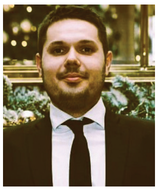
DOI: https://doi.org/10.14256/JCE.4465.2025

Građevinar 4/2026

Primljen / Received: 11.12.2025.
Ispravljen / Corrected: 21.4.2026.
Prihvaćen / Accepted: 29.4.2026.
Dostupno online / Available online: 10.5.2026.

Management of infrastructure projects in the Republic of Croatia – Analysis of the organisational environment and project delivery performance

Authors:



Kristijan Robert Prebanić, PhD. CE
University of Zagreb
Faculty of Civil Engineering
kristijan.robert.prebanic@grad.unizg.hr
Corresponding author

Prof. **Mladen Vukomanović**, PhD. CE
University of Zagreb
Faculty of Civil Engineering
mladen.vukomanovic@grad.unizg.hr

Original research paper

Kristijan Robert Prebanić, Mladen Vukomanović

Management of infrastructure projects in the Republic of Croatia – Analysis of the organisational environment and project delivery performance

Infrastructure projects support the fulfilment of society's most fundamental needs (e.g. transportation and water supply) and constitute an indicator of economic competitiveness. Globally, infrastructure investments amounting to approximately EUR 82 trillion are projected by 2040. This research analyses the organisational environment and project delivery performance based on a sample of fifty infrastructure projects in the Republic of Croatia, with the aim of addressing the lack of research in this field. The results indicate that Croatia is currently undergoing a major investment cycle, with emphasis on transport and municipal infrastructure, driven by co-financing from EU funds. The organisational environment is complex in the majority of projects, while management models remain relatively traditional. Cost overruns are present in 58% of projects, whereas schedule overruns occur in as many as 84% of projects. The construction phase is frequently extended by more than 20 % beyond the contractual duration. Social infrastructure projects demonstrated weaker cost performance compared to civil infrastructure projects, with overruns often exceeding 20 % of the contract value; this issue will be investigated in greater detail in future research. Given the importance of critical infrastructure for the development of the Republic of Croatia, public contracting authorities and other key stakeholders should address challenges such as delays, budget overruns, and the frequent use of traditional procurement models. Possible starting points include innovative administrative frameworks and procurement models analysed in this paper, whose implementation has not yet been recorded in Croatia.

Key words:
infrastructure, projects, organisation, administrative framework, project performance

Izvorni znanstveni rad

Kristijan Robert Prebanić, Mladen Vukomanović

Upravljanje infrastrukturnim projektima u Republici Hrvatskoj - analiza organizacijskog okruženja i uspješnosti provedbe projekata

Infrastrukturni projekti podržavaju zadovoljenje najosnovnijih potreba društva (npr. transport, opskrba vodom) i indikator su konkurentnosti gospodarstva. Globalno se predviđa oko 82 bilijuna eura investicija u infrastrukturu do 2040. godine. U ovom istraživanju analizirano je organizacijsko okruženje i uspješnost provedbe na uzorku od pedeset infrastrukturnih projekata u RH kako bi adresirali nedostatak istraživanja u ovom području. Rezultati pokazuju da u Hrvatskoj traje veliki investicijski ciklus s naglaskom na prometnu i komunalnu infrastrukturu koji je potaknut sufinanciranjem iz EU fondova. Organizacijsko je okruženje složeno u većini projekata, a upravljački su modeli još uvijek relativno tradicionalni. Troškovno prekoračenje prisutno je u 58 % projekata, a prekoračenje roka pojavljuje se u čak 84 % projekata. Faza izvođenja nerijetko se produlji za više od 20 % ugovornog trajanja. Društvena infrastruktura pokazala je slabije troškovno izvršenje od civilne infrastrukture (prekoračenja često prelaze 20 % ugovorne cijene), što će se ubuduće detaljnije istražiti. Zbog značaja vitalne infrastrukture za razvoj RH javni naručitelji i ostali ključni akteri trebali bi adresirati izazove poput kašnjenja i prekoračenja budžeta te učestalog korištenja tradicionalnih modela nabave. Moguća su polazišta inovativni administrativni okviri i modeli nabave koji su analizirani u radu, čija implementacija nije zabilježena u Republici Hrvatskoj.

Ključne riječi:
infrastruktura, projekti, organizacija, administrativni okvir, uspješnost projekata

1. Introduction

Over the past two decades, large-scale infrastructure projects have played a significant role in societal and economic development, primarily aimed at overcoming existing infrastructure capacity constraints or creating new business opportunities [1, 2]. Infrastructure projects are being implemented worldwide, both in developed countries that are expanding existing infrastructure capacities and in developing countries that are constructing vital infrastructure such as roads and railways for the first time [2-4]. The McKinsey Global Institute [5] estimates that the world will need to invest EUR 50 trillion in infrastructure between 2016 and 2030, while the *Global Infrastructure Outlook* report estimates required investments of EUR 82 trillion (USD 94 trillion) between 2016 and 2040 [6]. Current global infrastructure investment amounts to approximately EUR 2.8 trillion annually, compared to estimated needs of EUR 3.2 trillion per year, implying a cumulative financing gap of approximately EUR 10.4 trillion (USD 12 trillion) by 2040 [6]. In contrast, more recent estimates by the Organisation for Economic Co-operation and Development indicate annual investment needs ranging from EUR 5.5 to 5.9 trillion when climate objectives and sustainable development goals are taken into account, with an annual investment gap of approximately EUR 2.17 to 2.61 trillion [7, 8], corresponding to a cumulative infrastructure financing gap of EUR 15.4 trillion (USD 18 trillion) by 2040 [9].

In Croatia, transport infrastructure accounted for the largest share of the value structure of completed construction works in 2021, representing 30.1 % of the total [10]. When other types of infrastructure projects are also considered, it becomes evident that more than 50 % of the total value of construction works in Croatia relates to infrastructure projects. On 12 December 2014, the European Commission approved the *Operational Programme Competitiveness and Cohesion 2014–2020* [11] (with funds utilised until the end of 2023), through which Croatia was allocated EUR 6.881 billion in EU funding for investments aimed at growth and development. The largest share of investments, exceeding EUR 3.5 billion, was directed towards environmental protection (water and utility infrastructure and waste management), transport infrastructure, and climate change adaptation measures (flood protection and other natural disaster prevention initiatives) [12].

Throughout the long lifecycle of infrastructure projects, it is relatively common for the needs and interests of stakeholders to evolve, which may lead to deviations from initially defined project objectives (e.g. budget, schedule, etc.) [13]. Research in the field of construction project management has consistently shown that the performance of large-scale infrastructure projects is often unsatisfactory, with inappropriate projects being selected, costs underestimated, and anticipated project benefits overestimated [14]. Certain industry studies indicate that, on average, approximately 70 % of companies implement projects that fail to satisfy stakeholder expectations or achieve planned objectives [15, 16], with performance outcomes generally being weaker for large and complex projects than for smaller ones. Lovrinčević et al. [17], in their research on road infrastructure projects in Croatia, demonstrate the existence of cost overruns in road infrastructure projects. Brunet and Aubry [18], as well as Klakegg et al. [19], observed that the "anatomy" of large public projects is changing, characterised by increasingly complex relationships among stakeholders and supply chains, and called for more extensive scientific investigation of this emerging organisational phenomenon. A body of research on the management of large infrastructure projects has confirmed that such projects are often characterised by specific financial arrangements, complex procurement and contracting systems, and misaligned and intertwined stakeholder interests, leading to the development of a concept of complexity (i.e. project complexity) [2-4]. Traditional management and governance approaches do not yield satisfactory results in complex projects [20] and Wagner and Radujković [21] demonstrated that the development of the project management approach in the public sector across several European countries is lagging, which has a significant impact on the capacity for successful infrastructure project delivery.

Research in Croatia addressing the managerial context and the performance of infrastructure project delivery has predominantly been conducted using qualitative methods (e.g. expert interviews). Prebanić and Vukomanović [22] emphasise that, in Croatia, experts (e.g. project managers and client representatives) consider it is necessary to achieve improvements at several managerial levels (e.g. project teams, companies, etc.) to enhance the performance of infrastructure projects, which they consider relatively weak. Sjekavica et al. [23] provided general recommendations for improving the management of EU co-financed infrastructure projects (e.g. procurement processes and project management practices) and also identified several pressing issues in project execution. The importance of strengthening the implementation of project management roles was also highlighted in the study by Perić and Vukomanović [24]. Only one study, based on a sample of real projects, has examined delivery performance; however, it focuses exclusively on cost performance in transport infrastructure [17], thereby analysing only a single performance indicator within a single type of infrastructure project.

The aim of this study is to analyse the managerial and organisational context of infrastructure projects in Croatia based on a sample of completed projects, and to assess project performance by observing the indicators of budget, schedule, quality, and scope. From this objective, the following research questions are derived: (1) What types of infrastructure projects are implemented in Croatia and how are they financed? (2) What is the managerial and organisational environment of infrastructure projects? (3) What is the level of infrastructure project performance? and (4) Are there significant differences in performance between different types of infrastructure projects? The study is based on a sample of fifty infrastructure projects completed by 2022 in Croatia. The structure of the paper continues with a literature review, in which the concept of infrastructure construction projects, their organisational and managerial context, as well as the limitations of current scientific research in these areas are clarified. This is followed by the presentation of the methodology, the results of the study, and a discussion in which answers to the research questions are provided.

2. Literature review

2.1. Organisational context of infrastructure projects

In general, infrastructure can be divided into two categories: civil infrastructure and social infrastructure, i.e. hard and soft infrastructure [25]. Civil infrastructure supports the most fundamental societal and economic needs (e.g. energy, transport, water supply and wastewater systems), whereas social infrastructure is essential for the development of cultural norms and the promotion of a healthy population (e.g. courts, administrative services, schools, hospitals) [13, 26]. According to the *Spatial Development Strategy of the Republic of Croatia 2017–2030* [27], infrastructure systems and the associated construction projects are classified into four categories, while the strategy also recognises the concept of social infrastructure:

- Transport infrastructure (e.g. railway, road, inland waterway transport infrastructure, maritime infrastructure, air transport infrastructure, intermodal transport)
- Energy infrastructure (e.g. cogeneration plants, energy storage facilities)
- Water management infrastructure (e.g. protection against harmful water impacts, river flow regulation)
- Utility infrastructure (e.g. public water supply, public wastewater systems)
- Social infrastructure (e.g. schools, hospitals, courts, health centres).

