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PROJECT COMPLEXITY AND DESIGN SERVICE PRICING IN PUBLIC PROCUREMENT OF WATER INFRASTRUCTURE PROJECTS

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Abstract

The pricing of engineering design services represents an important component of infrastructure project preparation and directly influences the ability of design organizations to perform the investigations, calculations, and technical activities required for the development of reliable project documentation. However, in public procurement procedures, design service prices may be determined without systematic consideration of project technical complexity and the actual scope of engineering work.

This study evaluates the adequacy of design service pricing in public procurement procedures for water supply and irrigation infrastructure projects in the Republic of Armenia. The research is based on a comparative analysis of selected procurement procedures, project characteristics, contract prices, and estimated design costs derived from applicable pricing approaches. Project technical complexity is assessed using the Project Complexity Score (PCS), which integrates the principal engineering components of water infrastructure projects, including the number of settlements served, pipeline length, water intake structures, pumping stations, regulating reservoirs, and water treatment facilities.

The analysis compares project complexity levels with the design prices established in procurement procedures and examines whether increases in technical complexity are accompanied by corresponding increases in the financial resources allocated for design activities. To support the comparative assessment, a Design Price Adequacy Ratio (DPAR) is introduced as the ratio between the contracted design price and the estimated justified design price.

The results reveal substantial inconsistencies between project technical complexity and design service pricing. Projects with considerably different engineering workloads may receive similar levels of design financing, while in several cases the contracted design prices are significantly lower than the estimated values required for adequate project preparation. These findings indicate that project complexity and engineering workload are not systematically incorporated into the determination of design service prices.

The study concludes that integrating project complexity criteria and quantitative price adequacy indicators into public procurement planning could improve the transparency and technical justification of design service pricing, reduce the risks associated with underfunded design activities, and contribute to improving the quality and effectiveness of water infrastructure project preparation.

Keywords**:** public procurement; design service pricing; project complexity; Project Complexity Score; Design Price Adequacy Ratio; water supply systems; irrigation systems; engineering design.

Introduction

The preparation of reliable engineering design documentation is a critical stage in the development of infrastructure projects. Decisions made during the design phase influence project feasibility, construction cost, implementation schedules, operational reliability, and long-term infrastructure performance. Deficiencies originating during project preparation and design may subsequently lead to design modifications, rework, construction delays, cost overruns, quality deviations, and additional expenditures during project implementation [1–6]. Therefore, the effectiveness of infrastructure investment depends not only on the financial resources allocated for construction but also on the adequacy of resources provided for engineering investigations, technical analysis, and design activities before construction begins. Engineering design services represent a knowledge-intensive professional activity involving the integration of field investigations, engineering calculations, analysis of alternatives, development and verification of technical solutions, preparation of cost estimates, interdisciplinary coordination, and production of design documentation. The scope and intensity of these activities vary substantially depending on project size, technical configuration, the number and diversity of infrastructure components, environmental conditions, technological requirements, and the degree of interconnection among individual project systems [7–10]. Consequently, the resources required for engineering design should reflect the actual engineering workload and technical complexity of the project rather than being determined solely by the financial scale of the planned construction.

Water supply and irrigation infrastructure projects are particularly relevant in this context because their design frequently combines spatially extensive linear networks with hydraulic structures, mechanical and electrical equipment, and technological facilities. Engineering activities may include topographic and engineering-geological investigations, assessment of water sources, hydrological studies, water demand analysis, hydraulic modeling, pipeline design, and the development of water intake structures, pumping stations, regulating reservoirs, water treatment facilities, automation systems, and cost-estimation documentation [11–16]. The integrated development of these components requires the participation of specialists from several engineering disciplines and sufficient professional, organizational, and financial resources.

Public procurement procedures are intended to promote competition, transparency, equal treatment of economic operators, and efficient use of public resources. However, the economic efficiency of procurement cannot be evaluated solely through reductions in initial contract prices. Procurement approaches dominated by price competition may result in contract values that do not adequately reflect the actual scope, complexity, and professional effort required for engineering services [17–20]. This issue is particularly important for intellectual and professional services, where service quality depends strongly on specialist competence, labor input, data quality, technical analysis, and interdisciplinary coordination.

International research has demonstrated that procurement strategies and tender evaluation methods may significantly affect project performance. Excessive emphasis on the lowest initial price can encourage aggressive bidding and increase the risk that contractors or consultants operate under financial constraints inconsistent with the actual requirements of the assignment [17–22]. Although competitive pricing is an essential element of public procurement, insufficient financial resources for engineering design may restrict field investigations, reduce the depth of technical analyses, limit the assessment of alternative solutions, and decrease the resources available for design verification and coordination. Such limitations may subsequently contribute to design deficiencies, rework, project modifications, cost growth, and implementation difficulties [1–6, 21–24].

The determination of appropriate prices for engineering design services is complicated by the substantial differences among infrastructure projects. Projects with similar construction costs may require considerably different volumes of engineering work, whereas projects with different financial scales may involve comparable levels of technical effort. Construction cost alone therefore cannot provide a sufficient basis for evaluating the resources required for engineering design. Project complexity is a multidimensional characteristic associated with the number of technical components, their interdependencies, technological diversity, organizational interfaces, uncertainty, and the range of professional disciplines involved [7–10]. These characteristics directly affect the volume of investigations, engineering calculations, coordination activities, technical verification, and documentation required during the design process.

