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AN OVERVIEW OF THE RELATIONS WITHIN THE IRON TRIANGLE ON A SAMPLE OF CONSTRUCTION PROJECTS IN CROATIA

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The construction project's success generally implies completion within the planned deadline and budget and satisfactory quality performance. These three project performance parameters form the basic system of measuring its success - the iron triangle of project management. Unfortunately, construction projects often fail to meet the defined success parameters, one or more. The focus of this paper is the territory of Croatia, for which it was noticed that no comprehensive studies analyze the construction projects' success in terms of all three iron triangle parameters. This paper aimed to observe an extensive database of projects from Croatia, analyze their success in terms of time, costs, and construction quality, and determine the mutual relations between those three parameters. Based on a database of 49 construction projects, it was determined that a significant number of projects (46.94%) were not satisfactory regarding time and cost success. At the same time, problematic quality performance was less common (20.41%). Statistically significant correlations were established between the performance of time and cost. Developing reliable mathematical models for predicting real construction time and cost is also possible. As for the construction quality, the problem of its presentation and assessment has been established, and no statistically significant results have been determined by observing it. These results indicate the need for further research, primarily regarding the project performance quality. The overall results emphasize the importance of comprehensive, systematic and timely construction project management, primarily during the planning and execution phases, to achieve its goals.

Keywords: iron triangle, success, construction project, correlations, regression

1 INTRODUCTION

Managing a construction project implies applying knowledge, skills and techniques to regulate the flow of project activities to achieve project success [1]. According to Baccarini's [2] definition, project success includes meeting quality output standards and meeting the project's time and budget goals [3]. These three key project parameters - time, cost, and quality - must be considered during the implementation of project activities for project management to be effective [4, 5]. Bowen et al. [6] suggest that these three project success parameters can be represented as the three vertices of a triangle where neglecting one parameter has a certain harmful effect on the other two [5]. This principle is called the iron triangle of project management, sometimes called the triple constraint, and represents the basis of understanding success in projects [7]. Although it is one of the most commonly used measures for evaluating project performance, researchers also advocate the application of other criteria, such as safety, client satisfaction, profitability, productivity, etc., for a more comprehensive assessment of project success [8]. This paper deals exclusively with the parameters of success within the iron triangle.

Fig. 1 shows the iron triangle as a system of the most basic criteria for measuring project success: whether the project was delivered by the given date, within the budget, and at some agreed-upon quality level [7].