Locatelli et al. [28] note that, in addition to substantial financial expenditures, infrastructure projects are also characterised by the following features: a public-sector investor, delivery by many private companies, and a high degree of uncertainty and complexity arising from many stakeholders with misaligned interests.

The key role of the client is to initiate construction projects by defining the rationale for construction and the financing structure, while also seeking to demonstrate that the investment is justified and necessary [29, 30], which is particularly emphasised in public infrastructure projects. In the construction sector buying goods and services is commonly referred to as procurement [29] and involves a relatively complex process based on specific rules and procedures. Naoum and Egbu [31] state that the primary objective of procurement is to enable a project that meets the defined objectives and expectations of (public) clients. Table 1 presents two classifications of procurement methods, illustrating which elements of a construction project are influenced by procurement methods.

A common approach to classifying procurement systems in construction projects is based on the structure of the project organisation, i.e. the delivery model formed through procurement. Such classification identifies three main models [32, 34]: separated models (e.g. employer-designed contracts, such as the FIDIC Red Book), integrated models (e.g. design and build, various public–private partnership arrangements such as DBO, BOT, and PFI), and management-oriented models (e.g. contract management and construction management). A fourth model increasingly discussed in the literature is collaborative procurement systems, which are based on specific contractual structures such as alliances and other forms of partnership between clients and contractors [34]. Biesenthal and Wilden [35] emphasise the organisational complexity of infrastructure projects and in addition to adapting the procurement models to tackle with the complexity, they advocate the implementation of specific project governance mechanisms through dedicated organisational and administrative structures.

2.2. Specific organisational and managerial systems for public infrastructure projects in international practice and in Croatia

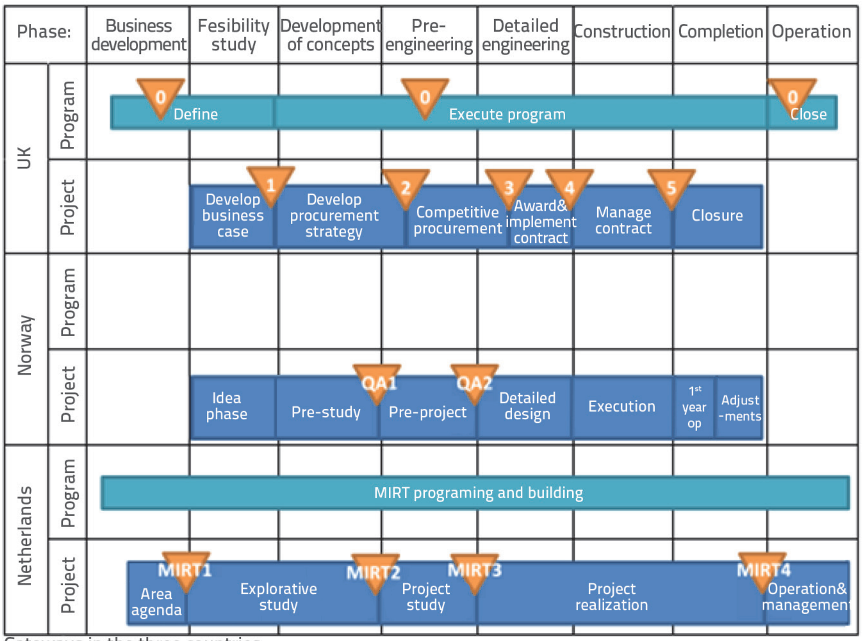
To professionalise public project management and improve the efficiency of public procurement expenditure, several developed countries have established governance and oversight frameworks for public (infrastructure) programmes and projects. One of the earliest and most influential models is the OGC Gateway Review Process introduced in 2001 in the United Kingdom [36, 37].

The British Office of Government Commerce (OGC) is an independent body within the Ministry of Finance, established to ensure value for money in public spending, with reported savings of approximately eight billion pounds by 2008 [38]. The main elements of the UK governance system are Gateway Reviews, which are used to validate the justification and readiness of a project at the end of each phase and to formalise the decision to proceed to the next stage (see Figure 1).

Such end-of-phase authorisations are colloquially referred to as 'phase gates'. The concept later evolved to include 'particularly critical projects' and other initiatives aimed at developing more effective systems for monitoring and delivering complex infrastructure projects [39, 40]. In addition to the British system, Klakegg et al. [19] also analyse and compare two further similar frameworks. The Dutch MIRT (Multi-Year Programme for Infrastructure, Spatial Planning and Transport) represents an integrated multi-annual programme and governance framework for the selection and financing of infrastructure investments in transport, water

Table 1. Two classifications of key characteristics of procurement models for construction projects

Molwus [32]	Eriksson et al. [33]
Project organisation	Delivery system, including the nature and timing of contractor involvement
Financial aspects	Remuneration system
Contract conditions	Contractor selection procedures (tendering process)
Management processes	Collaboration model



Gateways in the three countries:

UK	Norway	Netherlands
0 = Business need 1 = Business case review 2 = Procurement strategy 3 = Investment strategy 4 = Readiness for service 5 = Benefits realization	QA1 = Quality assurance of choice of concept QA2 = Quality assurance of budget proposal	MIRT1 = Intake decision MIRT2 = Decision on preferntial alternative MIRT3 = Project realization decision MIRT4 = Approval decision

Figure 1. The structure of the governance frameworks in the three countries compared on program and project level (used from Klakegg et al [19])

management, and spatial planning, linking national and regional levels of planning. MIRT is implemented through clearly structured phases, where each phase concludes with a political-administrative decision and the definition of conditions that a project must meet to qualify for national funding. Each country uses its own terminology for project development phases and decision gates through which a programme or project progresses (see Figure 1), clearly indicating that different countries adopt distinct approaches to the governance of infrastructure project delivery. Klakegg et al. [19] also describe several other characteristics of governance systems, including the use of external consultants as independent reviewers, a stronger emphasis on a more robust, clearer, and broader planning basis in the early stages (so-called 'front-end planning'), independent cost estimate reviews, and the professionalisation of public organisations responsible for infrastructure project delivery. They further note that these models have yielded outcomes such as cost savings, improved cost control, and faster decision-making but that certain challenges remain, including low data quality, difficulties in conducting cost–benefit analyses, and the limited applicability of these models to all public infrastructure projects [19].

Although such governance systems for complex infrastructure projects have been implemented only in a limited number of developed countries in Europe and worldwide, other models also exist that support the delivery of complex public projects. All European Union (EU) Member States are subject to common public procurement rules, such as the EU Public Procurement Directive and the Directive on procurement by entities operating in the water, energy, transport and postal services sectors [41, 42]. These directives are aligned with the rules of the World Trade Organization (WTO) and, through certain provisions, establish a broader administrative framework for project delivery. Over the past decade, a significant proportion of infrastructure projects in Croatia have been predominantly financed through EU grant funding [43, 44], and are therefore implemented under the European procurement and financing framework, which includes specific procedures and requirements related to the preparation and implementation of infrastructure projects.

2.2.1. Organisational context of infrastructure projects in Croatia

The study by Burcar Dunović [45], conducted on road infrastructure projects in Croatia and referencing the OGC Gateway governance system (UK) and the Quality at Entry regime (Norway) presented in Figure 1, represents one of the few attempts to investigate the existence of 'governance systems' among Croatian public infrastructure clients. The findings indicate that no formal project decision-making (review) system exists, and that the design and construction phases are primarily embedded within established construction practice and the existing regulatory framework [45]. The study also highlights the Law on Roads, which requires the preparation of a four-year road construction and maintenance plan, serving as a form of formalised planning for infrastructure projects. Following the adoption of the plan by the Government of the Republic of Croatia, responsibility for implementation is transferred to a state-owned company whose core mandate is the development and maintenance of road infrastructure. According to Prebanić [46] (2022), the dominant procedures and the regulatory approach to transport infrastructure have not changed significantly in the last 10 years.

Since 2015, with the adoption of the Act on Physical Planning and Building Activities [47], the role of the construction project manager (project leader) was introduced, aiming to professionalise project management within the construction sector. However, in practice, an inconsistency in the Croatian approach has been observed, whereby the construction project manager predominantly holds an advisory role, in contrast to practice in more developed countries, where project managers are mandated to manage all processes and are held accountable for project outcomes [24]. Perić and Vukomanović [24] further emphasise that the terminology of 'construction project manager' is too narrow, as construction, as defined under the Construction Act [48], does not encompass the full life cycle of a construction project. Furthermore, in Croatia the project manager is often appointed only at the execution phase, which is also contrary to best practices in more developed countries [22-24, 49]. A certain degree of progress in strategic programme and project management has been achieved indirectly through the implementation of EU co-financing as the dominant mechanism for financing and administering infrastructure projects in Croatia [22, 23, 50]. Public legal bodies are an indispensable component of all EU co-financed (infrastructure) projects, and the roles of individual institutions are defined by the following official documents:

- Act on the Institutional Framework for the Use of European Structural and Investment Funds in the Republic of Croatia in the 2014–2020 Financial Period [51]
- Regulations defining the competences of individual bodies within the management and control systems for the use of the European Social Fund, the European Regional Development Fund, and the Cohesion Fund, under the "Investment for Growth and Jobs" objective [52].