In water supply and irrigation projects, technical complexity may be influenced by the number of settlements served, total pipeline length, water intake structures, pumping stations, regulating reservoirs, water treatment facilities, and other hydraulic and technological components. An increase in the number and interconnection of such components generally increases the engineering workload required for project preparation. Nevertheless, procurement prices for design services are not always established using transparent quantitative criteria that explicitly reflect these differences in technical complexity and engineering effort.

Existing studies on public procurement primarily focus on competition, tender evaluation methods, procurement efficiency, construction costs, schedule performance, cost overruns, and the consequences of lowest-price selection [17–22, 25–27]. Research on project complexity, meanwhile, has developed conceptual and multidimensional approaches for understanding the influence of technical, organizational, and environmental characteristics on project management and performance [7–10]. However, considerably less attention has been given to the quantitative relationship between the technical complexity of infrastructure projects and the financial resources allocated for engineering design services, particularly in the water infrastructure sector.

This research addresses this gap by evaluating the relationship between project technical complexity and design service pricing in public procurement procedures for water supply and irrigation infrastructure projects in the Republic of Armenia. To provide a quantitative basis for comparative assessment, the study applies a Project Complexity Score (PCS) based on the principal technical components of water infrastructure projects. The obtained complexity scores are compared with contracted and estimated design prices to determine whether increasing project complexity is accompanied by a corresponding increase in the financial resources allocated for engineering design activities.

In addition, the study introduces the Design Price Adequacy Ratio (DPAR), defined as the relationship between the contracted design price and the estimated justified design price. The indicator is intended to support the identification of potential underpricing, overpricing, and disproportionality in the financing of engineering design services and to provide a quantitative basis for comparing procurement procedures involving projects with different technical characteristics.

The aim of the study is to determine whether the prices established for engineering design services adequately reflect the technical complexity and engineering workload of water supply and irrigation infrastructure projects and to identify potential inconsistencies in existing pricing practices. The results are expected to contribute to the development of more transparent, technically justified, and complexity-sensitive approaches to the pricing and procurement of engineering design services.

Literature Review

The scientific literature relevant to the pricing of engineering design services can be divided into several interconnected research directions: the consequences of deficiencies during project preparation and design, the multidimensional nature of project complexity, the technical characteristics of water infrastructure design, and the influence of procurement mechanisms and price-based competition on project performance. Although these research areas have developed largely independently, their integration provides an important theoretical basis for examining whether the financial resources allocated for engineering design services correspond to the technical complexity and engineering workload of infrastructure projects.

A substantial body of research has demonstrated that deficiencies originating during the design stage may significantly affect subsequent project implementation. Design errors, incomplete documentation, insufficient coordination, and inadequate technical analysis may contribute to rework, cost growth, delays, quality deviations, and additional expenditures during construction [1–6]. These findings indicate that engineering design should not be considered merely as a preliminary administrative stage of infrastructure development. Rather, it represents a critical professional process whose quality depends on the availability of sufficient technical, organizational, and financial resources.

Research on rework and design deficiencies has also shown that the consequences of inadequate project preparation may extend beyond direct correction costs. Design changes and errors can generate additional coordination requirements, disrupt construction processes, increase uncertainty, and affect overall project performance [1–6, 23, 24]. From the perspective of engineering service pricing, these findings are particularly relevant because insufficient resources allocated during the design stage may reduce the ability of design organizations to perform comprehensive investigations, evaluate alternatives, verify technical solutions, and coordinate the work of different engineering disciplines.

A second important research direction concerns the concept of project complexity. Project complexity has been described as a multidimensional characteristic that cannot be adequately represented by project size or construction cost alone. Baccarini conceptualized project complexity in terms of differentiation and interdependency among project elements [7], while subsequent studies expanded this understanding by incorporating technical, organizational, and environmental dimensions [8–10]. These approaches demonstrate that the resources required for project preparation and implementation depend not only on the financial scale of the project but also on the number of components, their interrelationships, technological diversity, organizational interfaces, uncertainty, and the range of professional disciplines involved.

The literature on project complexity therefore provides an important theoretical basis for evaluating engineering design services. As technical components and their interdependencies increase, the need for investigations, calculations, modeling, coordination, verification, and documentation also increases. However, most existing complexity frameworks have been developed primarily for project management, organizational analysis, and assessment of implementation risks [7–10]. Considerably less attention has been given to the direct quantitative relationship between project complexity and the financial resources required for engineering design activities.

Water supply and irrigation infrastructure projects provide a particularly relevant context for examining this relationship. The design of such projects may involve hydraulic modeling, optimization of water distribution systems, assessment of irrigation performance, design of pipelines and hydraulic facilities, and coordination of multiple interconnected technical components [11–16]. The literature demonstrates the increasing analytical and computational requirements associated with the design and optimization of water infrastructure systems. However, these studies primarily focus on technical performance, hydraulic optimization, system reliability, and operational efficiency rather than on the pricing and financial adequacy of professional engineering design services.