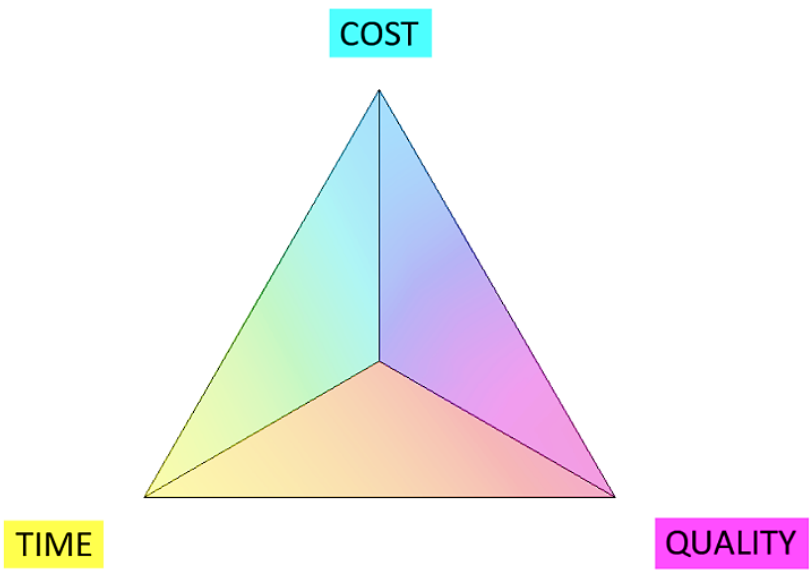

Fig. 1. The iron triangle of project management

Research on the execution and success of construction projects are at the center of numerous research interests, but in practice, deviations from the planned conditions still often occur [9]. Research that observes and/or measures success from the point of view of one of the parameters of the iron triangle includes works by authors such as Abas et al. (2015) [10], Asiedu et al. (2016) [11], Vaardini et al. (2016) [12], Akhund et al. (2017) [13], Derakhshanalavijeh and Teixeira (2017) [14], Keng et al. (2018) [15], Petruseva et al. (2019) [16], Sheikh et al. (2019) [17], Asiedu and Adaku (2020) [18], Tijanić et al. (2020) [19], Negesa (2022) [20], and Ahmed (2023) [21]. Often, studies look at the performance of construction projects through the prism of costs and time, thus combining the two aspects of the iron triangle. Such works include the authors: Memon et al. (2012) [22], Shibnai and Salah (2015) [23], Bhatia and Apte (2016) [24], Senouci et al. (2016) [25], An et al. (2018) [26], Bin Seddeeq et al. (2019) [27], Tijanić et al. (2019) [28], Tijanić and Car-Pušić (2019) [9], Susanti (2020) [29], Zhang et al. (2020) [30], Al Amri and Marey-Perez (2021) [31], Heravi and Mohammadian (2021) [32], and Galjanić et al. (2023) [8]. On the other hand, research that measures quality in addition to costs and time is not so common, and some works include works by authors such as Ramón and Cristobal (2009) [3] and El-Maaty et al. (2018) [33].

It has been noted that most research focuses on costs and time, while the number of those covering quality is significantly smaller. The reason for this is that time and costs and their realization can be measured relatively easily because they are measurable quantities. At the same time, quality is a more complex and subjective criterion. Even if a specific measurement system is established, quality may remain open to interpretation [7]. Also, it is often not possible to assess the actual quality of the project until its completion, and then it is already too late to do anything to solve the defects, or the defects can be solved but with additional costs and time [34]. Quality is a complex and multidimensional quantity that requires careful definition, standardization and constant monitoring to ensure the project's final result meets all requirements and expectations.

One of the biggest challenges in the project is harmonizing the project's time, cost and quality because they are connected in such a way that a change in one affects the other two [34]. Shifting one criterion, for example, in response to client requests or resource constraints, can put pressure on other criteria. Failure in one constraint will likely lead to negative pressure on one or both criteria [7]. According to Wang et al. (2021) [35], the three project goals are integrated, interconnected and conflicting. Creating a balance leads to the desired performance of the project while striving to simultaneously achieve time and cost minimization and quality maximization [36]. Research by authors such as Fu and Zhang (2016) [37], Wang et al. (2021) [35], and Schneider and Domsitzova (2024) [38] have been devoted to the problem and modelling of balancing these three parameters.

The performance and success of projects vary from country to country [39] due to different economic, political, legal, social and other conditions. Therefore, such research should be conducted in a narrower context to determine the characteristics of projects and shape the best management practices adapted to the region's specificities [40]. Despite the importance of construction projects for the growth of the Croatian economy [8, 9], no studies have been conducted in Croatia on the state and management of construction projects that look at the three key parameters of performance success - time, costs, and quality. Such analyses are valuable and can help adopt best practices, avoid observed errors, and continuously improve the project management process. Such research also provides a basis for further, more complex measurement and modelling of success that will potentially improve project management practices in the future.

This paper aims to identify and analyze the relationships between the project objectives in terms of meeting the requirements of time, cost, and quality of construction, which represent the basis of the iron triangle in the management of construction projects. Through the analysis of a large database, an overview of the state and analysis of the projects will be carried out regarding the observed parameters, which will give insight into the success of these projects. The interrelationships of these three key success parameters will be identified and attempted to be understood in order to gain insight into possible strategies for improving construction performance. The research was conducted on construction projects in Croatia.

The paper begins with an Introduction highlighting the problem and the research goal, together with a short and concise literature review. Chapter 2 describes the applied methodology in detail, with all necessary descriptions and explanations. In Chapter 3, the obtained results are presented and discussed. Chapter 4 presents the obtained conclusions.

2 MATERIALS AND METHODS

For analysis purposes, the database developed within the scientific project of the University of Rijeka (uniri-mladi-tehnic-23-59) will be used. The data was collected through visits to active construction sites and inspection of project documentation from 2020 to 2023. The database, therefore, contains data on more recent construction projects from Croatia.

For the purposes of this research, data for new construction projects that were in the central stage of construction were extracted from the wider database. To ensure consistency and comparability of the projects, all projects were viewed on the same basis and within the same time frame. In the subject projects, the phases of design and execution of works are separated, and the emphasis of this research is exclusively on the execution (construction) phase.

The available data (variables) that were researched are presented in Table 1.