Dragić and Orešković [49] examined the state of construction project management within the Croatian Waters (Hrvatske vode) organisation for projects co-financed by EU funds, and proposed changes to its organisational structure in order to enable more effective performance of its role as a Second-Level Intermediate Body for utility projects. The Second-Level Intermediate Body performs relatively active project oversight due to its obligation for financial monitoring and control of expenditure, including the approval of monthly payments from EU funds, and is, together with the beneficiary, one of three co-signatories of the grant agreement [44]. Sjekavica et al. [23] surveyed a significant number of infrastructure project managers in Croatia regarding the state of the profession, who indicated that EU co-financed projects show a shift towards the professionalisation of strategic and systematic project management, for example through the formal evaluation of project proposals. The manual of the Central Finance and Contracting Agency (SAFU), which acts as the Second-Level Intermediate Body for most priority axes, may be considered a step forward towards systematic project management, as it prescribes certain requirements within the framework of project organisation and management:

- the beneficiary of EU funds (i.e. the public contracting authority) is obliged to prepare and continuously update the procurement plan is required to update and, where necessary, further elaborate the implementation schedule defined in the project proposal, as well as to assume responsibility for its execution
- must establish its own implementation system (execution of activities) and update and, where necessary, further elaborate the project implementation plan outlined in the project proposal
- the project monitoring and implementation system must include:
  - systematic updating and monitoring of the project implementation plan
  - project team management
  - management of project outputs and results
  - procurement management within the project
  - human resources management
  - risk management
  - management of information and visibility obligations

Experts in infrastructure projects in Croatia indicate that a range of challenges remain which public contracting authorities still struggle to address [22], and that further professionalisation in the strategic management and governance of infrastructure projects in Croatia is required.

2.3. Project performance of infrastructure construction projects

Findings from a range of studies indicate that project success is a multidimensional concept: it means different things to different stakeholders, and context plays a crucial role in its interpretation [53]. It is also emphasised that the point in time at which success is measured is a relatively important aspect [54]. There are examples of projects that were delivered within budget and on schedule yet were still considered unsuccessful because their functional value did not meet user expectations, as well as projects that experienced delays and cost overruns but were later regarded as highly successful [55]. Construction project success is therefore a broad, contested, and complex subject, and it is common for organisations and individuals within a project to assess success differently, depending on their own objectives [54, 56]. In addition to the three traditional performance

Table 2. Success criteria and KPIs from two empirical studies based on construction projects

Gunathilaka et al. [57] – 9 success criteria	Toor and Ogunlana [58] – 9th KPI
PSC1: Budget/finance/cost performance	On time (KPI1)*
PSC2: Technical performance	Within budget (KPI2)
PSC3: Schedule performance	Meets specifications (KPI3)
PSC4: Stakeholder satisfaction	Efficient (resource utilisation) (KPI4)
PSC5: Time performance	Doing the right thing (effectiveness) (KPI5)
PSC6: Client satisfaction	Safety / occupational health and safety (KPI6)
PSC7: Quality performance	Error-free (high quality of execution) (KPI7)
PSC8: User satisfaction	In accordance with stakeholder expectations (KPI8)
PSC9: Productivity / efficiency	Minimised construction difficulties, disputes and conflicts (KPI9)

indicators (time, cost, and scope/quality) used in construction project delivery assessment, research and practice also increasingly incorporate other performance indicators, as shown in Table 2 [57, 58]. In several studies, it has been demonstrated that traditional project delivery performance indicators remain dominant in practice [59]. For example, in large public infrastructure projects in the United Kingdom, project managers themselves report that their projects are still primarily evaluated using traditional criteria, and that other performance indicators have not yet been successfully implemented in practice [60].

Flyvbjerg et al. [61] show that 9 out of 10 transport megaprojects experience cost and schedule overruns, while some studies report somewhat lower figures, with approximately 50 % of transport infrastructure projects exhibiting overruns [62]. Serrador and Turner [63] report an average score of 4.64 (out of 7) for construction project efficiency (measured through cost, time, and scope), indicating that projects, on average, exceeded their initial baseline targets by approximately 1–14 % (e.g. cost or schedule overruns). There is considerable debate in the academic and professional literature regarding the dominant causes of such delays, with managerial factors (e.g. inadequate project preparation and weak procurement implementation) more often identified as primary drivers, rather than excessive optimism in early-stage estimates [64]. Lovrinčević et al. [17] emphasise that the issue of cost overruns is also a matter of the reference point and conclude that it is more appropriate to consider overruns relative to contracted prices. Based on this assumption and a substantial sample of road, viaduct, and tunnel projects, they found that cost overruns are common; however, it is also not uncommon for final costs to be lower than contracted values. On average, road projects exhibit cost overruns of 6.6 %, while viaduct and tunnel projects show, on average, negative deviations of approximately 3.9 % and 1.7 %, respectively, i.e. costs below contracted prices. They further note that the greater the complexity and scale of road and tunnel projects, the higher the level of cost overruns. The Association *Glas poduzetnika* (2021) [65] conducted an analysis of public infrastructure projects with a total value exceeding EUR 13.33 million, showing that in twenty-one out of thirty projects (EU co-financed), contracted prices exceeded initial estimates by an average of 16.4 %, implying that approximately EUR 200 million will need to be additionally allocated from the Croatian state budget for their completion. The study also highlights the time elapsed between the initial cost estimation and the signing of construction contracts, noting that the average project duration is eight years, while inefficiencies in public procurement account for more than 25 % of this period [65]. The conclusion of both international and Croatian studies is that cost and schedule overruns are a frequent occurrence in infrastructure projects, and that organisational, managerial, and administrative systems are insufficiently developed, as well as insufficiently researched.

2.4. Research gaps in the area of management and delivery of infrastructure projects

A general limitation in research on the management and performance of construction project delivery is the fact that only 26 % of studies on construction project success have been conducted empirically [57]. Most empirical studies exhibit certain methodological limitations, for example: studies conducted on a single infrastructure project [58]; analyses covering multiple industries with only a small proportion of construction projects [63]; surveys of individuals' general perceptions of the success of previously completed infrastructure projects [66, 67]; or assessments focused on respondents' most recent individual project [68–71]. The studies [68–71] do not place project performance at the centre of analysis and do not report such data at all, most likely due to the possibility of repeated projects within the sample. In Croatia, there is only one study that examines cost performance on a sample of transport infrastructure projects [17], thereby assessing a single performance criterion within a single type of infrastructure project. Only a limited number of scientific studies measure infrastructure project performance indicators. Flyvbjerg et al. [61, 72] and Love et al. [62] examine cost overruns in transport infrastructure, Locatelli et al. [28] report on both cost and schedule performance of European transport infrastructure projects, while Volden [73] analyses a range of performance parameters on a sample of twenty infrastructure projects in Norway. Even this small body of work does not provide a complete picture, as it either focuses exclusively on cost performance [61, 62] or is limited to transport infrastructure [17, 28, 61, 62]. For this reason, it is evident why several researchers in the field call for a substantially greater number of empirical studies on infrastructure project delivery performance [28, 57, 64]. Furthermore, the importance of researching governance approaches and institutional framework models is emphasised [22, 61, 73, 74] to better understand which governance mechanisms may contribute to improving infrastructure project delivery capacity.

3. Methodology

This research addresses the general lack of empirical evidence on the performance of infrastructure project delivery, particularly within the Croatian context, as well as the insufficiently explored domain of managerial and organizational characteristics of such projects. The aim of this study is to quantitatively investigate the managerial and organizational context of infrastructure projects in Croatia and assess their delivery performance using a sample of completed projects. The findings are expected to provide deeper insights into the management mechanisms currently implemented in practice and their effectiveness in achieving project objectives, while also identifying potential challenges and opportunities for improving infrastructure project delivery. The research objective is operationalized through four research questions presented in the Introduction. To achieve the objectives of this study, a four-step research methodology was developed:

1. To identify relevant variables, measurement instruments, and scales for data collection through a comprehensive literature review;
2. To collect empirical data from real infrastructure projects implemented in Croatia;
3. To analyse and process the collected data and present the research findings;
4. To discuss the research results and provide answers to the proposed research questions.

The literature review resulted in the identification of a range of indicators and measurement instruments used to operationalize three key project performance variables, schedule, cost, and scope/quality, and to assess project delivery performance through a questionnaire survey [28, 58, 63, 67–69]. In addition, indicators related to the managerial context and the complexity of infrastructure projects were identified [68, 75]. From the broader set of existing survey items and measurement instruments identified in the literature, only those characterized by clear and straightforward wording were selected for inclusion, as many of the instruments were conceptually similar or partially overlapping in content. Minor adjustments to the wording were made during the translation process where necessary to improve clarity and contextual appropriateness.

1. Project information (eleven questions, including the project title);
2. Project organizational complexity (five questions);
3. Assessment of project delivery performance (cost measured through two indicators, schedule through three indicators, and quality/scope through seven indicators, all evaluated on a five-point scale);
4. Respondent information (seven questions).

The questionnaire items, that is, the measurement instruments used for the study variables, consisted of two components: a definition (question wording) and a measurement scale (number of response categories and their corresponding labels). A five-point ordinal scale (1–5) was selected, consistent with common practice and methodological recommendations in organizational and management research. In most cases, descriptive labels were provided for all five response categories to ensure consistent interpretation by respondents.

Depending on the nature of the variable being measured, the response labels were adapted accordingly. For example, Question 16(A), related to the cost performance indicator T1 ("...with respect to the following cost performance indicators – completion within budget..."), adopted and adapted the scale proposed by Serrador and Turner [63], in which each response category represents a percentage deviation from the contracted project cost (e.g., "1 – budget overrun exceeding 20 %" ... "4 – completion within the planned budget"). Within this scale, the midpoint category represents a moderate budget overrun. Following the same logic, for variables related to cost and schedule performance (T1, T2, V1, and V2), response categories 1 to 3 indicate varying degrees of cost or schedule overrun, whereas categories 4 and 5 indicate performance in accordance with contractual requirements or performance exceeding planned expectations.

A pilot study was conducted with seven participants, including one researcher experienced in the design and administration of survey-based studies and six practitioners with experience working on infrastructure projects. The purpose of the pilot study was to assess the clarity and comprehensibility of the questionnaire items and to verify the appropriateness of the measurement scales. Feedback was received on seventeen questionnaire items, primarily concerning minor wording modifications (e.g., replacing the term "dispute" with "conflict"), which resulted in several small revisions to the questionnaire. As a result of the pilot study, the original three indicators used to assess the quality and scope dimensions of project performance were further refined through the addition of four new indicators, resulting in a final set of seven indicators for these dimensions. Following the development of the revised questionnaire, two participants who had taken part in the initial pilot round reviewed and confirmed the updated version. Several additional measures were also implemented to enhance questionnaire quality, including the incorporation of brief instructions and explanatory notes for selected questions, the positioning of key questions in the central part of the questionnaire, and the provision of descriptive labels and explanations for response categories.

