact on the project success, 3 represents a medium impact, and 2 represents a low impact. By analyzing the data obtained from the questionnaire responses and creating a ranking of impact using the mean value of the received responses, we obtained the data presented below. The elements are arranged based on the level of impact on project success using the mean value of all 41 submitted responses. Initially, this was conducted in general for the impact of the degree of complexity on the success of the project through the mentioned phases of project execution.

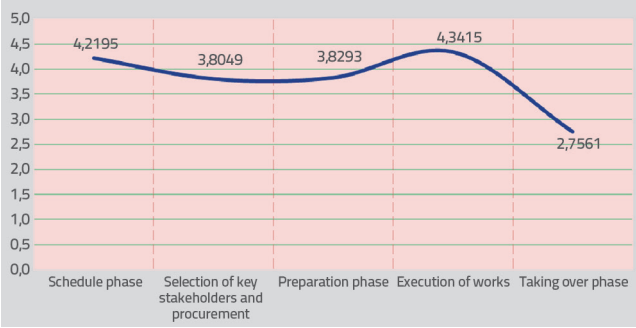

Figure 1. Analysis of the impact of complexity degree on project success in the project construction phase

The results showed that the degree of project complexity has the greatest impact on project success in the execution and schedule phases (Figure 1). Because the most important processes related to the execution of the works occur in the execution of works phase, it is reasonable to expect that the degree of complexity in this phase has the greatest impact on the results and success of the project. In the phase of execution of works, given the quantity of resources involved and the overall commitment of all parties, a significant degree of uncertainty about certain events exists; therefore, elements of complexity can impact the success of a project. Additionally, the degree of complexity has a high intensity of impact on success in the schedule phase, because the participants can significantly impact the reduction of the degree of complexity in this phase by taking appropriate preparatory steps in the project plan. If this is not addressed, the consequences for stakeholders in the later stages of the project will be more pronounced than they should be. Therefore, during these phases, close attention should be given to the project's complexity, as this can significantly influence its overall success. After the execution of works and during the beginning of the taking over phase, the possibility of the degree of impact of complexity on the success of the project decreases abruptly, because, given the existing type of contracts, the taking over phase itself does not have a significant impact on the results and success of the project.

4.1. Analysis of the impact of operational and technological complexity on the project success through the construction phase

In this research, the impact of individual groups of project complexity elements and complexity elements on the success of the project was analyzed through the phases of execution of the works. The operational and technological complexity of a project has the greatest impact on its success during the execution of works, because the greatest part of the operational and technological impact on the implementation of the project occurs in this stage. Thus, the impact of the degree of operational and technological complexity of the project increases from the beginning to the end of the construction phase, and its impact on the success of the project decreases significantly when entering the taking over phase. We can conclude that the operational and technological complexity has the greatest impact on the activation of risks during the execution of works on the project. When analyzing the impact of the individual elements of operational and technological complexity on project success, we confirmed that almost all the elements have the greatest impact on project success during the execution of works. The elements of complexity related to the need for preparatory works and the transportation system near the construction site have the greatest impact in the project preparation phase for the execution of the works, whereas the element of complexity related to the function of the building to be executed increases the significance of the impact on project success as the project end approaches. The impact of the other elements of operational and technological complexity decreases significantly in the taking over phase (Figure 2). We also highlight a divergence that relates to the importance of the impact of individual elements of complexity relative to the impact of a group of elements of complexity on project success at the key stakeholder selection and procurement phase. Taken as a group, operational and technological complexity have the greatest impact in this phase

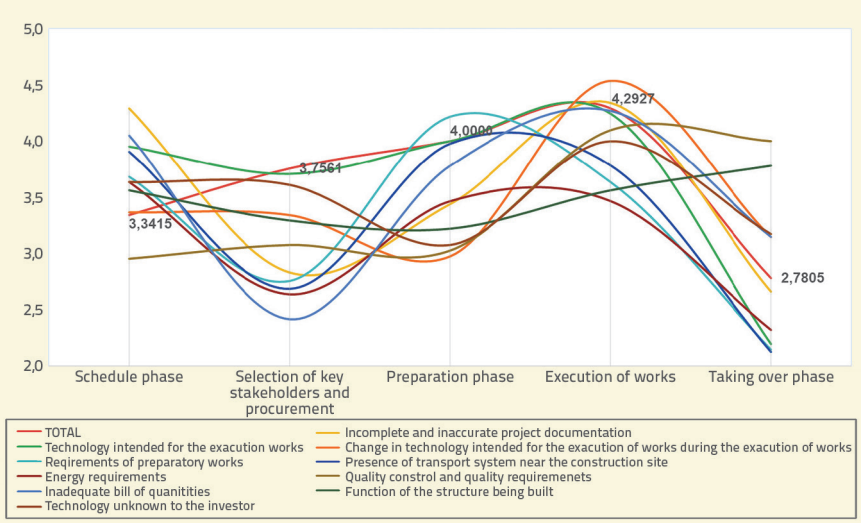

Figure 2. Analysis of the impact of operational and technological complexity on the project success through the project construction phase

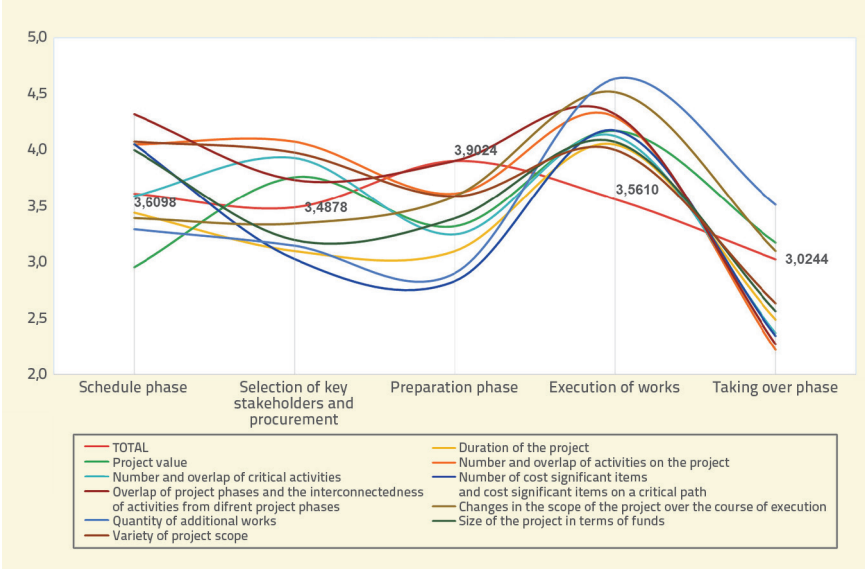

Figure 3. Analysis of the impact of scope complexity on project success through the project construction phase

of the work. All individual elements of this group of complexity have a minor or significantly lower impact on project success in this phase of the works (Figure 2).