Table 1. Database composition

Variable	Type	Measure/label
Planned construction time	quantitative	calendar days
Deviation from the planned construction time	quantitative	calendar days
Planned construction costs	quantitative	EUR with VAT
Deviation from the planned construction costs	quantitative	EUR with VAT
Construction quality assessment	qualitative	satisfactory (0)/ problematic (1)

The planned construction time is the agreed time frame for completing the works. Deviation from the planned construction time means delaying the deadline according to the time plan. On the other hand, the planned construction costs represent the total construction budget for the project. A cost deviation means an amount that exceeds the budget. Construction quality refers to the degree to which the completed works meet specified requirements and standards. According to the Special Regulations on Construction (2021) [41], high-quality work is carried out according to project requirements, technical regulations, and technical specifications. Quality is assessed by checking compliance with the specified requirements and the absence of errors and defects during the execution of work. Errors/shortcomings can result from various factors, such as human errors, poor project management, insufficient expertise of workers, improper use of materials and equipment, bad weather conditions, technical problems, etc. If the mentioned quality problems are noticed during the execution of the works, it is necessary to make repairs so that everything corresponds to the set requirements. In this study, quality was observed in such a way that its compliance with the planned performance was evaluated, i.e., if no deviations occurred, the quality was satisfactory (0), or if certain unplanned situations happened during the performance, such as errors, application of inadequate material and similar, was then evaluated as problematic (1). Because quality is a complex multidimensional quantity subject to subjective and difficult interpretation, it is modelled here as 0-1 values. This way allows for solving many difficult problems. The ability to model complex problems increases tremendously when binary variables are used [3, 42]. This approach to expressing quality is practical, clear, logical, fast and straightforward. However, it should be aware of the limitations because it cannot cover all nuances of quality, whereas, in the real world, there is a whole spectrum of deviations; therefore, in future research, it is recommended to observe the problem at a deeper level through more complex quality assessment models.

Connections will be determined as a correlation coefficient among the presented data. The correlation coefficient shows to what extent changes in the value of one variable are related to changes in the value of another variable. Pearson's and Spearman's correlation coefficients are often used, depending on the type of data and their distribution [43]. The statistical significance of the coefficient is expressed by the p-value, the threshold value of which is set at $\alpha=0.05$ and is used to test statistical hypotheses. Statistically significant correlation coefficients mean that such coefficients are relevant, can be interpreted, the results are not random and are valid for a wider population of projects. They also indicate the conditions for rejecting statistical null hypotheses.

When choosing the appropriate correlation coefficient, it is therefore necessary to check the distribution of the used data, which will be checked with the Shapiro-Wilk Test ($p<0.05$). The Pearson correlation coefficient is used in the case of normally distributed data. In contrast, the Spearman coefficient is commonly used for data that deviate from the normal distribution.

The strength of the connection between the variables is interpreted as shown in Table 2.

Table 2. Interpretation of the correlation coefficient [44]

Range of correlation coefficient values	Level of correlation
0.80 to 1.00, -1.00 to -0.80	very strong positive/negative
0.60 to 0.79, -0.79 to -0.60	strong positive/negative
0.40 to 0.59, -0.59 to -0.40	moderate positive/negative
0.20 to 0.39, -0.39 to -0.20	weak positive/negative
0.00 to 0.19, -0.19 to -0.01	very weak positive/negative

Calculating the correlation coefficient will enable understanding and quantifying the relationship between the time, costs and quality of construction. In this way, it is possible to recognize the key factors of success and economic feasibility of the project, which is useful for shaping strategies for success, i.e., efficient management of the entire construction.

In addition to correlation analysis, regression analysis will further examine the relationships between the researched success parameters and the modelling of the relationships between them. Regression models are effective due to a well-defined mathematical approach, the possibility of explaining the connections between independent and dependent variables, and the size and strength of this mutual influence [45, 46]. The statistical hypothesis testing procedure was also carried out in the regression analysis. This procedure determined whether and how reliable the available data are and whether they support the set assumptions depending on the level of statistical significance ($p<0.05$). The stepwise method was used to select the dependent variables that will be part of the model, ensuring that only statistically significant variables are included [47, 48].

The estimation error in regression models will be measured using the coefficient of determination (R^2) and mean absolute percentage error (MAPE).

The coefficient of determination R^2 is a statistical measure that evaluates the general suitability of the prediction model. It shows the percentage of changes in the experimental values of the dependent variable the model explains [46, 49].