The primary data collection technique involved administering the questionnaire either through structured face-to-face interviews with respondents or by distributing questionnaire forms to organizations that had agreed to participate in the study. In the latter case, participating organizations were asked to nominate employees who possessed relevant knowledge of the projects under investigation and were therefore considered suitable key informants (e.g., project managers).

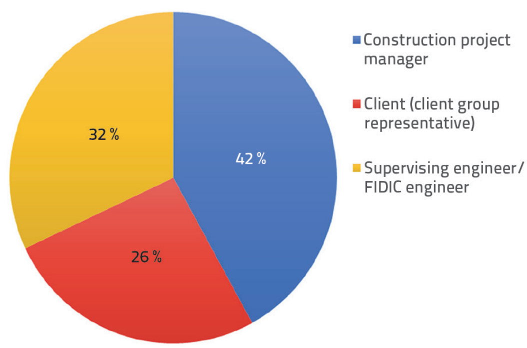


Figure 2. Distribution of respondents (key informants) by their role in the project

In addition, a number of questionnaires were administered electronically by sending potential participants an email invitation containing a hyperlink to the online survey. However, in such cases, the participating organizations and respondents had been contacted in advance and had agreed to take part in the study. All respondents (key informants) confirmed that they had access to project-related data and documentation and were familiar with the questionnaire content prior to completing the survey. The collection of project-level data, particularly the assessment of infrastructure project performance and complexity, was primarily intended for project clients and project managers, as these individuals typically possess the most comprehensive understanding of the relevant project information. In certain projects, FIDIC engineers or supervising engineers completed the questionnaire, for example, when no formally appointed project manager existed or when project managers and/or project clients explicitly referred the researchers to the FIDIC engineer or supervising engineer as the most appropriate source of information. Figure 2 presents the distribution of respondents according to their role in the project. It should be noted that the respondents' project role had no influence on the assessment results. Subsequent data analysis confirmed that no statistically significant differences in project evaluations were observed between respondents occupying different project roles.

To obtain a high-quality sample of infrastructure projects in Croatia, public organizations and local government units acting as project clients in infrastructure developments (e.g., Croatian Railways and the City of Zagreb) were contacted. In addition, invitations to participate were distributed to certified project managers from the construction sector (e.g., IPMA-certified project managers). Data were initially collected for sixty-four (64) projects. Following data screening and the removal of invalid cases (e.g., projects that had not yet been completed), the final sample consisted of fifty (50) completed infrastructure construction projects implemented in Croatia. Data collection was conducted over a three-month period, from March to June 2022, while the projects included in the sample had been completed between 2016 and 2022. Although no comprehensive national database of infrastructure projects exists in the Republic of Croatia, as projects are managed and recorded in a fragmented manner across sectors, programmes, and funding sources, available sectoral and European Union data consistently indicate a population comprising several hundred infrastructure projects during the observed period. In this context, the sample of fifty projects represents a meaningful proportion of the target population, particularly given the purposive sampling approach employed, which focused on projects of the greatest financial and institutional significance.

Data analysis for the research presented in this paper was conducted using the JASP and RStudio software packages. Both descriptive and inferential statistical analyses were performed on the collected dataset. Variables used to assess the organizational environment of infrastructure projects are predominantly discrete in nature and are therefore most appropriately presented through descriptive charts showing the frequency distribution of responses and the classification of projects into predefined categories. Variables related to project performance were analysed descriptively using measures of central tendency and dispersion, including the mean, mode, standard deviation, and variance. Inferential statistical methods were employed to examine the influence of infrastructure project characteristics on project performance. Specifically, the non-parametric Mann–Whitney (MW) and Kruskal–Wallis (KW) tests were used because the variables were measured on ordinal scales, did not follow a normal distribution, and the grouping of projects resulted in unequal subgroup sample sizes. Prior to conducting the MW and KW tests, the distributions of the analysed variables (e.g., T1, V2, and KVO6) were examined within the respective subgroups used for comparison (e.g., projects classified as social infrastructure and civil infrastructure). In all applications of the MW and KW tests, the distributions exhibited similar shapes across the compared groups but differed in their central tendency (i.e., their location along the measurement scale), thereby supporting the valid application of these tests for identifying statistically significant differences between groups. The scope of these findings is limited to a descriptive-comparative level, as the MW and KW tests employed in this study do not permit causal inferences regarding the relationships between project characteristics and project performance.

4. Research results

The answer to the question of what types of infrastructure projects are being implemented in Croatia is presented in Figure 3. The classification of infrastructure projects was based on the categorization adopted in the Croatian Spatial Development Strategy. As shown in the figure, transport infrastructure projects constitute the largest share of the sample. Among the eighteen transport infrastructure projects, the majority involved the reconstruction and construction of railway infrastructure, while road transport and inland waterway infrastructure projects were also represented. A substantial proportion of the sample also consisted of utility infrastructure projects, primarily water supply and wastewater management systems (commonly implemented through integrated water and wastewater infrastructure programmes, referred to as "agglomeration projects"), as well as social infrastructure projects, including hospitals, schools, and similar public facilities.

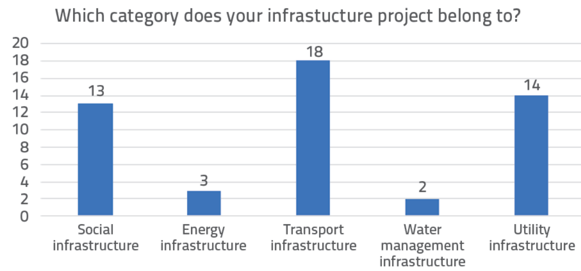


Figure 3. Types of infrastructure projects implemented in Croatia (n = 50)

As infrastructure construction projects are often classified as large-scale or complex projects, it is informative to examine the distribution of projects according to their financial value, expressed excluding VAT (Figure 4). Approximately one-quarter of the sample consists of projects with a value below EUR 5 million. This is followed by projects valued between EUR 5 million and EUR 10 million and those valued between EUR 20 million and EUR 50 million, each accounting for 22 % of the sample.

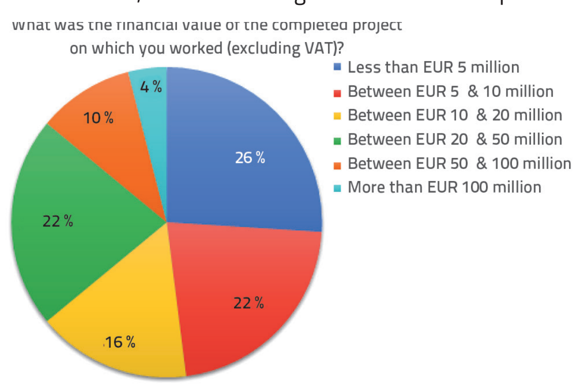


Figure 4. Distribution of projects by financial value (n=50)

It is important to identify the source of project funding, as this also determines the rules and procedures governing financial oversight during project implementation (Figure 5). As many as 70 % of the projects in the sample were co-financed by European Union funds. In most cases, EU co-financing represented the predominant source of project funding. In addition, five projects combined EU co-financing with another funding source (e.g., a World Bank loan) to secure the full amount of funding required for the construction and equipping of the infrastructure.

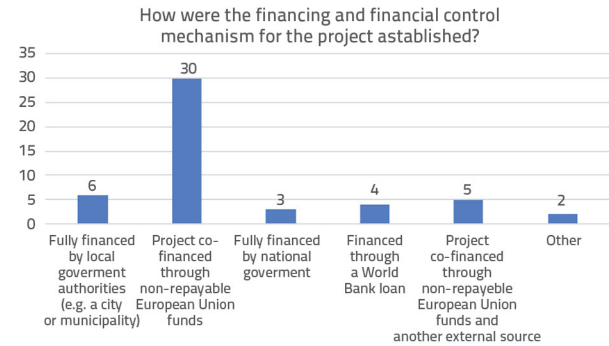


Figure 5. Distribution of projects by funding source (n = 50)

A particularly important characteristic of infrastructure projects is the procurement model, specifically the approach used to procure design and construction services (Figure 6). The traditional procurement model, involving the procurement of construction works based on the project client's design, was the predominant approach, accounting for 64 % of the projects in the sample. This approach was frequently implemented using the FIDIC Red Book. The integrated procurement model, under which design and construction services are procured under a single contract, was also applied in a proportion of the projects and was often based on the FIDIC Yellow Book. In addition, some projects employed different procurement approaches for separate project phases or components, resulting in a combination of traditional and integrated procurement models. Finally, one project utilized a contract form standardized within the organization, which did not fall into any of the predefined procurement categories.

An important question addressed in this study concerns how project management was organized and implemented. As shown in Figure 7, more than half of the projects had contracted external project management services. In 38 % of the projects, the project manager was employed by the project client's organization, while only 4 % of the projects did not have a formally appointed project manager. Furthermore, in 62 % of the projects, project managers became involved only during the construction phase. This indicates that project management activities during the earlier stages of project development, including project conception, design, permitting, and the procurement procedures for construction works, were carried out entirely by the project client.

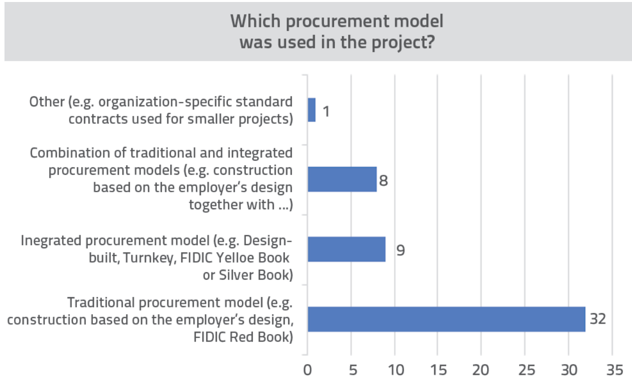


Figure 6. Distribution of projects by procurement model (n = 50)

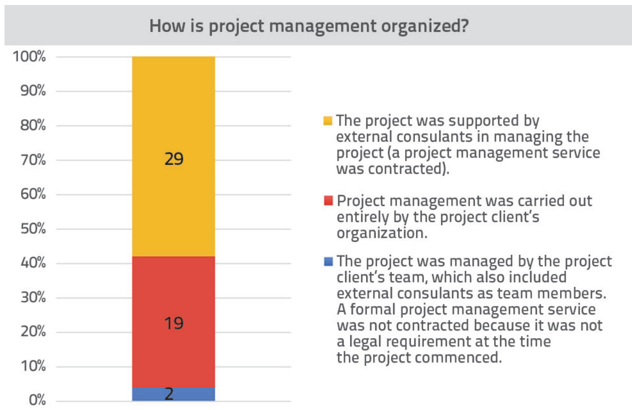


Figure 7. Distribution of projects by project management organization (n = 50)

The complexity of the project environment was assessed through three questionnaire items measured on a five-point scale. Based on the prevailing classifications in the literature, these dimensions represent aspects of organizational complexity. The distribution of responses for each indicator is presented in Figure 8.