4.2. Analysis of the impact of project scope complexity on the project success through the construction phase

The complexity of the project scope has an equal impact on the success of a project in the schedule, selection of key stakeholders and procurement, and phase of execution of the works. However, it has the greatest impact in the preparation phase (3.9024) because elements of scope complexity require more in-depth analysis before execution begins (Figure 3). Proper preparation of the work will significantly reduce or better control the impact of all project characteristics on the execution results in the later phases of the project. Therefore, high-quality preparation reduces the impact of these complex elements on the risks and consequently on the results and success of the construction project. The intensity of the impact of the complexity of the project scope does not decrease significantly during the transition from the execution of works phase to the project taking over phase, which applies to almost all other complexity groups.

When analyzing the impact of the individual elements of the complexity of the project scope on the success of the project, we confirmed that almost all the elements have the greatest impact on the success of the project in the execution of works phase. This represents a significant difference in terms of the impact of a group of elements of scope complexity on project success in this phase. The intensity curves of the elements of complexity from this group behave similarly in the execution of works and taking over phases, with almost all the impact curves following each other. The difference consists only of minor differences in intensity. Note that the variety of the project scope has the greatest impact on project success in the schedule phase, whereas it has the lowest intensity of impact on project success in the taking over phase. The impact of all elements of complexity decreases significantly in the final phase, i.e., in the taking over phase of the completed project.

4.3. Analysis of the impact of organizational complexity on project success through the construction phase

The organizational complexity of the project also has the greatest impact on the success of the project in the execution of works phase. Organizational problems for the project execution stakeholders often occur in the construction phase of the works. Therefore, it can have the greatest impact on the success of the project in this phase. The impact of this complexity group through the introductory phases related to schedule, selection of key stakeholders, and procurement is virtually constant (Figure 4). Thus, impacting the organization of the contractors in these phases can have a significant impact on the course of the project. Essentially, however, the stakeholders included in the construction

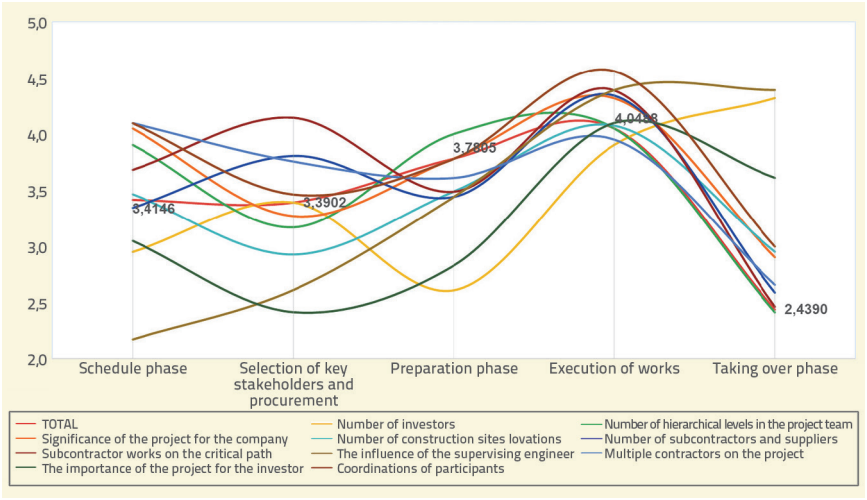

Figure 4. Analysis of the impact of organizational complexity on project success through the project construction phase

phase cannot significantly influence the organization itself until the project reaches the execution of works phase, where its role becomes most important. Therefore, attention should be given to the organizational complexity of the project in this phase. As the project enters the taking over phase, its impact on the success of the project decreases significantly.

When analyzing the effects of the individual elements of organizational complexity on project success, we confirmed that almost all the elements offered have the greatest impact on project success during the execution of works. For the elements of complexity related to the number of investors, the significance of the impact on project success increases from the preparation to the execution of works phase and is greatest in the taking over phase of the executed project. All elements that relate directly to the work on site and concern the coordination of stakeholders, the work of subcontractors on the critical path, and the influence of the supervising engineer have the greatest impact at the phase of execution of the works on the project. Because one of the key indicators of project complexity is the impact of the supervising engineer, which is established from the very beginning of the research, this impact has a high degree until the very end of the project. This clearly indicates that the engineer's actions impact the execution results and can cause the stakeholders to lose time and financial costs at the very last stage, i.e., when the completed works are taken over. Other elements of complexity from this group significantly reduce the intensity of their impact on the success of the project in the taking over phase. For this complexity, the impact curve for the complexity group represents the mean value of the influence of individual elements of this complexity group on the success of the project for most of the course of the project.

4.4. Analysis of the impact of resource complexity on project success through the construction phase

The complexity of the project in terms of resources also has the greatest impact on the success of the project in the execution of works phase. The curve of the impact of this complexity group on project success practically coincides with the curve of the impact of organizational complexity on project success. The impact of this complexity group is practically the same in the initial phases of scheduling, selection of key stakeholders, and procurement. The stakeholders in this phase of the construction project primarily allocate its resources to the project. Accordingly, the uncertainty regarding resources is greatest in this phase. Therefore, this group of complexity has the greatest impact on the results and success of the project, particularly in the execution of works phase. Through proper scheduling and selection of key stakeholders in the preparation phase, the contractor can certainly reduce the impact of this degree of complexity on the success of the project. By moving from the execution of works phase to the taking over phase, the impact of this complexity on project success is significantly reduced.

Examining the impact of each element of complexity related to resources on the project, we observe the same behavior in the change in the intensity of impact of all elements of complexity of this group through the phases of execution of the work on the project (Figure 5). Almost all elements, except for the change of project manager during the execution of the works, have the least impact on success in the project taking over phase and the greatest impact in the execution of works phase. This is to be expected, as a change of project manager during execution can result in changes in documentation procedures that can have a major impact on project delivery later on, both in terms of the work itself and the documents associated with the work performed. The provision of resources and labour turnover have virtually minimal impact on the success of the project in the initial phase of the project, whereas in the execution of works phase, they have the greatest impact on the success of the project. Because the current market situation exceeds expectations, the element of complexity related to the diversity and availability of workforce has the highest intensity of impact on the success of the project in the execution of works phase. Once again, the logic of the sudden decrease in the intensity of the impact of elements of complexity related to resources during the transition from the execution of works phase to the project taking over phase must be emphasized. With the completion of the execution of works phase, the use of resources in the project declines sharply and, with it, the impact of these elements of complexity on the results and the success of the project.