MAPE is a measure of prediction accuracy and is defined by the following formula [19] (1):

$$MAPE = \frac{1}{N}\left|\frac{actual\ value - estimated\ value}{actual\ value}\right| (\%) \quad (1)$$

Models with R^2 above 0.64 and MAPE below 30% are considered to describe the model well, i.e., they provide a solid, strong connection between actual and estimated values [19, 50]. The goal is to obtain models with the limit indicators of accuracy thus set.

Microsoft Excel 2021 with the statistical add-on Real Statistics will be used for data processing, testing and modelling.

3 RESULTS AND DISCUSSION

The entire database contains 49 samples of construction projects, which is considered to represent a large sample of data ($n>30$) that can potentially provide reliable, credible, and representative results [51].

Descriptive statistics of the database are shown in Table 3.

Table 3. Descriptive statistics of the database

Statistical metrics	Planned construction time	Deviation from the planned construction time	Planned construction costs	Deviation from the planned construction costs	Construction quality assessment
Mean	385.7551	19.1429	7,518,667.26	187,524.03	0.2041
Standard Error	35.5128	6.8932	2,789,139.65	95,943.08	0.0582
Median	335	0	1,327,228.08	0	0
Mode	550	0	1,327,228.08	0	0
Standard Deviation	248.5898	48.2523	19,523,970.54	671,601.60	0.4072
Sample Variance	61796.9	2328.292	3.81E+14	4.51E+11	0.1658
Kurtosis	0.2479	26.2921	12.6204	37.0352	0.3068
Skewness	0.9943	4.7091	3.6679	5.8497	1.5153
Range	965	312	87,875,837.10	4,496,019.45	1
Maximum	1040	305	87,950,493.68	4,496,019.45	1
Minimum	75	-7	74,656.58	0	0
Sum	18902	938	3.68E+08	9,188,678.61	10
Count	49	49	49	49	49

The average planned construction time is 386 days. The minimum planned time of the work is 75 days, and the longest is almost three years, i.e., 1040 days. The average deviation of the construction time compared to the planned is about 19 days; in the form of a percentage, it is 5.89%. The minimal deviation shows that the work was ahead of schedule in certain projects by a week. The maximum recorded time deviation is 305 days. The average planned construction costs are around EUR 7,520,000.00. The minimum estimated budget is around EUR 75,000.00, while the maximum budget reached EUR 87,950,493.68. The information on the maximum overrun indicates that it reaches EUR 4,496,019.45. In contrast, the minimum overrun is zero euros, which indicates some successful examples of management where costs are carefully controlled and aligned with plans. Looking at all projects, the average overrun amounts to EUR 187,524.03, a percentage of 4.19%. As for the quality of construction, satisfactory quality (0) is foreseen in all projects. Given that certain problems appeared in certain projects (1), the average numerical state of construction quality was expressed as 0.2041, indicating that it tends to be satisfactory in most projects.

Considering the size of the standard deviation, it is evident that the projects differ in scope, complexity, time and cost aspects, and quality standards. Analyzing such a database provides useful insights into Croatia's various spectrum of projects.

Project performance ratios within the planned values are shown in Table 4.

Table 4. Projects performance analysis

Project parameter	Performance	Share (number)	Share (%)
Time	within the deadline	26	53.06
	out of deadline	23	46.94
Cost	within the budget	26	53.06
	out of budget	23	46.94
Quality	satisfactory	39	79.59
	problematic	10	20.41

The performance of time and costs is equal, with slightly more than half of the projects whose performance is within the planned values. On the other hand, almost half of the projects are not within the planned values, where we saw in the previous table that the problem of the size of the time overrun is somewhat more pronounced. It should be noted that although the numbers are the same, these are not the same projects. A combination of cost and time overruns was recorded in 16 projects (32.65%). The quality of work performance in most projects is characterized as satisfactory. However, in about 20% of the projects, certain quality problems were recorded, which indicates the need for further improvements in quality control and ensuring compliance with standards. This result suggests that although most projects successfully meet quality standards, there is a non-negligible percentage of projects where additional efforts are needed to prevent errors and ensure consistent performance quality.

All these data indicate the diversity of projects in terms of dynamics, finances and quality, as well as the challenges in their management in construction projects. The indicators emphasize the need for careful planning, monitoring, supervision and control to ensure a more successful implementation of projects in terms of the observed success parameters.