Another major research direction concerns public procurement and the mechanisms used for selecting contractors and professional service providers. Existing studies have examined tender evaluation methods, the role of price and non-price criteria, competition among bidders, and the influence of procurement strategies on project outcomes [17–22]. This literature demonstrates that the selection mechanism applied in procurement procedures may influence bidder behavior, contract prices, and subsequent project performance.

Particular attention has been given to procurement approaches dominated by the lowest initial price. Competitive bidding may contribute to the efficient use of public resources, but excessive price competition can also create incentives for aggressive bidding and contract prices that may not correspond to the actual requirements of the assignment [17–22]. For engineering design services, this issue is especially important because the final quality of the service depends strongly on specialist labor, professional expertise, investigation activities, technical analysis, interdisciplinary coordination, and design verification.

Studies addressing construction performance, cost overruns, and project implementation risks further demonstrate that decisions made during procurement and project preparation can have long-term consequences [23–27]. However, much of this literature focuses on construction contracts, large infrastructure projects, and implementation-stage performance. Professional engineering services are often considered indirectly, despite their critical role in determining the technical quality and reliability of project documentation.

The reviewed literature therefore reveals an important research gap. Existing studies provide substantial evidence regarding the consequences of design deficiencies, the multidimensional nature of project complexity, the technical requirements of water infrastructure design, and the influence of procurement and price competition on project performance. Nevertheless, these research directions have rarely been integrated into a quantitative framework for evaluating whether the prices established for engineering design services are proportionate to project technical complexity and engineering workload.

In particular, limited attention has been given to the development of measurable indicators that enable the comparison of project complexity with contracted design prices and justified design costs. The absence of such indicators restricts the ability of contracting authorities, researchers, and engineering organizations to identify potential underpricing, overpricing, or disproportionality in the financing of engineering design services.

Accordingly, the present study integrates two analytical dimensions that have generally been examined separately in previous research: the technical complexity of infrastructure projects and the financial adequacy of engineering design service pricing. The Project Complexity Score (PCS) is applied to provide a quantitative representation of the principal technical components affecting engineering workload, while the Design Price Adequacy Ratio (DPAR) is introduced to evaluate the relationship between contracted design prices and estimated justified design prices. The integration of these indicators provides the conceptual basis for the subsequent formulation of the research problem and methodological framework.

Conflict Setting

The pricing of engineering design services in public procurement involves a fundamental conflict between the objective of achieving cost efficiency through competitive procurement and the need to allocate sufficient financial resources for the proper preparation of technically complex infrastructure projects. Contracting authorities seek to obtain engineering services under economically advantageous conditions, whereas design organizations must perform the full scope of investigations, calculations, technical analyses, coordination activities, and documentation required to produce reliable design solutions.

This conflict becomes particularly significant when the financial resources allocated for engineering design are determined without explicit consideration of project technical complexity and engineering workload. Water supply and irrigation infrastructure projects may differ substantially in the number of settlements served, pipeline length, number and type of water intake structures, pumping stations, regulating reservoirs, treatment facilities, and other hydraulic and technological components. Consequently, projects included within the same general procurement category may require substantially different levels of professional effort, specialist participation, investigation activities, engineering calculations, and interdisciplinary coordination.

However, the pricing of engineering design services may not adequately reflect these differences. Projects characterized by substantially different technical configurations and engineering workloads may receive comparable levels of design financing. Conversely, projects with similar levels of technical complexity may be assigned considerably different contract prices. Such inconsistencies indicate that the relationship between project complexity and design service pricing requires systematic quantitative assessment.

A further methodological problem concerns the determination of a justified reference price for engineering design services. The contracted price resulting from a competitive procurement procedure represents the market outcome of bidding but does not necessarily indicate the financial resources objectively required for the adequate performance of the design assignment. At the same time, construction cost alone cannot serve as a sufficient indicator of engineering workload because projects with similar construction costs may differ substantially in technical complexity and design requirements.

Therefore, the assessment of design price adequacy requires two interconnected analytical dimensions. The first is the quantitative characterization of project technical complexity. The second is the comparison of the contracted design price with an estimated justified design price determined using a consistent and transparent calculation approach. The integration of these dimensions makes it possible to examine whether increasing project complexity is accompanied by a proportional increase in design financing and to identify cases of potential underpricing, overpricing, or disproportionality.

In this study, project technical complexity is evaluated using the Project Complexity Score (PCS), which integrates the principal technical components affecting engineering workload in water supply and irrigation infrastructure projects. The financial adequacy of design service pricing is evaluated using the Design Price Adequacy Ratio (DPAR), defined as the ratio of the contracted design price to the estimated justified design price.

Accordingly, the central research problem addressed in this study is the potential mismatch between the technical complexity of water supply and irrigation infrastructure projects and the financial resources allocated for engineering design services through public procurement procedures.

The main research question is formulated as follows: To what extent do the prices established for engineering design services in public procurement procedures reflect the technical complexity and engineering workload of water supply and irrigation infrastructure projects?

To answer this question, the study addresses three interconnected research questions:

1. Is there a statistically identifiable relationship between project technical complexity, expressed through the Project Complexity Score (PCS), and the contracted price of engineering design services?
2. To what extent do contracted design prices differ from estimated justified design prices for projects with different levels of technical complexity?
3. Can the Design Price Adequacy Ratio (DPAR) provide a consistent quantitative basis for identifying potential underpricing, adequate pricing, and overpricing of engineering design services?