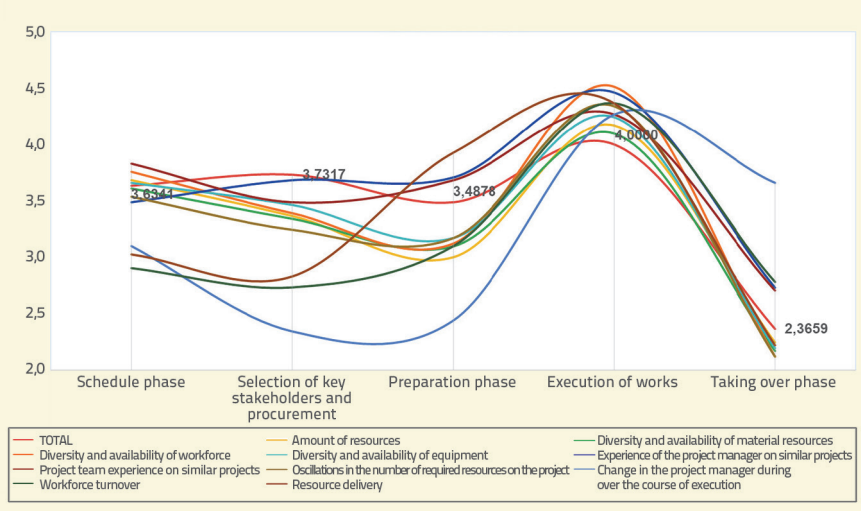

Figure 5. Analysis of the impact of resource complexity on project success through the construction phase

4.5. Analysis of the impact of legal and sociopolitical complexity on the project success through the construction phase

The legal and sociopolitical complexity of the project plays a major role in the preparation phase for the actual execution of the work. Compliance

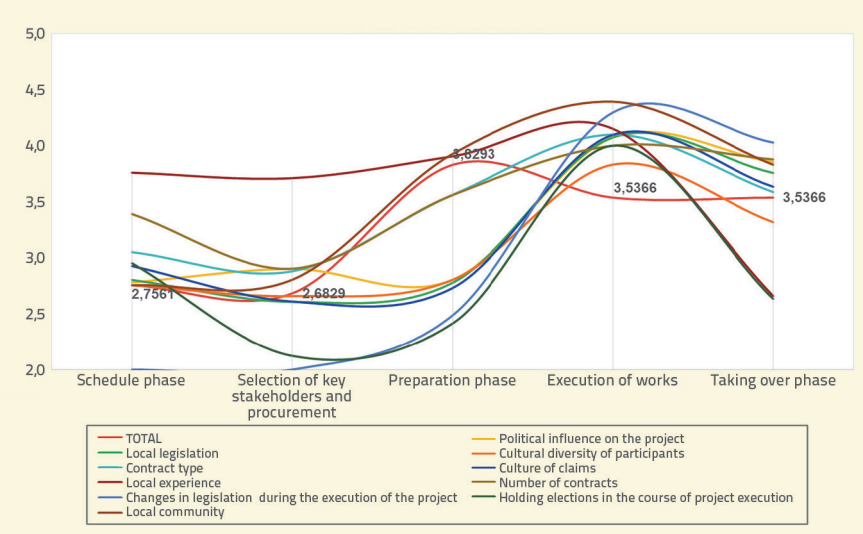

Figure 6. Analysis of the impact of legal and sociopolitical complexity on project success through the project construction phase

with local legislation, adaptation to local regulations, and the establishment of quality relations with the local community play an almost decisive role for the stakeholders in the phase of preparation for the execution of the work on the project. According to the researcher's assessment, this complexity group is generally assumed not to have a particularly large impact on the degree of complexity of the project, i.e., the success of the project. At the stage of scheduling and selection of the main stakeholders and procurements, the intensity of the impact of legal and sociopolitical complexity on the success of the project is practically insignificant. Additionally, note that the intensity of impact is the same in the execution of works and taking over phases. The characteristic of this complexity group is that it is the only one that does not experience a decrease in the intensity of impact during the transition from the construction phase to the taking over phase of the work.

Examining the impact of the individual elements of legal and sociopolitical complexity on the project, we observe a significant difference in the impact in relation to the complexity group. All elements have the greatest impact on project success in the execution of works phase (Figure 6). The validity of the research results is also evidenced by the fact that the impact of change of legislation during the execution of the project has practically no impact on the success of the project in the scheduling phase of the execution itself, whereas in the execution of works phase, it has the greatest impact of all elements of this complexity group. Furthermore, this element of complexity has the greatest impact in the taking over phase of the works. The local community, which as an element of complexity can play a key role in a certain type of stability in the execution of the work on the project, has a significant impact both in the scheduling phase and in the phase of selecting the stakeholders and procurement. Selecting local companies as subcontractors, hiring local workforce, and involving the local community in project preparation can significantly increase the success of the project at these stages of the construction project. With the elements of this group of complexity, it is almost the rule that as the work is completed, the intensity of the impact on the success of the project decreases.

4.6. Analysis of the impact of economic complexity on the project success through the construction phase

The economic complexity of the project also has the greatest impact on the success of the project in the execution of works phase. The curve of the impact of this complexity group on project success practically coincides with the curve of the impact of organizational complexity and project resource complexity on project success. The impact of this complexity group on project success decreases slightly in the introductory phases of scheduling, selection of key stakeholders and procurement, and preparation phase. Certain economic characteristics of the project can be considered qualitatively in the scheduling phase as part of the construction phase. Therefore, economic complexity plays a significant role in this phase. However, the highest financial costs for the stakeholders and the highest costs for the investor are incurred during the construction phase. This means that the economic complexity in this phase has the greatest impact on the