A deeper insight into the execution of projects, which is not examined in detail here, found that some of the most common causes of time and cost deviations are unplanned works, weather conditions, health crises, and economic conditions (inflation, price changes). Quality problems most often include design errors that require revisions and additions, which is beyond the scope of this paper. During the actual execution of the works, the problems that arise include errors in the execution of the works or deficiencies in the installed materials, especially concrete, where segregation, cracking, etc., subsequently occur.

In theory, the observed performance parameters of construction projects should be correlated; that is, time problems should affect costs to some extent and vice versa, or quality problems should affect time and costs [7, 35]. This will be examined in more detail by statistical testing. The size of the correlation coefficient between them will measure connections between individual project success parameters. The observed variables are the deviation from the planned construction time, the deviation from the planned construction costs, and the construction quality assessment.

The following statistical hypotheses are established:

- $H0_1$: There is no statistically significant relationship between the project's success in terms of realization within the planned time and costs of construction.
- $H0_2$: There is no statistically significant relationship between the project's success in terms of realization within the planned time and the quality of construction.
- $H0_3$: There is no statistically significant relationship between the project's success in terms of realization within the planned costs and the quality of construction.

By checking the normality of the data with the Shapiro-Wilk test, it was determined that they do not follow a normal distribution (p-value<0.05; normal: no). Therefore, Spearman's correlation coefficient was used to test the correlation. The obtained correlation coefficients and their p-values are shown in Fig. 2.

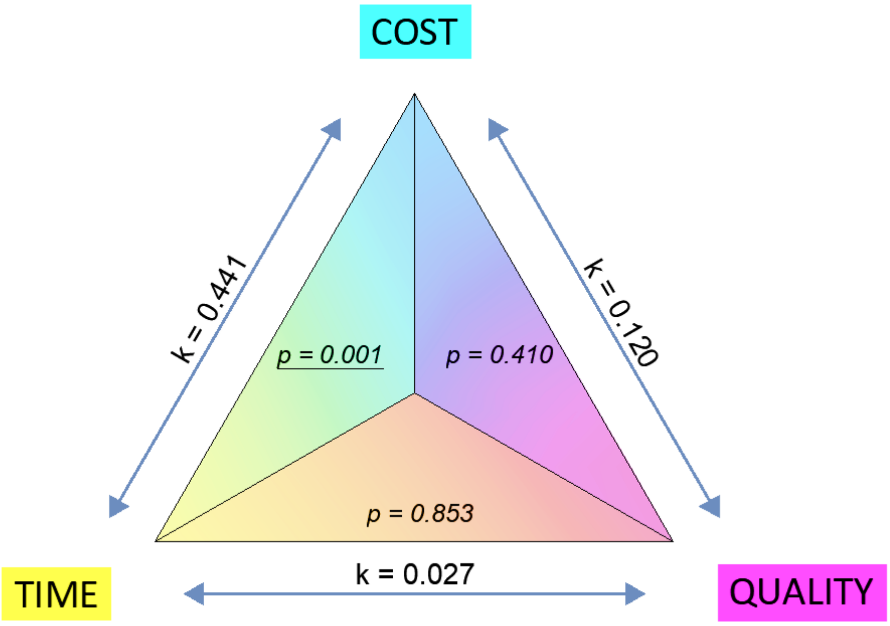

Fig. 2. Correlations between parameters of the iron triangle

Checking the p-value shows that it is significant only in the case of the correlation between time and costs. Only in the case of this relationship is H0 rejected; that is, we can say that there is a statistically significant correlation between the project's success, looking at the time and construction costs (p=0.001). Considering the size of the corresponding correlation coefficient (k=0.441), the strength of this connection is moderately positive. A moderately positive correlation between time overruns and construction cost overruns means a moderate relationship exists between the two parameters: when construction time overruns, construction costs also tend to increase, and vice versa. This relationship is not strong, which indicates that other factors can have an impact on overruns and the success of construction in the form of achievement within the planned values and are expressed through, for example, changes in design during construction, unforeseen problems on the ground, fluctuations in material prices, weather conditions, regulatory requirements, efficiency of project management, etc., which was determined by a wider observation of projects.