The analysis of these questions provides the basis for evaluating whether existing design service pricing practices adequately account for differences in project technical complexity and for developing a more transparent and technically justified approach to the financial assessment of engineering design services.

Materials and Methods

Research Design and Data Selection

The study was designed as a quantitative comparative assessment of engineering design service pricing in public procurement procedures for water supply and irrigation infrastructure projects in the Republic of Armenia. The analytical framework was developed to examine whether differences in project technical complexity are reflected in the financial resources allocated for engineering design activities.

The empirical dataset consisted of selected public procurement procedures for engineering design services related to water supply and irrigation infrastructure projects. The unit of analysis was an individual procurement contract for the preparation of engineering design documentation. Projects were selected to ensure sufficient variation in technical characteristics, engineering workload, and contracted design prices.

The selection criteria required that each procurement procedure contain sufficient technical and financial information to identify the principal infrastructure components included in the design assignment and to determine the initial estimated procurement price and the final contracted design price. Projects for which the available procurement documentation did not provide sufficient information for consistent technical characterization or price comparison were excluded from the analysis.

For each selected project, data were collected on the type and scope of infrastructure, number of settlements served, total pipeline length, number of water intake structures, pumping stations, regulating reservoirs, water treatment facilities, and other major hydraulic and technological components. Financial data included the initial estimated procurement price and the final contracted price of the engineering design services.

To ensure comparability among projects with different technical configurations and financial scales, the analysis was conducted in four consecutive stages. First, the technical characteristics and financial data of the selected projects were compiled and standardized. Second, project technical complexity was quantified using the Project Complexity Score (PCS).

Third, contracted design prices were compared with estimated justified design prices, and the Design Price Adequacy Ratio (DPAR) was calculated. Finally, statistical relationships between project complexity and design service prices were examined, and the obtained results were interpreted through comparative analysis of projects with different complexity levels.

The methodological framework was therefore structured to evaluate two interconnected dimensions of engineering design service pricing: whether higher project complexity is associated with higher contracted design prices and whether the financial resources allocated through procurement procedures are proportionate to the estimated justified cost of the engineering design activities required.

Research Results

Financial Characteristics of the Selected Procurement Procedures

The empirical analysis included 30 public procurement procedures for engineering design services related to water supply, irrigation, and associated infrastructure projects in the Republic of Armenia. The analyzed procedures covered projects with substantially different construction costs and corresponding design price scales, providing an appropriate empirical basis for evaluating variations in the financial resources allocated for engineering design activities.

The construction costs of the analyzed projects ranged from approximately AMD 8.10 million to AMD 800.00 million. Depending on the construction cost category, the estimated justified design prices were calculated using design price rates ranging from 2–3% to 6–7%. The comparison revealed substantial variation between the estimated justified design price ranges and the prices established in the procurement procedures.

The results demonstrate that the analyzed procurement procedures cannot be characterized by a uniform relationship between construction cost and design service pricing. While some procurement prices were within or close to the estimated justified price ranges, a considerable number of cases were characterized by substantial underpricing. Several procedures showed particularly large discrepancies, with procurement prices representing only a fraction of the estimated minimum design price.

Tab. 1 presents the complete financial dataset used as the initial empirical basis for the subsequent analysis of project complexity and design price adequacy.

Project Complexity Assessment Using the Project Complexity Score (PCS)

To evaluate differences in the engineering workload associated with water supply and irrigation infrastructure projects, project technical complexity was quantified using the Project Complexity Score (PCS). The indicator was developed to transform the principal technical characteristics of the analyzed projects into a comparable quantitative measure of engineering complexity.

The PCS framework includes six technical components that directly influence the volume of investigations, engineering calculations, hydraulic analysis, interdisciplinary coordination, and design documentation required during project preparation: the number of settlements served, total pipeline length, number of water intake structures, pumping stations, regulating reservoirs, and water treatment facilities.

Table 1

Financial Characteristics of the Analyzed Procurement Procedures

Project	Construction Cost (AMD million)	Applicable Design Rate (%)	Estimated Justified Design Price (AMD million)	Procurement Price (AMD million)
P1	565.00	2–3	11.30–16.95	3.50
P2	800.00	2–3	16–20	12.75
P3	23.69	6–7	1.42–1.66	1.056
P4	66.00	6–7	3.96–4.62	4.40
P5	257.94	3–4	7.74–10.32	18.00
P6	51.78	6–7	3.11–3.62	2.20
P7	47.14	6–7	2.83–3.30	3.00
P8	37.40	6–7	2.24–2.62	3.10
P9	25.00	6–7	1.50–1.75	0.50
P10	13.20	6–7	0.79–0.92	0.80
P11	27.50	6–7	1.65–1.93	2.00
P12	20.60	6–7	1.24–1.44	1.20
P13	55.00	6–7	3.30–3.85	1.80
P14	8.10	6–7	0.54–0.63	0.90
P15	81.40	6–7	4.88–5.70	4.00
P16	12.21	6–7	0.73–0.85	0.40
P17	33.00	6–7	1.98–2.31	8.00
P18	≈18–22	6–7	1.08–1.54	0.25
P19	8.80	6–7	0.53–0.62	0.60
P20	24.45	6–7	1.47–1.71	1.50
P21	214.50	4–5	8.58–10.73	9.30
P22	20.90	6–7	1.25–1.46	1.344
P23	157.30	4–5	6.29–7.87	2.90
P24	9.60	6–7	0.58–0.67	0.60
P25	209.00	4–5	8.36–10.45	5.60
P26	230.00	4–5	9.20–11.50	2.00
P27	250.80	3–4	7.52–10.03	2.34
P28	≈28–35	6–7	1.68–2.45	1.64
P29	209.00	4–5	8.36–10.45	9.225
P30	223.27	4–5	8.93–11.16	10.55

Source: Authors' calculations based on public procurement documentation.