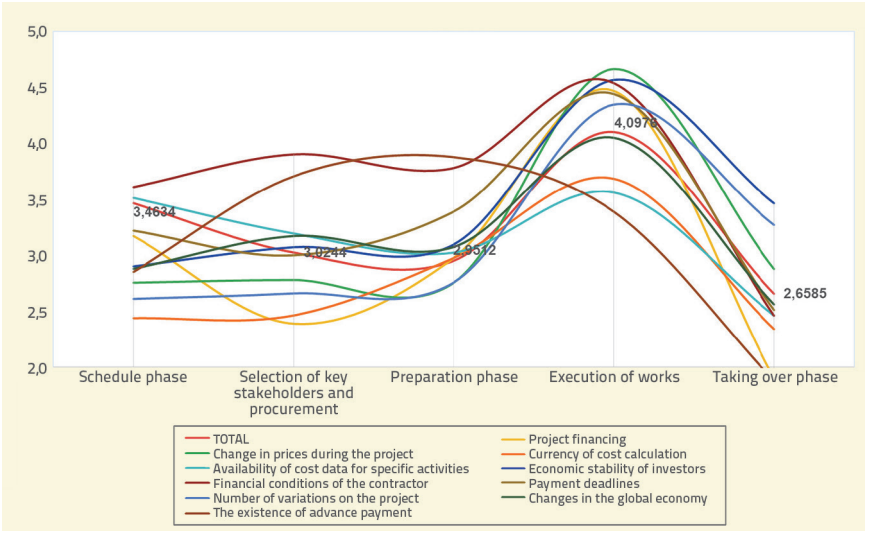

Figure 7. Analysis of the impact of economic complexity on project success through the project construction phase

results and success of the project. With the transition from the execution of works phase to the taking over phase, the impact of this complexity on the success of the project decreases significantly. The analysis of the results of the research on the impact of the individual elements of economic complexity shows that most of them follow the curve of the intensity of the impact of the overall economic complexity on the success of the project in its phases. A prominent element with a completely different impact curve is the existence of advance payments (Figure 7). This element has the greatest impact on the success of the project in the preparation phase. The intensity of its impact increases from the scheduling phase to the preparation phase, whereas it has no impact on the results in the taking over phase. All other elements have the greatest impact in the execution of works phase, the intensity of which decreases sharply after the execution of works phase. The greatest impact on the construction project success in the construction phase is the change of prices over the course of the project. This response of the responders is probably also a consequence of the current market situation, in which prices are increasing daily. Such a price change, which could not be planned in any segment, significantly increases the cost of the works, which cannot be compensated in any way. Therefore, for all stakeholders, this element is the most important economic factor influencing the success of the project. In addition to the existence of an advance payment, the availability of cost data for specific activities has the least impact on the success in the execution of works phase. The intensity of the impact of this element is highest in the scheduling phase of the works.

4.7. Analysis of the impact of communication complexity on the project success through the construction phase

The communication complexity of the project also has the most significant impact on the success of the project in the execution of works phase. The course of the curve of the impact of this group of complexity on project success largely coincides with the curve of the impact of organizational complexity and resource project complexity on project success. The difference is that communication complexity has a greater intensity of impact compared to the above. According to the results of the research, communication complexity has the most significant impact on the success of the project. This is the result of a large dose of uncertainty in the communication itself on the project. Trust in the project also significantly affects the intensity of this complexity. By increasing trust in the project, one can significantly impact the reduction of the impact of this complexity on project results. Communication complexity from the beginning of the project, i.e., the schedule phase and through the phase of selection of key stakeholders and procurement, increases all the way to the peak in execution of works phase. Thereafter, as in other cases, the intensity of the impact of this complexity on the success of the projects decreases, but in the final phase of the taking over of the project, it is still higher than the intensity in the first two phases.

Examining the results of the study on the impact of the individual elements of the communication complexity of the project, we can conclude that nine out of ten of these elements have the greatest impact on the success of the project in the execution of works phase. The only element with a greater impact on complexity in the schedule phase than the construction phase is communication within the project team (Figure 8). Communication within the project team plays a key role in the scheduling phase of project execution. Problems with communication in the schedule phase can have a significant impact on increasing the overall complexity of the project for all stakeholders, and proper communication has a significant impact on better planning of the deliverables in the project construction phase. Concealment of information between project stakeholders and communication with the supervising engineer are the most important elements of communication complexity. Their impact is greatest in the construction phase, conceals many uncertainties, and can have a major impact on the results of the project. Characteristic of these elements is the level of trust between the contractor's representative and the supervisory team, as well as the level of trust within the project team. By strengthening mutual trust, the intensity of the impact of these elements of complexity on the overall complexity of the project can be reduced significantly, i.e., the introduction of risks and the success of the project. Considering the aforementioned importance of trust and its influence on the level of communication complexity, the relationship between trust and complexity and the success of the construction project should be adequately defined from the contractor's perspective. Even with the elements of communication complexity, the intensity of the impact on

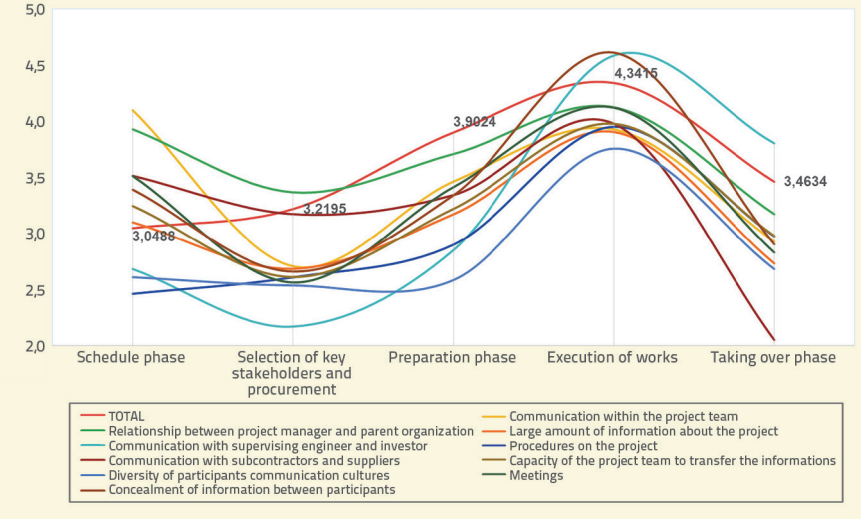

Figure 8. Analysis of the impact of communication complexity on the project success through the project construction phase