In the case of the correlation of time and costs with the quality of construction, no statistically significant relationships were shown, which indicates that these results are not generally applicable outside the observed database. Additional tests and analyses on larger or different data sets are needed to determine whether and to what extent relationships exist between these parameters in other contexts. The obtained sizes of the correlation coefficients are almost negligible, emphasizing the need for additional research. The reason for such findings may be the composition and specificity of the database, the method of measuring and expressing quality within the database, and the influence of other factors that are not covered here. Also, the quality of construction in the projects is mostly under strict supervision, so major problems do not appear at this stage. Major quality problems were observed in the design phase during the creation of project documentation, which required alterations and additions in quite a few cases and could significantly affect construction costs and time. The design phase, however, is not covered by this analysis.

The results indicate the importance of comprehensive preparation, planning, and project management to minimize unforeseen circumstances that can lead to increased costs, extended construction time, and reduced quality performance. Also, they indicate the need for additional research that could examine other factors that significantly contribute to the success or failure of construction projects regarding the observed parameters to achieve optimal results in future projects.

Research and modelling the relationship between success parameters within the iron triangle will also be done by regression analysis, where the goal is to model the relationship between their realized and planned values. Realized values of time, costs, and quality are dependent variables that will be tried to be explained by independent variables, i.e., planned (contracted) values of time, costs, and quality. The goal is to better understand their mutual relationships and obtain predictive models that can optimize the construction process and make quality project decisions.

The following hypotheses are put forward:

- $H0_1$: None of the independent variables (contracted time (T_C), contracted costs (C_C), contracted quality (Q_C)) has a statistically significant relationship with the realized construction time (T_R).
- $H0_2$: None of the independent variables (contracted time (T_C), contracted costs (C_C), contracted quality (Q_C)) has a statistically significant relationship with the realized construction costs (C_R).
- $H0_3$: None of the independent variables (contracted time (T_C), contracted costs (C_C), contracted quality (Q_C)) has a statistically significant relationship with the realized construction quality (Q_R).

The developed regression models are shown in Table 5.

Table 5. Regression models for estimating real time, cost and quality of construction

Dependent variable	Significant independent variables (p<0.05)	Is H0 rejected?	Regression formula	R^2	MAPE
T_R	T_C	yes	T_R=17.648+1.004T_C	0.963	8.04%
C_R	C_C	yes	C_R=144234.300+1.006C_C	0.998	28.25%
Q_R	none	no	-	-	-

In the case of estimating real costs and time, the null hypothesis is rejected, i.e., there are independent variables that have a statistically significant relationship with the dependent variables. Regression formulas were developed that describe the relationships between realized times and costs with the associated statistically significant independent variables. The accuracy indicators show the good performance of these two models, with the predictive time model giving better MAPE values, i.e., the difference between the actual and estimated time values is smaller in this case. This difference may result from the nature of the data, where time data is easier to track and predict. At the same time, costs are more subject to complexity and greater uncertainty in estimation due to the impact of various constraints, changes and risk events.

In the case of predicting the quality of the works, it is impossible to develop an adequate predictive regression model by observing the available independent variables. This result may be the result of various already mentioned causes, such as the specificity and limitations of the database used, the method of quality assessment within the database, its multidimensionality, which is not always easy to visualize, as well as the possible influence of other factors that are not covered by this research. Quality as a highly subjective parameter of project success may vary depending on the evaluator's perception, standards or specific project requirements. While the time and cost of the project are quantitative and relatively easy to measure, quality includes a whole series of criteria that are not easy to quantify, such as aesthetics, customer satisfaction, technical aspects, etc. Therefore, quality prediction often requires additional qualitative and quantitative analyses that can more adequately encompass the issue's complexity. Because of the above, in future research, it is necessary to consider more complex, alternative approaches to modelling that will better describe the relationships and connections between realized quality and other parameters of the project and its success. Such approaches include, for example, machine learning or the application of hybrid models that can combine qualitative and quantitative aspects of quality.

Any deviation from the set standards of time, costs, and quality adversely affects the parties involved in the construction project because it causes delays, financial losses, unprofitability, reduced project quality, reduced quality of services, etc. [40, 52]. For this reason, it is important to try to reduce irregularities, deviations and losses and deliver projects at optimal values. In this case, predictive models can help improve the accuracy of initial assessments, optimize resources, improve decision-making, reduce risk exposure, and improve transparency and accountability, thus becoming a useful tool for more efficient construction and successful project management [40]. Optimization of resource consumption, minimization of unnecessary costs, adequate management of deadlines and delivery of products of satisfactory quality contribute to increasing the efficiency of projects. Therefore, examining the correlations between individual project success parameters represents a basis for continuous improvement of their performance, as it enables monitoring, analysis and understanding of changes in relationships through different projects. In this way, it is possible to obtain important information for developing advanced methodologies and tools for improving and predicting performance, which can further improve the management of complex construction projects.