Because the selected technical components differ in measurement units and potential ranges, their raw values cannot be directly aggregated. Therefore, each component was transformed into a standardized component score using predefined ordinal scoring intervals. The scoring intervals were established to represent increasing levels of engineering workload associated with each technical characteristic.

The Project Complexity Score was calculated as:

$$PCS = w_1 S + w_2 L + w_3 I + w_4 P + w_5 R + w_6 T$$

where: **S** is the standardized score for the number of settlements served; **L** is the standardized score for total pipeline length; **I** is the standardized score for the number of water intake structures; **P** is the standardized score for the number of pumping stations; **R** is the standardized score for the number of regulating reservoirs; **T** is the standardized score for the number of water treatment facilities; and w_1–w_6 are the weighting coefficients assigned to the respective technical components.

The weighting coefficients were introduced because the selected technical components do not contribute equally to engineering workload. Pipeline length primarily affects the volume of surveying, hydraulic calculations, longitudinal profiles, and preparation of linear infrastructure documentation. Water intake structures, pumping stations, regulating reservoirs, and treatment facilities require additional structural, hydraulic, mechanical, electrical, technological, and automation design activities. The number of settlements served increases the spatial distribution of the project and the requirements for network coordination, demand assessment, and integration of individual system components.

For the present comparative assessment, the following weighting structure was applied:

Table 2

Weighting Coefficients Used for the Calculation of the Project Complexity Score (PCS)

Technical Component	Symbol	Weight
Number of settlements served	S	0.15
Total pipeline length	L	0.20
Water intake structures	I	0.15
Pumping stations	P	0.15
Regulating reservoirs	R	0.15
Water treatment facilities	T	0.20
Total		**1.00**

Each technical component was evaluated on a five-point ordinal scale ranging from 1 to 5. A score of 1 represents projects with a limited technical scope, while a score of 5 represents projects characterized by a large number or substantial scale of technical components and, consequently, greater engineering workload.

Table 3

Scoring Criteria for the Technical Components of the Project Complexity Score (PCS)

Score	Settlements Served	Pipeline Length (km)	Water Intakes	Pumping Stations	Regulating Reservoirs	Treatment Facilities
1	1	≤5	0	0	0–1	0
2	2–3	>5–15	1	1	2–3	1
3	4–6	>15–30	2	2	4–6	2
4	7–10	>30–50	3	3	7–10	3
5	>10	>50	≥4	≥4	>10	≥4

The resulting PCS values range theoretically from 1.00 to 5.00. For interpretation and comparative analysis, the projects were classified into four complexity levels.

Table 4

Classification of Projects According to the Project Complexity Score (PCS)

PCS Range	Complexity Level
1.00–1.99	Low complexity
2.00–2.99	Moderate complexity
3.00–3.99	High complexity
4.00–5.00	Very high complexity

The proposed PCS framework provides a consistent quantitative basis for comparing projects with different technical configurations. Rather than using construction cost as a proxy for engineering complexity, the indicator directly incorporates the principal infrastructure components that determine the scope of engineering investigations, calculations, coordination activities, and preparation of design documentation.

The calculated PCS values were subsequently compared with the procurement prices and estimated justified design prices presented in Table 1. This comparison was used to examine whether higher project complexity was accompanied by a corresponding increase in design financing and to identify potential inconsistencies between engineering workload and the financial resources allocated for project preparation.

Project Complexity Results

The application of the proposed PCS framework requires the technical characteristics of each analyzed project to be converted into standardized component scores according to the criteria presented in Table 3. The weighted component scores are then aggregated to obtain the final PCS value for each project.

However, the financial dataset presented in Table 1 does not by itself contain sufficient technical information for calculating PCS values for all 30 projects. Therefore, the PCS-based analysis was limited to those procurement procedures for which the available documentation provided complete and comparable information on the technical components included in the PCS framework.

Based on the completeness of the available technical documentation, projects with sufficient information on the number of settlements served, pipeline length, water intake structures, pumping stations, regulating reservoirs, and treatment facilities were selected for the PCS-based assessment. For each selected project, the original technical characteristics were converted into standardized scores using the criteria presented in Table 3, after which the weighted PCS value was calculated according to the adopted weighting coefficients.

The calculated component scores and the resulting PCS values for the selected projects are presented in Table 5. The table provides the quantitative basis for comparing project technical complexity with the corresponding design service prices and for the subsequent calculation of the Design Price Adequacy Ratio (DPAR).

Due to the absence of complete and comparable technical component data for all 30 procurement procedures, the subsequent price adequacy assessment was based primarily on the financial dataset presented in Table 1, while the PCS framework was used as a methodological basis for interpreting project complexity differences.