The three indicators of project environment complexity were: (1) the complexity of project interests and objectives, (2) the complexity of relationships within the project client organization

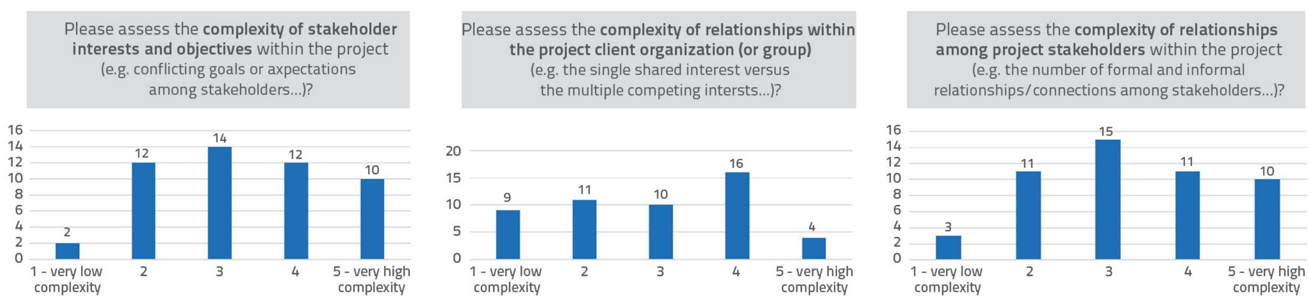


Figure 8. Assessment of the project complexity based on three indicators of stakeholder (organizational) complexity (n=50)

(or client group), and (3) the complexity of relationships among project stakeholders. The results indicate that a relatively large proportion of projects were implemented in complex organizational environments. Ratings of 4 and 5, which represent complex and highly complex environments, were recorded for between 20 and 22 projects, depending on the indicator considered. It should also be noted that 58 % of the projects received a rating of 4 or 5 on at least one of the three complexity indicators, suggesting the presence of a complex project environment in at least one organizational dimension. In contrast, only 8 % of the projects received exclusively ratings of 1 or 2 across all three indicators, indicating project environments characterized by a very low level of organizational complexity and relatively straightforward management requirements.

The study was conducted on a sample of completed infrastructure projects, as well as projects that were substantially completed. To support this assessment, data were collected on the year in which each project was completed (Figure 9). Some projects had not yet been fully completed at the time of data collection; however, they had reached a sufficient level of completion to allow respondents to provide a reliable assessment of most project activities and outcomes. For example, an occupancy permit had been issued for all or a substantial part of the facility, or a part of the infrastructure had already been commissioned and put into operation. More than half of the projects included in the sample were completed in 2021 and 2022.

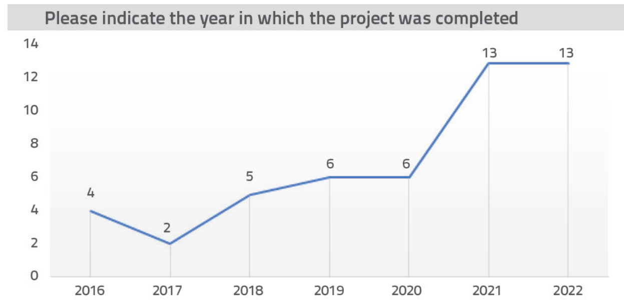


Figure 9. Distribution of projects by year of completion (n = 50)

Table 3. Project performance variables and indicators used to assess project delivery performance

Variables used to evaluate "Project Execution Success"
Schedule Performance variables
V1 – The project was completed on time (within the planned schedule)
V2 – Key milestones were achieved on time
V3 – Overall success in delivering the project within the planned schedule
Cost performance variables
T1 – The project was completed within budget
T2 – Overall success in delivering the project within the planned budget
Scope and quality performance variables
KVO1 – Amount of work completed relative to the amount of work initially planned (completed/planned) – Scope
KVO2 – Quantity of completed construction works relative to the quantity initially planned (e.g., m^2/m^2, m/m) (completed/planned)
KVO3 – Number of agreed project scope changes
KVO4 – Deviation from the defined project scope (e.g., as defined in the feasibility study)
KVO5 – Achievement of the project client's initially defined requirements (e.g., requirements specified in the feasibility study)
KVO6 – Quality of the completed work and final deliverables in accordance with contractual requirements
KVO7 – Successful completion of quality inspections and technical acceptance procedures

Table 4. Descriptive statistics for schedule, cost, and quality performance variables

N (number of projects)	T1	T2	V1	V2	V3	KVO1	KVO2	KVO3	KVO4	KVO5	KVO6	KVO7
	50	50	50	50	50	50	50	50	50	50	50	50
Mean	3.360	3.800	2.180	2.460	3.240	4.120	4.040	3.240	3.460	3.760	3.900	3.420
Mode	3.000	4.000	1.000	1.000	3.000	4.000	4.000	3.000	3.000	4.000	4.000	3.000
Std. Deviation	1.139	0.948	1.207	1.199	1.098	1.003	0.947	0.771	0.885	0.687	0.364	0.499
Variance	1.296	0.898	1.457	1.437	1.207	1.006	0.896	0.594	0.784	0.472	0.133	0.249
Minimum	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	1.000	3.000	3.000
Maximum	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	5.000	4.000	5.000	4.000

4.2. Analysis of infrastructure project performance

For the three commonly used dimensions of project performance, cost, schedule, and scope/quality, a variety of measurement instruments can be found in the literature. Table 3 presents the indicators most frequently used in previous studies and adopted in this research. As noted in the methodology section, all indicators were assessed using five-point scales. The response categories were defined through numerical thresholds or criteria to facilitate a more objective and quantifiable assessment of project performance (e.g., rating 3 = budget overrun between 0 % and 10 %).

The lowest-performing indicator was V1 ("project completed on time"), which achieved a mean score of 2.180, while the highest-rated indicator was KVO1 ("amount of work completed relative to the amount of work initially planned"), with a mean score of 4.120 (Table 4). Variables KVO3, KVO4, and KVO5 exhibit balanced distributions and appropriate variation around their mean values, suggesting that they represent suitable indicators for assessing project performance in terms of scope and quality. Two of these variables have mean values below 3.5, indicating a moderate degree of deviation from the originally agreed scope and quality requirements. The mean value of T1 was 3.36, while the most frequently observed rating (mode) was 3, indicating that projects most commonly fell into the category of budget overruns of up to 10 %. Overall, 58 % of the projects experienced budget overruns. However, it should also be noted that 20 % of the projects were completed below budget, resulting in cost savings.

For the schedule performance indicators V1 and V2, the mean values were below 2.5 (i.e., closer to a rating of 2), indicating average schedule overruns in the range of 10 % to 20 %. Furthermore, twenty-two projects (44 % of the sample) received the lowest rating (1), corresponding to schedule overruns exceeding 20 %. Overall, as many as 84 % of the projects received ratings between 1 and 3 and therefore experienced delays relative to their contractual completion dates (Appendix 2).

4.3. Analysis of differences in project performance according to project type

To determine whether differences exist in the performance of various types of infrastructure projects, the projects were grouped into several subcategories. Different grouping approaches were examined, including classifications based on infrastructure type, procurement model, and project completion period. The resulting groups were then compared to identify potential differences in project performance. When projects were grouped according to their procurement model, statistically significant differences were identified for several performance variables (Table 5). Specifically, projects employing a traditional procurement approach—characterized by the separate procurement of design and construction services and the execution of construction works based on the project client's design—were compared with projects using integrated and hybrid procurement models, which combine or integrate design and construction processes. The results indicate that projects delivered under the traditional procurement model experienced smaller schedule overruns (V1) and achieved higher quality-related performance, as reflected by variables KVO5 and KVO7, than projects delivered under integrated and hybrid procurement arrangements.

Statistically significant differences were also identified when projects were grouped into two broad infrastructure categories. The first category comprised social infrastructure projects (e.g.,

Table 5. Impact of the procurement model (Traditional vs. other models) on project performance

Variable	Test	U-value test statistic	p-value
V1	Mann-Whitney	191.500	0.040
KVO5	Mann-Whitney	203.500	0.005
KVO7	Mann-Whitney	199.000	0.046

Table 6 Impact of infrastructure type (social vs. civil infrastructure) on project performance)

Variable	Test	U-value test statistic	p-value
T1	Mann-Whitney	91.000	< 0.001
V2	Mann-Whitney	147.500	0.033
KVO6	Mann-Whitney	295.000	0.047

Table 7. Descriptive statistics for variable T1 ("Completion Within Budget") by infrastructure type

Project type	Mean value	Stand. Dev	N
Social infrastrutcture	2.385	0.961	13
Energy infrastrutcture	3.333	0.577	3
Utility infrastrutcture	3.583	1.240	14
Transport infrastrutcture	3.722	0.958	18
Water management infrastructure	4.500	0.500	2

Table 8. Results of dunn and conover–iman post hoc tests with holm correction for pairwise comparisons of infrastructure project types (Variable T1)

Pairwise comparisons	Dunn post hoc test (p-value)	Cannover-Iman post hoc test (p-value)
Social – Energy	1.000	1.000
Social – Utility	0.050	0.032
Social – Transport	0.021	0.012
Social – Water Management	0.109	0.065
Energy – Utility	1.000	1.000
Energy – Transport	1.000	1.000
Energy – Water management	1.000	1.000
Utility – Transport	1.000	1.000
Utility – Water management	1.000	1.000
Transport – Water management	1.000	1.000

hospitals, schools, public squares, and similar facilities), while the remaining four infrastructure types were classified as civil infrastructure (i.e., utility and transport infrastructure), in accordance with the basic infrastructure classification adopted in this study. To examine these differences, non-parametric Mann–Whitney tests were conducted to compare the distributions of the performance variables between the two groups (Table 6). The results indicate that variable T1 ("project completed within budget") differed statistically significantly between social and civil infrastructure projects. Statistically significant differences were also observed for variable V2, related to schedule performance, and variable KV06, related to scope and quality performance (Table 21). For variables V2 and KV06, statistical significance was established at the 95 % confidence level (p-values close to 0.05). In contrast, the significance level for variable T1 exceeded 99.9 %, providing very strong evidence that cost performance differs substantially between social and civil infrastructure projects.