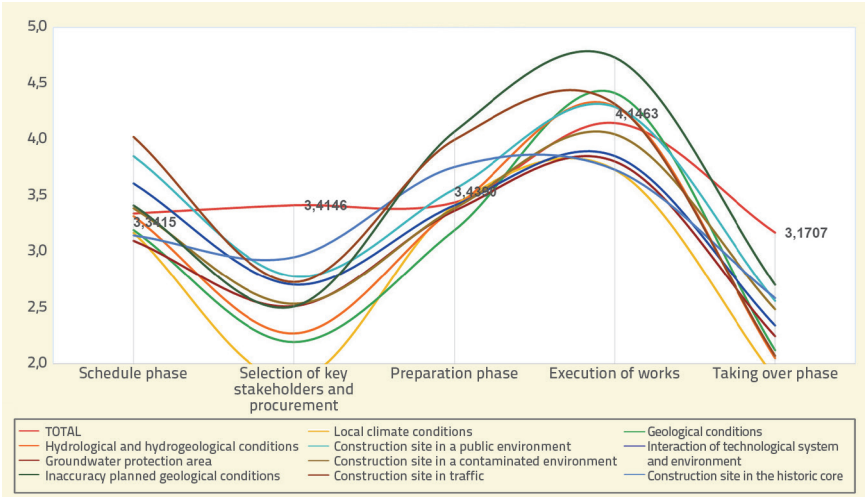

Figure 9. Analysis of the impact of environment complexity on the project success through the project construction phase

project success decreases significantly in the taking over phase of the works.

4.8. Analysis of the impact of environment complexity on project success through the construction phase

The complexity of the project environment at the beginning of the execution of the work in the schedule phase has no significant impact on project success. The intensity of this complexity increases slightly in the phases of selecting the key stakeholders and preparation phase of the project. Thereafter, the intensity of the impact of this complexity on the success of the project increases significantly in the execution of works phase. The uncertainties of the project environment, i.e., the risks caused by this complexity, can be triggered primarily in the execution of works phase. The decisive factor for this complexity is that the stakeholders cannot influence the possibility of their actions on the project in any way. Only by properly scheduling for the potential impact of this complexity can they more confidently plan its outcomes and thus impact the success of the project. In the taking over phase of the works, the intensity of the impact of the environment decreases significantly and has the least impact on the success of the project compared with the other project phases.

Examining the results of the research on the impact of the individual elements of the complexity of the project environment, we observe that all elements have the greatest impact on the success of the execution of works phase (Figure 9). Another characteristic of these elements of complexity is that their intensity of impact coincides in the phase of selection of the key stakeholders and procurement and in the taking over phase. The element related to local climatic conditions has almost no impact on project success in these two phases. The most important element of complexity that affects the project in the execution of works phase is the inaccuracy of the planned geological conditions. This element can significantly affect the slowing down of works, the occurrence of additional works, interruptions, and even the complete suspension of works. All these occur with a significant number of unknowns that can affect the success of the construction project for all stakeholders. Although we analyze this issue of contractor project managers, it is fair to say that this element of complexity can be fatal to the entire project if the contractor is not prepared to start it. Additionally, in this complexity group, all elements of complexity significantly reduce the intensity of their impact on project success when moving from the execution of works phase to the taking over phase. The environment of the project in this phase cannot have a significant impact on the results and success of the project.

At the end of this part of the presentation of the research findings on the impact of complexity on project success in the certain phases of the execution of the construction project, a comparative diagram of the overall impact of complexity on project success and the impact of the complexity groups on project success in the individual phases is presented (Figure 10). It shows that the impact of the overall complexity defined based on the research results for the schedule phase differs considerably with regard to all groups of complexity elements in this phase. In the schedule phase, which can largely determine the course of work execution, the resource-related and project scope complexities have the greatest intensity of impact on the success of the project. The legal and sociopolitical complexity

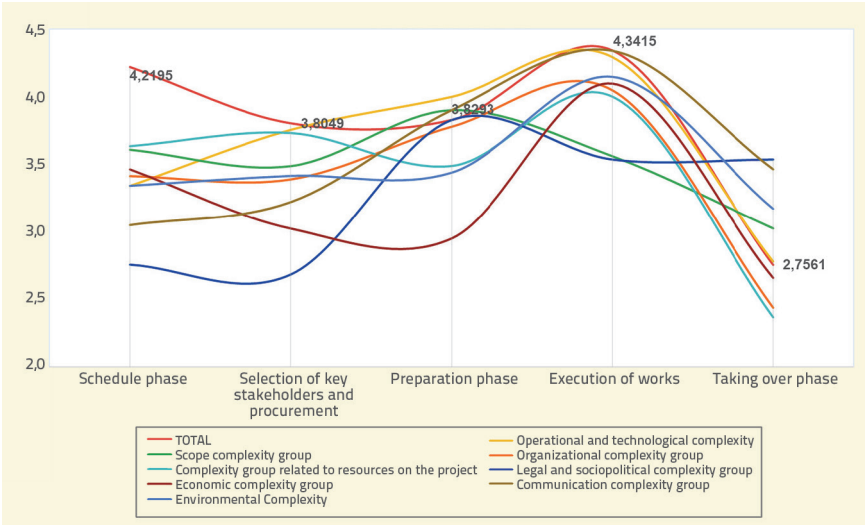

Figure 10. Analysis of the impact of the degree of complexity and complexity groups on project success through the project construction phase

is the least important in the first phase, as well as in the phase of selecting the key stakeholders and procurement. The intensity of the impact in this phase compared with the schedule phase increases with communication, resource, operational and technological, and environmental complexities. The impact of overall complexity on project success decreases in this phase compared to the initial phase. The complexity of the project scope, the organizational complexity, and the economic, legal, and sociopolitical complexity also decrease. Additionally, the impact of the overall complexity is greater than all the individual impacts of the complexity elements in this phase. Here, too, the legal and sociopolitical complexity of the project has the least impact.

The impact of the overall complexity in the preparation phase is almost as strong as in the previous phase. Note that even in this phase, individual elements of complexity have a greater intensity of impact on complexity than the overall intensity of complexity of the project. This relates to communication, operation, and the complexity of the project scope. In the preparation phase, legal and sociopolitical complexity has the strongest impact compared with the other phases of the project. A clear jump in the intensity of the impact of this group of complexity elements is visible when comparing the previous and this phase of construction project execution. Economic complexity has the least impact on the success of the project in this phase.

In the construction phase of the construction project, six out of eight groups of complexity elements have the greatest impact on the rest of the project. We emphasize that communication complexity and operational and technological complexity have the greatest impact on the success of the project. In this phase, the intensity of the impact of legal and sociopolitical complexity, as well as the complexity of the project scope, decreases. In the taking over phase, seven out of eight groups of complexity elements show a significant decrease in the intensity of impact, as we have already observed. The only exception is legal and sociopolitical complexity, which has the same impact on project success as in the construction phase. Organizational and resource complexities have almost no impact on the results in the taking over phase.