This study analyzed the success of construction projects in Croatia in terms of time requirements, costs and construction quality and identified the relationships between these three observed parameters of success. Analyzing the data, it was observed that there are problems regarding the fulfilment of costs and construction time in many projects. In contrast, the situation regarding the quality of construction is somewhat better, but the occurrence of problems is still not negligible. The results suggest that a comprehensive and systematic approach to project management is needed, where the focus should be on detailed project preparation and planning, detailed definition of technical requirements and project specifications, development of a detailed plan flexible to the impact of changes, constant monitoring, supervision and control of the performance of works and installed materials, constant monitoring of market conditions as well as proactive risk management related to natural, economic and other factors. The quality of technical documentation largely determines the issue of construction quality. Therefore, the quality of technical documentation is particularly emphasized. Planning, professional execution and supervision of works, a systematic approach to risk management and timely response to changes and problems are key to successfully managing projects and achieving goals within the stipulated framework.

The results of this paper contribute to the academic and practical field of the construction profession by providing a basis for improving the practice of construction project management. They contributed to the understanding of construction projects and the conditions for their realization within the framework of meeting the requirements of time, costs and quality of construction. The study's findings have a valuable contribution to the area of Croatia.

The study's main limitation is observing a separate geographical area that includes only Croatia. Therefore, the results do not apply to other areas with conditions and practices that differ from those observed here. The composition of the database, which contains only a certain number of variables, is also a limitation, as well as how individual variables within the database are expressed. This is especially true of quality observation, which here is very simplified, so it does not maintain all aspects and nuances of real-world quality. Also, the results obtained here look at projects exclusively during construction and up to the middle stage, which gives very useful insights and hints at further trends. However, the project's outcomes may differ from those presented here.

In future research, it is recommended to collect complete data at the end of the construction works, as well as to observe all phases of the construction project and to observe more deeply the influence of a wider range of factors on certain parameters of the project's success. In addition to costs, time and quality, future research can include other success evaluation criteria such as productivity, profitability, client satisfaction, etc. Also, it is recommended to use more complex evaluation models for project quality evaluation that will more realistically convey the levels and state of quality from reality. One of the special areas of efficiency improvement in the success segments of construction projects is the development of innovative computer models for estimating project time, costs and quality. Therefore, it is recommended that further research be expanded in this direction as well.

4 CONCLUSIONS

This work deals with the issue of successful implementation of projects in terms of time, costs and quality of construction. The mentioned aspects form a system of three basic criteria by which the project's success is measured, and this principle is called the iron triangle. The literature states that in construction practice, projects often do not meet the success criteria defined within the iron triangle of project management. In Croatia, which is the focus of this research, there is also a lack of broader studies that observe, evaluate and analyze the success of construction projects through the mentioned parameters.

Within this research, a large database of construction projects from Croatia was analyzed, based on which an overview and analysis of the success of the projects were given about the realization of the planned time, costs and quality of construction. The results revealed that almost 50% of the observed projects did not satisfactorily meet the time and cost aspects. Regarding construction quality, problems appeared in about 20% of the projects. Examining the mutual relationships between the success of time, costs and construction quality, it was revealed that a statistically significant relationship exists only between time and costs. In contrast, no such relationships were recognized in the case of quality. While developing mathematical predictive models, a similar situation was observed. Regression models for predicting real time and construction costs gave good results looking at accuracy indicators (R^2, MAPE), while in the case of quality, such models cannot be developed. These results indicate the need for further research, primarily regarding constructing quality assessment, analysis and prediction.

The results emphasize the importance of preparation, planning, professional execution, supervision and control of construction works. Comprehensive, systematic and proactive project management is essential for achieving goals within the stipulated framework.

This study contributes to the academic and practical field of the construction profession, providing a basis for improving project management practices in the context of achieving project success in terms of time, cost and construction quality. Limitations of the research include regional observation of the issue, limited database, and simplified assessment of construction quality. In future research, it is recommended that the database be expanded and completed and that more advanced evaluation and prediction methods of certain project success parameters be used.

5 ACKNOWLEDGEMENT

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