Design Price Adequacy Assessment

To quantitatively evaluate the adequacy of design service pricing, the procurement prices presented in Table 1 were compared with the estimated justified design prices. Since the justified design price was expressed as a range, the midpoint of the corresponding interval was used as the reference value for comparative calculations.

The Design Price Adequacy Ratio (DPAR) was calculated as:

$$DPAR = \frac{CP}{JPR}$$

where **CP** is the procurement price of the engineering design services and **JDP** is the estimated justified design price represented by the midpoint of the corresponding justified price interval.

Table 5

Design Price Adequacy Ratio (DPAR) for the Analyzed Procurement Procedures

Project	JDP Midpoint (AMD million)	Procurement Price (AMD million)	DPAR	Interpretation
P1	14.125	3.50	0.25	Underpricing
P2	18.000	12.75	0.71	Underpricing
P3	1.540	1.056	0.69	Underpricing
P4	4.290	4.40	1.03	Relatively adequate
P5	9.030	18.00	1.99	Overpricing
P6	3.365	2.20	0.65	Underpricing
P7	3.065	3.00	0.98	Relatively adequate
P8	2.430	3.10	1.28	Overpricing
P9	1.625	0.50	0.31	Underpricing
P10	0.855	0.80	0.94	Relatively adequate
P11	1.790	2.00	1.12	Relatively adequate
P12	1.340	1.20	0.90	Relatively adequate
P13	3.575	1.80	0.50	Underpricing
P14	0.585	0.90	1.54	Overpricing
P15	5.290	4.00	0.76	Relatively adequate
P16	0.790	0.40	0.51	Underpricing
P17	2.145	8.00	3.73	Overpricing
P18	1.310	0.25	0.19	Underpricing
P19	0.575	0.60	1.04	Relatively adequate
P20	1.590	1.50	0.94	Relatively adequate
P21	9.655	9.30	0.96	Relatively adequate
P22	1.355	1.344	0.99	Relatively adequate
P23	7.080	2.90	0.41	Underpricing
P24	0.625	0.60	0.96	Relatively adequate
P25	9.405	5.60	0.60	Underpricing
P26	10.350	2.00	0.19	Underpricing
P27	8.775	2.34	0.27	Underpricing
P28	2.065	1.64	0.79	Relatively adequate
P29	9.405	9.225	0.98	Relatively adequate
P30	10.045	10.55	1.05	Relatively adequate

Source: Authors’ calculations based on the financial data presented in Table 1.

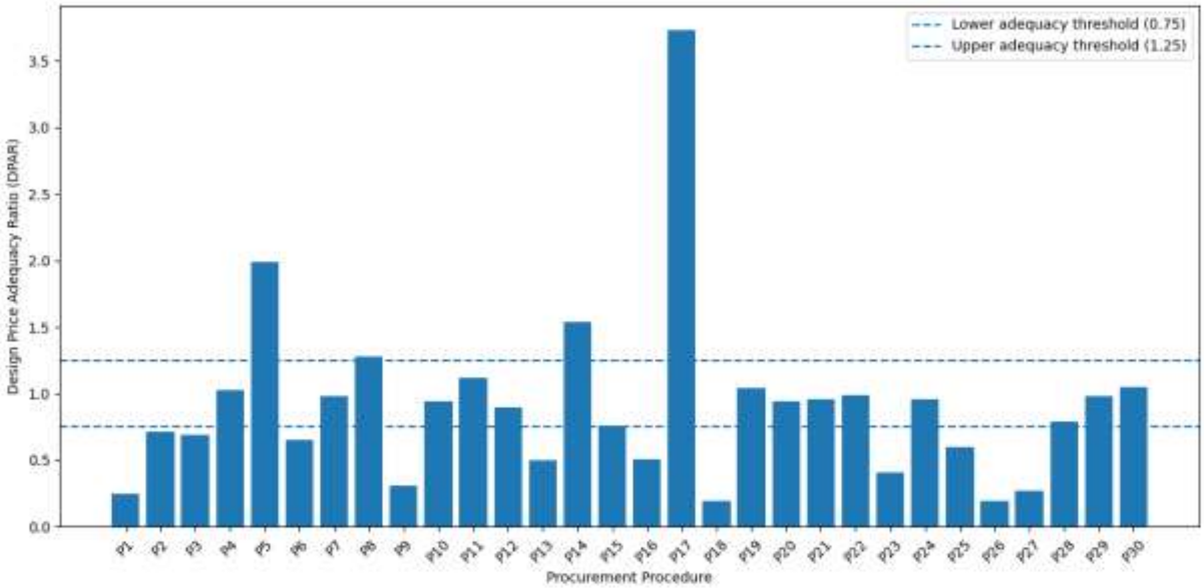

Fig. 1. Distribution of the Design Price Adequacy Ratio (DPAR) across the Analyzed Procurement Procedures

The distribution of DPAR values across the analyzed procurement procedures is presented in Fig. 1. The figure visually demonstrates substantial differences between procurement prices and estimated justified design prices. While a considerable number of procedures fall within the relatively adequate pricing range ($0.75 \leq \text{DPAR} \leq 1.25$), several cases are located substantially below or above the adopted adequacy thresholds. Particularly pronounced deviations are observed for P17 on the upper side and for P18 and P26 on the lower side. The simultaneous presence of substantial underpricing and overpricing provides additional evidence of inconsistencies in the existing pricing practices for engineering design services.