5. Discussion

Previous studies have not analyzed the impact of project complexity on success in a more detailed analysis of the individual phases. They have only found a correlation between complexity and the success of a project [8, 31, 33]. Furthermore, they found that the impact of complexity on project success varies in intensity across project phases [31]. Therefore, this research identified the current state of change in the intensity of these impacts. Considering the characteristics of construction processes and the current state of the construction industry, we observe that the greatest intensity of the impact of individual elements is complexity in the execution of works phase as the phase with the largest number of participants and greatest number of interactions between the participants. The determination of the change in the intensity of the influence of complexity on project success was conducted through five parts of this phase for each of the eight groups of elements of complexity.

First, the results of the change in the impact of overall complexity on project success through the phases of the work are presented. The review of the results revealed the expected parameters in terms of the highest impact of complexity on project success in the schedule and execution of works phases. However, as expected, complexity generally has the greatest impact in the execution of works phase. This is owing to the characteristics of the construction project, which include the most significant financial flows in this phase and the greatest number of uncertainties. Therefore, for project success, special attention should be given to complexity and its impact on the course of the project during execution in the project planning phase. This will result in an appropriate plan and better data for project control in the construction phase. At the end of the construction phase, the impact of complexity on project success is often significantly lower, and the intensity of the impact on project success is the lowest of all other phases in the taking over phase.

The impact of the elements of operational and technological complexity of the project on project success the greatest, given the numerous uncertainties in the execution of works phase. For this group of complexity elements, their impact on project success gradually increases from the schedule phase to the execution of works phase and then decreases significantly. Therefore, when merging groups of complexity elements, much attention should be paid to the project preparation phase. This relationship is quite expected if we analyze the fact that the more significant activities related to these elements of complexity already begin in the preparation phase and continue in the execution of works phase. The greatest intensity of impact in relation to other elements of complexity at the construction stage is a change in construction technology and incomplete or incorrect project documentation. Their impact can be crucial for the development of the project, as these elements can have severe consequences, occasionally even leading to shorter or longer work interruptions.

The increase in the number of activities in a project and their mutual overlaps have a significant impact on the success of the construction project. These elements of complexity, as well as an element related to the scope of additional works, can cause major problems in project management and affect the results and success of the construction project at the stage of execution of the works if they are not properly planned. Thus, additional works can occasionally present an opportunity for individual stakeholders to have a positive impact on outcomes and success, but they often present major uncertainties that can have a severe negative impact on outcomes and the timely completion of the project.

When we generally discuss the necessary conditions for project success with those involved in the construction project, we primarily talk about the organization. Therefore, organizational complexity and its elements have a significant impact on project success. However, the intensity of the impact of these elements on project success changes considerably from phase to phase. As a consequence of all the above and considering the characteristics of the execution of works phase, we expect that the coordination of those involved in the execution of the project has the greatest impact on project success. Therefore, any significant deficiencies related to the coordination of participants can have a negative impact on the

results of a project and thus on its success. In today's construction market, which suffers from chronic workforce shortages, we can assume that resource-related complexity elements have a major impact on the success of the project. Their intensity is likely to be highest during the execution of works phase, considering that most of the project's resources are practically activated and utilized during this phase. The element of availability and diversity of the workforce is particularly noteworthy. Therefore, proper project planning, which includes the correct distribution of available resources, is essential for the stable execution of the project and the reduction of possible negative effects on the project's success. If this is not the case and additional human resources are required at this stage, particularly skilled workers, considering the state of the construction market, this can have a significant impact on the duration of the project as well as the quality of its execution.

The impact of politics, local communities, and possible changes in legislation can traditionally have a significant impact on the success of a construction project. The intensity of their impact increases in the preparation and execution of works phase and decreases drastically in the taking over phase. Their impact in the taking over phase reduces because of the reduction of work on site, interactions between stakeholders, and the number of project participants at this stage of construction significantly reduces the possibility of political or local community influence. The result of all this is that the intensity of the impact of complexity related to social and sociopolitical issues is highest in the execution of works phase and is significantly lower in both the initial and final phases of project execution.

The element of economic complexity has a much greater impact on the success of the project in the execution of the works phase than in the other phases. The financial state of the contractor and the economic stability of the investor have the highest intensity of influence. Because most of the financial flows related to the project occur in this phase, the consequences of a possible financial instability of the investor or the contractor can be decisive for project success. Without the financial stability of the investor, no payments will be made to the other parties involved in the project, and without the financial stability of the contractor, work can almost certainly be halted. This can result in a reduction in the intensity of the work, possible interruption of the work, and ultimately a delay in the completion of the project itself. Therefore, uncertainties related to the elements of economic complexity have a significant impact on project success and, therefore, must be properly planned for and controlled.

The appropriate communication in a project can significantly reduce the impact of complexity on the success of the project. As a form of complexity with a high degree of uncertainty, communication complexity and its elements can have a major impact on project success. As expected, communication as a constant form of complexity exhibits considerable differences in the intensity of its impact on project success in the various phases. Concealment of information between project participants and communication between contractors, investors, and supervising engineers are elements of complexity with a high intensity of impact on project success in the execution of works phase. Gaps in communication between key stakeholders or the withholding of information can have severe consequences for the success of the project. If constant communication problems occur between contractors, construction managers, and investors during the construction phase, resulting in mistrust between them, this can have negative consequences for the progress of the project and its success. In any case, proper communication between project stakeholders, particularly in the execution of works phase, can play a key role in facilitating project implementation, creating a positive atmosphere and trust, thus influencing the results and success of the project.

The elements related to the environment of the project also have the greatest intensity of impact in the execution of works phase. This group of complex elements is characterized by their high intensity of impact in the project schedule phase. Most planning documents are closely related to the schedule phase. Therefore, elements from this complexity group can have a significant impact on the success of the project in this phase. Thereafter, their impact decreases and increases again depending on the progress of the execution of the work. In this phase, as construction progresses, both geological conditions and incorrectly assumed geological conditions can have a high degree of intensity of impact on the success of a project. If the geology is not assumed correctly, this often results in changes in the design, suspension of work until solutions are found that correspond to the reality of the geological problem, and an increase in costs. This undoubtedly means that these elements can have a negative impact on the success of the construction project at the construction phase.