Based on the results obtained for variable T1, the sample was further divided into five more detailed infrastructure categories. Table 7 presents the mean values of variable T1 and the corresponding sample sizes for each of the five infrastructure project types. To examine whether differences existed among the groups, a Kruskal–Wallis test was performed. This test was used to assess whether statistically significant differences in the distribution of T1 values were present across the five infrastructure categories.

The Kruskal–Wallis test indicated statistically significant differences in cost performance (variable T1) across the five infrastructure categories. Consequently, Dunn and Conover–Iman post hoc tests were performed to identify the specific pairs of groups between which statistically significant differences occurred (Table 8). The post hoc analyses revealed statistically significant differences in T1 between social infrastructure projects and transport infrastructure projects, as well as between social infrastructure projects and utility infrastructure projects. Although the tests account for unequal sample sizes, only limited evidence of a difference between social infrastructure and water management infrastructure projects was observed. This indication emerged solely in the Conover–Iman post hoc test and should therefore be interpreted with caution. These results clearly suggest that social infrastructure projects tend to experience greater budget overruns than at least two categories of civil infrastructure projects, with some indication that a similar difference may also exist in relation to a third infrastructure category.

5. Discussion

The results of this study indicate that, up to 2022, investments in Croatia were made across all major infrastructure categories, with transport and utility infrastructure projects (primarily water supply and wastewater agglomeration projects) accounting for the largest share of the sample (64 %). In terms of project value and funding structure, 14 % of the projects exceeded EUR 50 million in value, thereby qualifying as large-scale projects in the European context, while 52 % of the projects exceeded EUR 10 million in value. It should also be emphasized that as many as 70 % of the projects were predominantly financed through European Union funds, whereas a smaller proportion of projects were financed primarily by local government authorities or the national government. These findings provide an answer to the first research question concerning the types of infrastructure projects implemented in Croatia and their funding arrangements. The availability of European Union grants has stimulated infrastructure investment at a scale that would have been difficult to achieve without such funding, which is consistent with findings reported in previous Croatian studies [22, 23]. Transport infrastructure was the most represented infrastructure category in the sample, accounting for 36 % of all projects, and represented one of the most significant areas of investment. This finding is consistent with data reported by the OECD [76] and with official statistics published by the Croatian Bureau of Statistics, where transport infrastructure was identified as the most significant individual category of construction investment in Croatia in 2021 [10].

Many previous studies have focused exclusively on transport infrastructure projects [28, 62, 72], primarily examining roads, railways, tunnels, and bridges [28, 72]. In this respect, they differ from the present study, which encompasses a broader range of infrastructure types. The study by Volden [73], which also includes multiple infrastructure categories, reported a sample in which transport infrastructure accounted for 55 % of all projects, compared with 36 % in the present study. In the research conducted by

Flyvbjerg et al. [72], approximately 30 % of the sample consisted of projects valued at more than EUR 85 million, whereas in the present study 14 % of the projects exceeded EUR 50 million in value. Similarly, Volden [73] examined projects that were subject to the Norwegian Quality Assurance (QA) regime, implying project values above EUR 90 million. In the study by Love et al. [62], project values ranged from EUR 2.4 million to EUR 329 million, which is broadly comparable to the range observed in the present study. However, their sample included a larger proportion of very large projects and megaprojects. The managerial and organizational characteristics of infrastructure projects were examined through several survey questions. The traditional procurement and project delivery model remains the dominant approach, being used in 80 % of the projects. In contrast, integrated procurement models were employed only occasionally, while collaborative procurement approaches, such as alliancing, were not identified in any of the projects included in the sample. More than 50 % of the infrastructure projects were characterized by a complex organizational environment, as reflected in the responses to the three organizational complexity indicators (see Figure 8). Furthermore, external project management services were contracted in most projects. These findings provide an answer to the second research question concerning the current organizational and managerial framework governing infrastructure project delivery in Croatia. The broader governance and management framework identified in this study appears to be more closely aligned with traditional approaches observed in countries such as Germany than with countries that have increasingly adopted innovative procurement and contracting models in infrastructure development, such as Australia, Sweden, and the Netherlands [33, 34]. All projects examined by Love et al. [62] in their Hong Kong sample employed the traditional Design–Bid–Build procurement model, which is broadly comparable to the 80 % share observed in the present study and demonstrates that traditional procurement approaches remain common even in highly developed economies. The Australian experience suggests that collaborative contracting models can substantially reduce uncertainty and lower the perceived complexity of the project environment [77]. Furthermore, despite the predominantly complex organizational environments observed in Croatian infrastructure projects, no evidence was found of the implementation of specific governance systems or administrative assurance frameworks for infrastructure projects (see Figure 1), which have been shown to increase the likelihood of successful project delivery in complex project environments [19, 73].

With respect to cost performance, 58 % of the projects experienced budget overruns, whereas schedule overruns were recorded in 84 % of the projects. The magnitude and frequency of scope deviations were reflected in an average score of approximately 3.72, indicating a moderate increase in project scope. Similarly, the variables measuring quality achieved average scores close to 3.7, suggesting that the quality of the completed infrastructure was generally satisfactory and consistent with contractual requirements. These findings provide an answer to the research question concerning the performance of infrastructure projects in Croatia. Overall, schedule performance appears to be relatively poor, cost performance somewhat better, while scope and quality performance can be considered satisfactory and generally aligned with contractual expectations. The frequency of cost overruns observed in this study is consistent with the findings reported by Love et al. [62]. It is also important to note that 20 % of the projects were completed below budget, generating cost savings (Appendix 1), which supports the findings of Lovrinčević et al. [17] that a proportion of infrastructure projects are delivered below their contracted cost. Although construction cost escalation associated with the COVID-19 pandemic and the war in Ukraine was clear, with construction price growth peaking in 2022 [78], no statistically significant differences in cost performance were identified between projects completed before 2019 and those completed during the 2020–2022 period. This result may partly be explained by the structure of variable T1, in which response categories represent ranges of cost overrun percentages (e.g., a score of 2 corresponds to a budget overrun of 10–20 %). It may also indicate that the overall increase in project costs was not sufficiently large, on average, to produce statistically detectable differences between the two periods. The average level of cost overrun observed in the sample was below 10 %, which corresponds closely to the findings reported by Serrador and Turner [63] for construction projects. In contrast, several other studies have reported substantially larger average cost overruns [72]. However, those studies included a higher proportion of very large projects and megaprojects than the sample examined in the present research [62].

Research conducted in Norway indicates that approximately 90 % of projects are delivered within their approved cost limits, a result that is likely attributable to the implementation of the Quality Assurance (QA) governance framework for public projects [19]. Under this framework, projects are subject to independent reviews of costs and benefits at two key decision points (see Figure 1). The average schedule overrun observed in the present study was between 10 % and 20 %, while 44 % of the projects experienced delays exceeding 20 % of the planned project duration (Appendix 2). These findings are comparable to those reported in other studies, which have likewise identified substantial extensions of planned project durations [28]. Quality performance in the present study is broadly consistent with the findings of Serrador and Turner [63], who reported that construction projects generally perform well with respect to stakeholder satisfaction with the quality of the final project deliverables.

The final research question concerned potential differences in performance among different types of infrastructure projects. The results revealed statistically significant differences in three variables (T1, V2, and KVO6), with the most substantial and practically relevant difference observed in cost performance (T1). The subgroup analyses demonstrated that social infrastructure projects (e.g., hospitals, kindergartens, and schools) exhibited significantly poorer cost performance than utility and transport infrastructure projects, with some indication of poorer performance relative to water management infrastructure projects as well. These findings provide an answer to the fourth research question concerning differences in performance among infrastructure project types. The stringent financial control requirements associated with EU-funded projects do not appear to contribute directly to improved cost performance, as the comparison between EU-funded and non-EU-funded projects did not reveal statistically significant differences in cost performance. However, the rigorous project appraisal and preparation procedures required for EU-funded projects [23, 49] may indirectly contribute to improved project preparation and cost performance. This explanation is particularly relevant given that civil infrastructure projects in the sample were more frequently financed through EU funds than social infrastructure projects. As noted previously, many studies focus exclusively on transport infrastructure, and their findings regarding performance differences are mixed. Some studies have identified significant differences in cost overruns among transport infrastructure subtypes (e.g., railways versus roads) [72], whereas others have found no significant differences between infrastructure categories [62]. The study by Volden [73] did not assess cost performance directly but instead examined project efficiency, a broader concept combining cost, schedule, and scope performance. Consequently, its findings cannot be directly compared with the cost-performance differences identified in the present study. Nevertheless, it is noteworthy that Volden reported efficiency scores of 4.3 and 4.4 (on a six-point scale) for railway and road projects, respectively, compared with a score of 5.4 for building construction projects. These results suggest that building construction projects were delivered more efficiently than transport infrastructure projects in the Norwegian context.