For interpretation purposes, DPAR values below 1.00 indicate that the procurement price is lower than the estimated justified design price, while values above 1.00 indicate that the procurement price exceeds the estimated justified reference value. In this study, DPAR values below 0.75 were interpreted as underpricing, values from 0.75 to 1.25 as relatively adequate pricing, and values above 1.25 as overpricing.

The DPAR results reveal substantial variation in the adequacy of design service pricing across the analyzed procurement procedures. Of the 30 cases, 12 were classified as underpriced, 14 as relatively adequate, and 4 as overpriced. Thus, 40% of the analyzed procedures were characterized by design prices below the adopted adequacy threshold, while only 46.7% fell within the relatively adequate pricing range. The remaining 13.3% exceeded the upper adequacy threshold. These results indicate that design service pricing practices are highly heterogeneous and that a considerable proportion of procurement procedures do not provide financial resources proportionate to the estimated justified design price.

The calculated DPAR values ranged from 0.19 to 3.73, indicating substantial differences in the relationship between procurement prices and estimated justified design prices. The lowest DPAR values were observed for P18 and P26 (0.19), followed by P1 (0.25) and P27 (0.27), demonstrating cases in which the procurement price represented only a small fraction of the estimated justified design price. Conversely, P17 showed the highest DPAR value (3.73), followed by P5 (1.99) and P14 (1.54), indicating substantial overpricing relative to the adopted reference value. The simultaneous presence of pronounced underpricing and overpricing suggests the absence of a consistent pricing mechanism capable of maintaining proportionality between procurement prices and estimated engineering design requirements.

The distribution of DPAR values further demonstrates that deviations from the estimated justified design prices were not limited to isolated procurement procedures. Underpricing was observed across projects with different construction costs and design price scales, indicating that inadequate design financing cannot be attributed exclusively to a particular project size category. Similarly, relatively adequate and overpriced cases were distributed across different financial groups. This pattern suggests that the observed pricing inconsistencies are systemic rather than associated solely with the financial scale of individual infrastructure projects.

Overall, the DPAR analysis demonstrates that the existing procurement pricing practices do not consistently ensure proportionality between the financial resources allocated for engineering design services and the estimated justified design prices. The results support the need for more transparent and quantitatively grounded pricing approaches that can reduce extreme deviations and improve the financial adequacy of engineering design contracts.

The identified variation in DPAR values raises an important question regarding the factors responsible for the observed pricing inconsistencies. Since projects with different construction costs exhibited underpricing, relatively adequate pricing, and overpricing, construction cost alone does not appear to provide a sufficient basis for determining appropriate design service prices. The obtained results therefore require further interpretation in relation to project technical complexity, procurement pricing practices, and the potential consequences of inadequate design financing.

Discussion

The results demonstrate that the pricing of engineering design services cannot be adequately explained by construction cost alone. The coexistence of substantial underpricing, relatively adequate pricing, and overpricing across projects of different financial scales indicates that the current pricing approach does not consistently reflect the actual engineering workload required for project preparation. This finding is particularly important for water supply and irrigation infrastructure projects, where the volume of engineering investigations, hydraulic calculations, technical solutions, and interdisciplinary coordination depends strongly on project configuration and technical complexity.

The DPAR distribution also indicates that the observed pricing inconsistencies cannot be interpreted simply as a general tendency toward underpricing. Although underpriced procedures constituted a substantial share of the analyzed cases, several projects were characterized by procurement prices considerably exceeding the estimated justified reference values. This bidirectional variation suggests that the principal problem lies not only in insufficient financing but also in the absence of a consistent and transparent mechanism for determining design service prices. A pricing system that produces both pronounced underpricing and overpricing may lead to inefficient allocation of public resources and reduce the predictability of engineering service procurement.

The results further indicate that construction cost-based pricing approaches should be complemented by explicit consideration of project technical complexity. Projects with similar construction costs may differ substantially in the number and type of infrastructure components, spatial extent, hydraulic configuration, and interdisciplinary design requirements. Consequently, the engineering workload associated with project preparation may vary even when projects belong to the same financial category. The PCS framework proposed in this study provides a methodological basis for incorporating these differences into the assessment of design service pricing and for moving toward more complexity-sensitive procurement practices.

The financial adequacy of engineering design contracts may also have implications for the quality of project preparation. When procurement prices are substantially lower than the estimated justified design prices, design organizations may face constraints in allocating sufficient resources to field investigations, engineering calculations, alternative analysis, technical verification, and interdisciplinary coordination. Conversely, procurement prices considerably exceeding justified reference values may indicate inefficient allocation of public funds. Therefore, improving design service pricing requires a balanced approach that seeks to ensure sufficient financing for technically adequate project preparation while simultaneously preventing unjustified expenditure of public resources.

The proposed combination of DPAR and PCS also has practical implications for public procurement decision-making. DPAR enables the identification of substantial deviations between procurement prices and estimated justified design prices, whereas PCS provides a structured basis for considering differences in project technical complexity. Used together, these indicators can support a more transparent preliminary assessment of whether the financial resources allocated for engineering design services are broadly consistent with the characteristics of the project. However, they should be regarded as decision-support tools rather than substitutes for detailed cost estimation and professional engineering judgment.