From the analysis of the results, we can conclude, as assumed, that the intensity of the impact of elements of complexity on the success of the project changes in the various phases of the work. It is highest in the execution of works phase, for several reasons, among which the large number of resources, participants, and interactions between project participants are prominent in this phase. Therefore, we observe that in this phase, particular attention should be given to complexity and its impact on the course of the project. Previous research has focused on the relationship between complexity and project success, without significantly quantifying these influences. This research confirmed the variability of the intensity of these effects through the individual phases of the work, without quantifying these effects. These results cannot be compared with some of the previous research, which did not address such analyses of complexity and the relationship between complexity and the success of a construction project.

The established representations of the changes in the intensity of the impact of complexity on the success of a construction project provide a good basis for those involved in the execution of the work on a project. They have a real impact on stakeholders if they are applied promptly in the planning phase of the project, with an adequate analysis of the complexity based on the characteristics of the project to be constructed. Therefore, future research should establish a framework that assesses the impact of the elements of complexity on the results and success of the project in relation to all other elements. This must be performed for the entire project and for each of the individual phases of the construction project. Thus, these results will be fully applicable in construction practice.

Therefore, the results of this investigation can be viewed with several limitations in mind. They primarily refer to the thoughts of the

interviewed project managers from a contractor's perspective. Note that, given the limitations of the market, the research was conducted primarily among experienced project managers in the construction infrastructure sector, whereas other construction sectors are not significantly represented. In addition, the construction companies included in this study belong to very similar organizations according to their characteristics. Therefore, the survey did not equally represent companies of different sizes, different types of projects they are involved in, and different markets in which they operate. Most of the companies surveyed are either from or operate primarily in Southeast Europe. Therefore, the research can be expanded to analyze changes in the intensity of the impact of complexity on the success of projects with regard to size, contract price of those projects, the number of participants in them, and the size of the company that executes them. Thus, more precise results would be obtained by considering the increase in detail in the research as well as the different characteristics of the projects being investigated. Therefore, the established representations of changes in the intensity of the impact of complexity on the success of projects represent a quality basis for more precisely defining the results with respect to the various characteristics of projects, and this would additionally contribute to the success of construction projects.

6. Conclusion

This research aimed to determine the impact of elements of complexity on the success of a construction project in the construction phase. Analyzing the existing research related to complexity and project success, we established their connection on a theoretical basis, without any significant research into the very forms of impact of complexity on project success. This particularly applies to the phase of project execution, which represents a key phase for the connection between complexity and success and its impact on the course of a project. This connection, as well as the groups and elements of complexity and individual phases of construction project execution, was determined through a literature review. This served as a theoretical basis for conducting the research itself. The research, conducted among construction project managers, resulted in the presentation of changes in the intensity of the impact of complexity as groups and elements of complexity on the success of the project through the phases of construction project execution. Thus, based on the characteristics of the project they are executing at any moment for any phase of the project, participants in the execution of the construction project can determine the intensity of the impact on project success in relation to other phases of the project. These results represent the basis for further analysis of the connection between complexity and project success, as well as further improvement to better plan the phase of the execution of the works on construction projects. Future research should analyze and quantify each of these impacts with respect to all other groups of elements and elements of complexity. This must be implemented for the overall project, as well as for each phase of the construction project. Based on this, a framework can be created in which participants in a construction project can better plan and control the results of a project. Thus, they can influence the success of the construction project.

REFERENCES

[1] Parmenter, D.: Key Performance Indicators: Developing, Implementing, and Using Winning KPIs, John Wiley & Sons, Hoboken, 2010

[2] Flyvbjerg, B., Bruzelius, N., Rothengatter, W.: Megaprojects and Risk: An Anatomy of Ambition, Cambridge University Press, 2003

[3] Williams, T.M.: Modelling Complex Projects, West Sussex: John Wiley and Sons, 2002

[4] Neleman: Shell gaat diep, FEM Business, 9 (2006) 4, pp. 30-34.

[5] Nikolić, M., Cerić, A.: Classification of Key Elements of Construction Project Complexity from the Contractor Perspective, Buildings, 12 (2022), 696.

[6] Puddicombe, M.S.: Novelty and technical complexity: Critical constructs in capital projects, Journal of Construction Engineering and Management, 138 (2012) 5, pp. 613-620.

[7] Antoniadis, D.N, Edum-Fotwe, F., Thorpe, T.: Socio-organo complexity and project performance, International Journal of Project Management, 29 (2011) 7, pp. 808-816.

[8] Luo, L., He, Q., Jaselskis, E.J., Xie, J.: Construction Project Complexity: Research Trends and Implications, Journal of Construction Engineering and Management, 143 (2017) 2, 04017019.

[9] Bosch-Rekveldt, M., Jongkind, Y., Mooi, H.G., Bakker, H.L.M., Verbraeck, A.: Grasping project complexity in large engineering projects: The TOE (technical, organizational and environmental) framework, International Journal of Project Management, 29 (2011) 6, pp. 728-739.

[10] Zakari, M., Benjamin, B.A., Samuel, K.A.: Construction Projects Success: Time, Cost, Quality and Safety, International Journal of Research and Innovation in Social Science (IJRISS), 7 (2023) 9, pp 680-688

[11] Kumar, V., Pandey, A., Singh, R.: Project success and critical success factors of construction projects: project practitioners perspectives, Organization, Technology and Management In Construction, 15 (2023), pp. 1–22

[12] Wood, H.L., Gidado, K.: Project complexity in construction, Cobra, (2008), pp. 1-13.

[13] Raymond, N.N.: Construction time-influencing factors: the contractor's perspective, Construction Management and Economics, 13 (1995) 1, pp. 81-89.

[14] Molenaar, K.R., Songer, A.D.: Model for public sector design-build projects selection, Journal of Construction Engineering and Management, 124 (1998) 6, pp. 467-479.

[15] Austin, S., Newton, A., Steele, J., Waskett, P.: Modelling and managing project complexity, International Journal of Project Management, 20 (2002) 3, pp. 191-198.

[16] Chan, A.P.C., Scott, D., Chan, P.L.: Factors affecting the success of a construction project, Journal of Construction Engineering and Management, 130 (2004) 1, pp. 153-155.