When interpreting the findings of this study, several methodological and research limitations should be taken into consideration. These limitations are characteristic of studies of this type and provide important context for understanding the results and their implications. The first limitation relates to the partially subjective nature of certain assessments used to evaluate project performance and the organizational complexity of projects. As described in the methodology section, respondents were contacted prior to completing the questionnaire and were familiarized with its structure and content. In addition, all respondents confirmed that they possessed project documentation and had access to the relevant project information required to provide informed responses. A pilot study was conducted, and several additional measures were implemented during the development of the measurement instruments (questionnaire), as described in detail in the methodology section. Furthermore, most of the data were collected through face-to-face administration of the questionnaire at the respondents' organizations, which may increase confidence in the reliability of the responses, although it cannot eliminate subjective bias. This limitation is particularly relevant for questions related to quality and scope performance variables, as well as the assessment of project environment complexity. The second limitation concerns the extent to which the findings can be generalized to the broader population of infrastructure projects. Although no centralized database of infrastructure projects exists in Croatia, the sources discussed in the methodology section indicate a population consisting of several hundred infrastructure projects during the period under consideration. In this context, the sample of fifty projects represents a meaningful and substantial proportion of the underlying population. Furthermore, given that infrastructure investment is concentrated in a relatively limited number of large-scale projects, the sample examined in this study—which includes a considerable proportion of projects with high financial value—may be regarded as broadly representative of the key characteristics of infrastructure projects within the observed context. Nevertheless, the findings should be interpreted within the boundaries of the research design and sampling approach adopted in this study, and caution should be exercised when generalizing the results beyond the examined context.

6. Conclusion

The findings of this study indicate that Croatia is currently experiencing an intensive cycle of infrastructure investment, largely supported by substantial European Union funding, while the managerial and procurement approaches adopted in these projects remain predominantly traditional.

The results reveal relatively frequent cost overruns and very frequent schedule overruns, with a substantial proportion of projects experiencing significant delays exceeding 20 % of the contracted construction period. In contrast, project performance with respect to scope and quality was generally satisfactory and largely consistent with contractual requirements. Social infrastructure projects, such as hospitals and schools, exhibited noticeably poorer cost performance than utility and transport infrastructure projects. This finding warrants further investigation to better understand the underlying causes and identify potential measures for improving cost performance in this category of infrastructure projects.

The findings of this study provide insights into the current state of infrastructure project delivery in Croatia and identify several management-related challenges that can be addressed more systematically. To date, no evidence has been found of the use of collaborative procurement models (e.g., alliancing) in Croatian infrastructure projects, nor have formal governance and assurance frameworks for administrative project oversight been established, such as the Norwegian QA regime or the Dutch MIRT framework. Previous research has highlighted the potential benefits of such approaches, including improved project performance, reduced perceived project complexity, and enhanced innovation capacity, as discussed in the preceding sections. Consequently, one of the key implications of this study is the need to gradually introduce collaborative procurement models and to develop governance frameworks for infrastructure projects based on practices adopted in more advanced economies (see Figure 1). Future research should focus on a more detailed examination of the influence of organizational, administrative, and broader contextual factors on project management and project performance. In addition, further studies should investigate whether differences exist in management approaches and project performance between publicly funded infrastructure projects and large privately financed projects, as well as the underlying reasons for such differences. Such research would contribute to a better understanding of the role of context in infrastructure project governance and delivery. Main objective is to deepen understanding of the key challenges affecting infrastructure project implementation and to identify effective measures for improving the management and delivery of infrastructure projects in Croatia.

REFERENCES

[1] Kumaraswamy, M., Wong, K.K.W., Chung, J.: Focusing megaproject strategies on sustainable best value of stakeholders, Built Environment Project and Asset Management, 7 (2017) 4, pp. 441-455., https://doi.org/10.1108/BEPAM-01-2017-0003

[2] Love, P.E.D., Ika, L.A., Matthews, J., Fang, W.: Large-scale transport infrastructure project performance: generating a narrative of context and meaning, IEEE Transactions on Engineering Management, 70 (2023) 10, pp. 3637-3652., https://doi.org/10.1109/TEM.2021.3094511

[3] Hu, Y, Chan, A.P.C., Le, Y., Jin, R.: From construction megaproject management to complex project management: bibliographic analysis, Journal of Management in Engineering, 31 (2015) 4., https://doi.org/10.1061/(ASCE)ME.1943-5479.0000254

[4] Prebanić, K.R., Vukomanović, M.: Realizing the need for digital transformation of stakeholder management: a systematic review in the construction industry, Sustainability, 13 (2021), 27., https://doi.org/10.3390/su132212690

[5] Agarwal, R., Chandrasekaran, S., Sridhar, M.: Imagining construction's digital future, Capital Projects and Infrastructure, McKinsey Productivity Sciences Center, Singapore, June, 2016, Paper 13.

[6] Oxford Economics: Global Infrastructure Outlook, 2017.

[7] OECD: Green Infrastructure in the Decade for Delivery, OECD Publishing, Paris, 2020.

[8] OECD: Infrastructure for a Climate-Resilient Future, OECD Publishing, Paris, 2024.

[9] OECD: Infrastructure-Policy Issues, dostupno na: https://www.oecd.org/en/topics/policy-issues/infra, 2026.

[10] Državni zavod za statistiku Republike Hrvatske: Građevinski radovi u 2021.-Godišnji izvještaj o građevinskim radovima u Republici Hrvatskoj, pravne osobe s pet i više zaposlenih, 2022.

[11] Vlada Republike Hrvatske: Operativni program Konkurentnost i kohezija 2014.-2020., v1.2, 2014.

[12] Ministarstvo regionalnog razvoja i fondova Europske unije: Operativni programi, 2020, dostupno na: https://razvoj.gov.hr/o-ministarstvu/djelokrug-1939/eu-fondovi/financijsko-razdoblje-eu-2014-2020/operativni-programi/356.

[13] Henisz, W.J., Levitt, R., Scott, W.R.: Toward a unified theory of project governance: economic, sociological and psychological supports for relational contracting, Engineering Project Organization Journal, 2012., https://doi.org/http://dx.doi.org/10.1080/21573727.2011.637552

[14] Flyvbjerg, B.: What you should know about megaprojects and why: an overview, Project Management Journal, 45 (2014) 2., https://doi.org/10.1002/pmj.21409

[15] The Standish Group: CHAOS Manifesto 2013: Think Big, Act Small, The Standish Group International, pp. 1-52, 2013.

[16] Project Management Institute: Success Rates Rise. Transforming the High Cost of Low Performance. 9th Global Project Management Survey, PMI's Pulse of the Profession, 2017.

[17] Lovrinčević, M., Vukomanović, M., Perić, R.: Influence of technical reasons on cost overruns of infrastructural projects: a sustainable development perspective, Sustainability, 16 (2024)., https://doi.org/10.3390/su16219413

[18] Brunet, M., Aubry, M.: The three dimensions of a governance framework for major public projects, International Journal of Project Management, 34 (2016), pp. 1596-1607., https://doi.org/http://dx.doi.org/10.1016/j.ijproman.2016.09.004

[19] Klakegg, O.J., Williams, T., Shiferaw, A.T.: Taming the "trolls": major public projects in the making, International Journal of Project Management, 34 (2016) 2, pp. 282-296., https://doi.org/http://dx.doi.org/10.1016/j.ijproman.2015.03.008

[20] Luo, L., He, Q., Jaselskis, E.J., Xie, J.: Construction project complexity: research trends and implications, Journal of Construction Engineering and Management, 143 (2017) 7., https://doi.org/10.1061/(ASCE)CO.1943-7862.0001306.

[21] Wagner, R.F., Radujković, M.: Effects of lagging projectification in the public sector on realizing infrastructure projects, Organization, Technology and Management in Construction: an International Journal, 14 (2022), pp. 2559-2570., https://doi.org/10.2478/otmcj-2022-0002

[22] Prebanić, K.R., Vukomanović, M.: Exploring stakeholder engagement process as the success factor for infrastructure projects, Buildings, 13 (2023), 1785., https://doi.org/10.3390/buildings13071785

[23] Sjekavica Klepo, M., Butković, D., Rastovski, T.: Using the framework analysis to identify infrastructure project challenges and opportunities, in: 6th IPMA SENET Project Management Conference: Digital Transformation and Sustainable Development in Project Management, 2022, pp. 60-78., https://doi.org/10.5592/CO/SENET.2022.5

[24] Perić, R., Vukomanović, M.: Djelatnost upravljanja projektom gradnje u Republici Hrvatskoj: analiza trenutačnog stanja, Građevinar, 74 (2022) 9, pp. 749-767., https://doi.org/10.14256/JCE.3424.2021

[25] Dyer, M., et al.: Framework for soft and hard city infrastructures, Urban Design and Planning, 172 (2019) 6, pp. 219-227., https://doi.org/10.1680/jurdp.19.00021

[26] Al-Bahar, J.F., Crandall, K.C.: Systematic risk management approach for construction projects, Journal of Construction Engineering and Management, 116 (1990) 3, pp. 533-546., https://doi.org/10.1061/(ASCE)0733-9364(1990)116:3(533)

[27] Hrvatski sabor: Strategija prostornog razvoja Republike Hrvatske, 2017.

[28] Locatelli, G., Invernizzi, D.C., Brookes, N.J.: Project characteristics and performance in Europe: an empirical analysis for large transport infrastructure projects, Transportation Research Part A, 98 (2017), pp. 108-122., https://doi.org/http://dx.doi.org/10.1016/j.tra.2017.01.024

[29] Greenhalgh, B., Squires, G.: Introduction to Building Procurement, Spon Press, Abingdon, Oxon, 2011.

[30] Winch, G.M.: Managing Construction Projects, Wiley-Blackwell, Chichester, United Kingdom, 2010.

[31] Naoum, S., Egbu, C.: Critical review of procurement method research in construction journals, Procedia Economics and Finance, 21 (2015), pp. 6-13., https://doi.org/10.1016/S2212-5671(15)00144-6

[32] Molwus, J.J.: Stakeholder Management in Construction Projects: A Life Cycle Based Framework, 2014.

[33] Eriksson, P.E., Lingegård, S., Borg, L., Nyström, J.: Procurement of railway infrastructure projects-a European benchmarking study, Civil Engineering Journal, 3 (2017) 4, pp. 199-213., https://doi.org/10.28991/cej-2017-00000086

[34] Walker, D.H.T., Lloyd-Walker, B.M.: Collaborative Project Procurement Arrangements, Project Management Institute, Inc., Newtown Square, Pennsylvania, USA, 2015.

[35] Biesenthal, C., Wilden, R.: Multi-level project governance: trends and opportunities, International Journal of Project Management, 32 (2014) 8, pp. 1291-1308., https://doi.org/10.1016/j.ijproman.2014.06.005

[36] Office of Government Commerce: The OGC Gateway Process: Gateway to Success, 2004, pp. 4-5.

[37] The State of Queensland: Gateway Review Guidebook for Project Owners and Review Teams, 2013, Paper 17.

[38] HM Treasury: HM Treasury Resource Accounts 2007-08, 2008, p. 84.

[39] Australian Government: Australian Government Assurance Reviews-Resource Management Guide No. 106, 2017.

[40] Burcar Dunović, I.: Upravljanje rizicima kod velikih infrastrukturnih projekata, PhD thesis, University of Zagreb, Zagreb, HR, 2012.

[41] European Commission: EU Public Procurement Directives, 2019, dostupno na: https://ec.europa.eu/environment/gpp/eu_public_directives_en.htm.

[42] Hackett, M., Statham, G.: The Aqua Group Guide to Procurement, Tendering & Contract Administration (2nd ed.), Wiley-Blackwell, 2016.

[43] Ministarstvo regionalnog razvoja i fondova Europske unije: Operativni program Konkurentnost i kohezija 2014.-2020., v9.0, Priprema programskih dokumenata za financijsko razdoblje Europske unije 2014.-2020., 2020, pp. 1-39.

[44] Središnja agencija za financiranje i ugovaranje: ESI fondovi, 2020, dostupno na: https://www.safu.hr/hr/esi-fondovi.

[45] Burcar Dunović, I.: A study of project governance frameworks for large infrastructure projects with reflection on road transport projects, Organization, Technology and Management in Construction: an International Journal, 2 (2010) 1, pp. 145-155.

[46] Prebanić, K.R.: Analysis of the impact of stakeholder engagement on the successful performance of infrastructure projects, PhD thesis, University of Zagreb, Faculty of Civil Engineering, 2022.

[47] Narodne novine 78/15, 118/18, 110/19: Zakon o poslovima i djelatnostima u prostornom uređenju i gradnji, 2019.

[48] Narodne novine 153/13, 20/17, 39/19, 125/19: Zakon o gradnji, Narodne novine, 2019.

[49] Dragić, D., Orešković, M.: Upravljanje graditeljskim projektima Hrvatskih voda, Građevinar, 71 (2019) 11, pp. 995-1014., https://doi.org/10.14256/JCE.2651.2019

[50] Hrvatska gospodarska komora: Kohezijska politika Europske unije i Hrvatska 2014.-2020.: Vodič kroz strateški okvir i pregled mogućnosti financiranja, 2015.

[51] Narodne novine 92/14: Zakon o uspostavi institucionalnog okvira za provedbu europskih strukturnih i investicijskih fondova u Republici Hrvatskoj u razdoblju 2014.-2020., 2014.

[52] Narodne novine 107/14, 23/15, 129/15, 15/17, 18/17, 46/21: Uredba o tijelima u sustavima upravljanja i kontrole korištenja Europskog socijalnog fonda, Europskog fonda za regionalni razvoj i Kohezijskog fonda, u vezi s ciljem "Ulaganje za rast i radna mjesta", 2021.

[53] Jugdev, K., Müller, R.: A retrospective look at our evolving understanding of project success, Project Management Journal, 36 (2005) 4, pp. 19-31., https://doi.org/10.1177/875697280503600403

[54] Turner, R., Zolin, R.: Forecasting success on large projects: developing reliable scales to predict multiple perspectives by multiple stakeholders over multiple time frames, Project Management Journal, 43 (2012) 5., https://doi.org/10.1002/pm

[55] Pinto, J.K., Slevin, D.P.: Project success: definitions and measurement techniques, Project Management Journal, 19 (1988) 1.

[56] Wawak, S., Ljevo, Ž., Vukomanović, M.: Understanding the key quality factors in construction projects-a systematic literature review, Sustainability, 12 (2020), 25., https://doi.org/10.3390/su122410376

[57] Gunathilaka, S., Tuuli, M.M., Dainty, A.R.J.: Critical analysis of research on project success in construction management journals, in: Proceedings of the 29th Annual Association of Researchers in Construction Management Conference (ARCOM 2013), 2013, pp. 979-988.

[58] Toor, S.R., Ogunlana, S.O.: Beyond the "iron triangle": stakeholder perception of key performance indicators (KPIs) for large-scale public sector development projects, International Journal of Project Management, 28 (2010) 3, pp. 228-236., https://doi.org/10.1016/j.ijproman.2009.05.005

[59] Davis, K.: A method to measure success dimensions relating to individual stakeholder groups, International Journal of Project Management, 34 (2016) 3., https://doi.org/10.1016/j.ijproman.2015.12.009

[69] Davis, K.: An empirical investigation into different stakeholder groups' perception of project success, International Journal of Project Management, 35 (2017) 4., https://doi.org/http://dx.doi.org/10.1016/j.ijproman.2017.02.004

[61] Flyvbjerg, B., Garbuio, M., Lovallo, D.: Delusion and deception in large infrastructure projects: two models for explaining and preventing executive disaster, California Management Review, 51 (2009) 2, pp. 170-194.

[62] Love, P.E.D., Sing, M.C.P., Ika, L.A., Newton, S.: The cost performance of transportation projects: the fallacy of the planning fallacy account, Transportation Research Part A, 122 (2019), pp. 1-20., https://doi.org/10.1016/j.tra.2019.02.004

[63] Serrador, P., Turner, J.R.: The relationship between project success and project efficiency, Project Management Journal, 46 (2015) 1, pp. 30-39., https://doi.org/10.1002/pmj.21468

[64] Adam, A., Josephson, P.E.B., Lindahl, G.L.L.: Aggregation of factors causing cost overruns and time delays in large public construction projects, Engineering, Construction and Architectural Management, 24 (2017) 3, pp. 393-406., https://doi.org/10.1108/ECAM-09-2015-0135

[65] Udruga Glas poduzetnika: Analiza stanja velikih javnih infrastrukturnih projekata financiranih iz OPKK 2014.-2020., 2021, p. 11.

[66] Khan, K.A., Turner, J.R., Maqsood, T.: Factors that influence the success of public sector projects in Pakistan, in: Proceedings of IRNOP 2013 Conference, 2013.

[67] Bryde, D.J., Robinson, L.: Client versus contractor perspectives on project success criteria, International Journal of Project Management, 23 (2005) 8, pp. 622-629., https://doi.org/10.1016/j.ijproman.2005.05.003

[68] Khan, A., Warris, M., Panigrahi, S., Sajid, M.R., Rana, F.: Improving the performance of public sector infrastructure projects: role of project governance and stakeholder management, Journal of Management in Engineering, 37 (2021) 2, 20., https://doi.org/10.1061/(ASCE)ME.1943-5479.0000886.

[69] Xue, J., et al.: Influence of formal and informal stakeholder relationship on megaproject performance: a case of China, Engineering, Construction and Architectural Management, 27 (2020) 7, pp. 1505-1531., https://doi.org/10.1108/ECAM-07-2019-0353

[70] Erkul, M., Yitmen, I., Celik, T.: Dynamics of stakeholder engagement in mega transport infrastructure projects, International Journal of Managing Projects in Business, 13 (2020) 7, pp. 1465-1495., https://doi.org/10.1108/IJMPB-09-2018-0175

[71] Manley, K., Chen, L.: Collaborative learning to improve the governance and performance of infrastructure projects in the construction sector, Journal of Management in Engineering, 2017., https://doi.org/10.1061/(ASCE)ME.1943-5479.0000545.

[72] Flyvbjerg, B., Holm, M.K.S., Buhl, S.L.: How common and how large are cost overruns in transport infrastructure projects?, Transport Reviews, 23 (2003) 1, pp. 71-88., https://doi.org/10.1080/01441640022000016667

[73] Volden, G.H.: Public project success as seen in a broad perspective: lessons from a meta-evaluation of 20 infrastructure projects in Norway, Evaluation and Program Planning, 69 (2018), pp. 109-117., https://doi.org/10.1016/j.evalprogplan.2018.04.008

[74] Hu, Y., Le, Y., Gao, X., Li, Y., Liu, M.: Grasping institutional complexity in infrastructure megaprojects through the multi-level governance system: a case study of the Hong Kong-Zhuhai-Macao Bridge construction, Frontiers of Engineering Management, 5 (2018) 1, pp. 52-63., https://doi.org/10.15302/J-FEM-2018074

[75] Aaltonen, K., Kujala, J.: Towards an improved understanding of project stakeholder landscapes, International Journal of Project Management, 34 (2016) 8, pp. 1537-1552., https://doi.org/10.1016/j.ijproman.2016.08.009

[76] OECD: Strategic Transport Infrastructure Needs to 2030, OECD Publishing, 2012.

[77] Walker, D.H.T., Harley, J., Mills, A.: Performance of project alliancing in Australasia: a digest of infrastructure development from 2008 to 2013, Construction Economics and Building, 15 (2015) 1, pp. 1-18., https://doi.org/http://dx.doi.org/10.5130/ajceb.v15i1.4186

[78] Amca, Y., Yorucu, V., Kırıkkaleli, D.: Construction cost index: political, economic, and financial risk indices within the European continent, Sustainability, 17 (2025) 3., https://doi.org/10.3390/su17030917

Appendix

Appendix 1 – Frequency distribution of ratings for variable T1 ("the project was completed within budget")

Rating	Frequency	Percentage	Cumulative percentage
1 – Overrun exceeding 20 %	3	6.00	6.00
2 – Overrun between 10 % and 20 %	7	14.00	20.00
3 – Overrun of up to 10 %	19	38.00	58.00
4 – Completed within budget	11	22.00	80.00
5 – Completed below budget (cost savings achieved)	10	20.00	100.00
Total sample size	50	100.00	

Appendix 2 – Frequency distribution of ratings for variable V1 („The project was completed on time")

Rating	Frequency	Percentage	Cumulative percentage
1 – Overrun exceeding 20 %	22	44.00	44.00
2 – Overrun between 10 % and 20 %	6	12.00	56.00
3 – Overrun of up to 10 %	14	28.00	84.00
4 – Completed within the deadline	7	14.00	98.00
5 – Completed below the deadline (time savings achieved)	1	2.00	100.00
Total sample size	50	100.00	