[17] Hass, B.K.: Managing Complex Projects: A New Model, Vienna, VA: Management Concepts, 2009

[18] Remington, K., Pollack, J.: Tools for complex projects, Gower, Farnham, U.K., 2007

[19] Foti, R.: Managing large construction projects, PM Network, 15 (2011) 8, pp. 24–31

[20] Dimitriou, H., Ward, E.J., Wright, P.G.: Mega transport projects-Beyond the iron triangle: Findings from the OMEGA research programme, Progress in Planning, 86 (2013), pp. 1–43.

[21] Kardes, I., Ozturk, A., Cavusgil, S.T., Cavusgil, E.: Managing global megaprojects: Complexity and risk management, International Business Review, 22 (2013) 6, pp. 905-917.

[22] Stocks, R.K., Male, S.P.: An investigation into the client's perceptions of contractual form and procedures: the instigation of good practice, Proceedings, CIB W-65 Organization and Management of Construction, Waterloo, Ontario, Canad,a (1984), pp. 291-299.

[23] Bertelsen, S.: Construction as a complex system, 11th Annual Conference of the International Group for Lean Construction, Blacksburg, Virginia, 2003

[24] Gidado, K.I.: Project complexity: The focal point of construction production planning, Construction Management and Economics, 14 (1996) 3, pp. 213-225.

[25] Baccarini, D.: The concept of project complexity-a review, International Journal of Project Management, 14 (1996) 4, pp. 201-204.

[26] Mills, A.: A systematic approach to risk management for construction, Structural survey, 19 (2001) 5, pp. 245-252.

[27] Gidado, K.I., Millar, A.J.: The effect of simple overlap of stages of building construction on the project complexity and contract time, Progress of the 8th Annual conference, Association of Researchers in Construction Management, Isle of Man, (1992), September, pp. 307-317.

[28] Bennett, J.: International Construction Project Management: General Theory and Practice. Butterworth–Heinemann, London, (1991), pp. 387.

[29] Vidal, L.A., Marle, F., Bocquet, J.C.: Measuring project complexity using the analytic hierarchy process, International Journal of Project Management, 29 (2011) 6, pp. 718-727.

[30] Patil, D.T., Patil, A.: Effectiveness of Complexity Science In Managing Complexity In Construction Projects, Journal of critical reviews, 7 (2020) 7, pp. 265-275.

[31] Vidal, L.A., Marle, F., Bocquet, J.C.: Measuring project complexity using the analytic hierarchy process, International Journal of Project Management, 29 (2011) 6, pp. 718-727.

[32] Lu, Y., Luo, L., Wang, H., Le, Y., Shi, Q.: Measurement model of project complexity for large-scale projects from task and organization perspective, International Journal of Project Management, 33 (2015) 3, pp. 610-622.

[33] Pinto, J.K., Prescott, J.E.: Variations in critical success factors over the stages in the project life cycle, Journal of Management, 14 (1988) 1, pp. 5-18.

[34] Shenhar, A.J., Dvir, D., Levy, O., Maltz, A.C.: Project Success: A Multidimensional Strategic Concept, Long Range Planning, 34 (2001) 6, pp. 699–725.

[35] Pinto, J.K., Slevin, D.P.: Critical success factors across the project life cycle, Project Management Journal, 19 (1988) 3, pp. 67-75.

[36] Baccarini, D.: The logical framework method for defining project success, Project Management Journal, 30 (1999) 4, pp. 25-32.

[37] Ika, L.A.: Project success as a topic in project management journals, Project Management Journal, 40 (2009) 4, pp. 6-19

[38] McLeod, L., Doolin, B., MacDonell, S.G.: A Perspective-Based Understanding of Project Success, Project Management Journal, 43 (2012) 5, pp. 68-86

[39] Parfitt, M.K., Sanvido, V.E.: Checklist of Critical Success Factors For Building Projects, Journal of Management in Engineering, ASCE, 9 (1993) 3, pp. 243-249.

[40] Chan, A.P.C, Scott, D., Lam, E.W.M.: Framework of success criteria for design/build projects, Journal of Management in Engineering, 18 (2002) 3, pp. 120-128

[41] de Wit, A.: Measurement of Project Success, International Journal of Project Management, 6 (1988), pp. 164-170.

[42] Müller, R., Turner, R.: The Influence of Project Managers on Project Success Criteria and Project Success by Type of Project, European Management Journal, 25 (2007) 4, pp. 298-309.

[43] Westerveld, E.: The Project Excellence Model: linking success criteria and critical success factors, International Journal of Project Management, 21 (2003) 6, pp. 411-418.

[44] Guo, J.X.: Measuring Information System Project Success through a Software-Assisted Qualitative Content Analysis, Information Technology and Libraries, 38 (2019) 1, pp. 53-70.

[45] Chan, A.P.C., Chan, A.P.L.: Key performance indicators for measuring construction success, Benchmarking: An International Journal, 11 (2004) 2, pp. 203-221.

[46] Sanvido, V., Grobler, F., Parfitt, K., Guvenis, M., Coyle, M.: Critical Success Factors for Construction Projects, Journal of Construction Engineering and Management, 118 (1992) 1, pp. 94-111.

[47] Xia, W., Lee, G.: Complexity of Information Systems Development Projects: Conceptualization and Measurement Development, Journal of Management Information Systems, 22 (2005) 1, pp 45-83.

[48] Kauffman, S.A.: At Home in the Universe, The Search for the Laws of Self-organization and Complexity, Oxford University Press, 1995

[49] Corning, P.A.: Complexity is just a word!, Technol Forecast Soc, 59 (1998), pp. 197-200.

[50] Williams, T.M.: The need for new paradigms for complex projects, International Journal of Project Management, 17 (1999) 5, pp. 269-273.

[51] Bertelsen, S., Koskela, L.: Avoiding and Managing Chaos in Projects, Proceedings of IGLC-11, Blacksburg, Virginia, 2002

[52] Tatikonda, M.V., Rosenthal, S.R.: Technology novelty, project complexity, and product development project execution success: A deeper look at task uncertainty in product innovation, IEEE Transactions on Engineering Management, 47 (2000) 1, pp. 74-87.

[53] PMI Project Management Institute, A Guide to the Project Management Body of Knowledge: PMBOK Guide 5th edition, Newtown Square, PA: Project Management Institute, Inc., 2013

[54] Brockmann, C., Kähkönen, K.: Evaluating Construction Project Complexity, CIB Joint International Symposium, 2012

[55] Wood, H., Ashton, P.: The factors of project complexity, Proceedings., TG62-Special Track, 18th CIB World Building Congress, CIB Publication, Rotterdam, Netherlands, 2010