The findings of this study are consistent with previous research emphasizing that procurement decisions based predominantly on price may not adequately reflect the requirements of professional engineering services [17–22]. At the same time, the results extend the existing literature by demonstrating that the problem is not limited to lowest-price selection alone. The substantial dispersion of DPAR values indicates broader inconsistencies in the relationship between procurement prices and estimated justified design costs. This finding supports the need to complement conventional procurement criteria with quantitative indicators capable of evaluating price adequacy and project-specific engineering complexity.

The study has several limitations that should be considered when interpreting the results. The analysis was based on a limited dataset of public procurement procedures and on estimated justified design price ranges derived from the adopted pricing approach. In addition, complete and comparable technical data required for calculating PCS values were not available for all analyzed projects, which limited the empirical integration of project complexity and price adequacy. Future research should therefore expand the procurement dataset, apply the PCS framework to projects with complete technical characteristics, and examine the statistical relationship between project complexity, design service prices, and subsequent project implementation outcomes.

Overall, the findings demonstrate that improving the procurement of engineering design services requires moving from predominantly cost-based pricing toward a more differentiated approach that considers both financial adequacy and project-specific technical complexity. The combined use of DPAR and PCS provides a methodological basis for identifying pricing inconsistencies and supporting more transparent and technically justified procurement decisions. Although further empirical validation is required, the proposed framework offers a practical direction for improving the allocation of financial resources for engineering design services in water supply and irrigation infrastructure projects.

Conclusions

1. The analysis demonstrated substantial inconsistencies between the procurement prices of engineering design services and the estimated justified design prices for water supply and irrigation infrastructure projects. Only 46.7% of the analyzed procedures were classified as relatively adequate, while 40.0% were characterized by underpricing and 13.3% by overpricing.
2. The calculated DPAR values ranged from 0.19 to 3.73, revealing substantial dispersion in the relationship between procurement prices and estimated justified design prices. The simultaneous occurrence of pronounced underpricing and overpricing indicates that the identified problem cannot be explained solely by a general tendency toward insufficient financing of engineering design services.
3. The distribution of DPAR values across projects with different construction costs demonstrates that pricing inconsistencies are not confined to a particular financial scale of infrastructure projects. Construction cost alone therefore does not provide a sufficient basis for determining financially adequate prices for engineering design services.
4. The results support the need to complement construction cost-based pricing approaches with explicit consideration of project-specific technical complexity. The proposed PCS framework provides a structured methodological basis for representing differences in engineering workload associated with the number, scale, and configuration of the principal technical components of water infrastructure projects.
5. The combined application of DPAR and PCS provides a methodological framework for evaluating engineering design service pricing from two complementary perspectives: financial adequacy and project technical complexity. These indicators may support more transparent and technically justified procurement decisions but should be used as decision-support tools rather than substitutes for detailed cost estimation and professional engineering judgment.
6. Substantial underpricing of engineering design services may restrict the resources available for field investigations, engineering calculations, alternative analysis, technical verification, and interdisciplinary coordination, thereby increasing risks related to the quality of project preparation. Conversely, substantial overpricing may lead to inefficient allocation of public financial resources.
7. The findings demonstrate the need for a more transparent, differentiated, and quantitatively grounded mechanism for determining the prices of engineering design services in public procurement procedures. Such a mechanism should seek to ensure proportionality between the technical characteristics of infrastructure projects, the engineering workload required for project preparation, and the financial resources allocated for design activities.
8. Further research should expand the empirical procurement dataset, apply the PCS framework to projects with complete and comparable technical characteristics, and

statistically examine the relationships between project complexity, design service pricing, and subsequent project implementation outcomes. Such analysis would allow further validation and refinement of the proposed methodological framework.

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PROJECT COMPLEXITY AND DESIGN SERVICE PRICING IN PUBLIC PROCUREMENT OF WATER INFRASTRUCTURE PROJECTS

ՆԱԽԱԳԾԵՐԻ ԲԱՐԴՈՒԹՅՈՒՆԸ և ՆԱԽԱԳԾԱՅԻՆ ԾԱՌԱՅՈՒԹՅՈՒՆՆԵՐԻ ԳՆԱԳՈՅԱՑՈՒՄԸ ՋՐԱՅԻՆ ԵՆԹԱԿԱՌՈՒՑՎԱԾՔՆԵՐԻ ՊԵՏԱԿԱՆ ԳՆՈՒՄՆԵՐՈՒՄ

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[2] Հայաստանի պետական տնտեսագիտական համալսարան

Ինժեներական նախագծային ծառայությունների գնագոյացումը ենթակառուցվածքային նախագծերի նախապատրաստման կարևոր բաղադրիչ է և անմիջականորեն ազդում է նախագծային կազմակերպությունների՝ հուսալի նախագծային փաստաթղթերի մշակման համար անհրաժեշտ հետազննությունները, հաշվարկները և տեխնիկական աշխատանքներն իրականացնելու հնարավորության վրա: Սակայն պետական գնումների ընթացակարգերում նախագծային ծառայությունների արժեքները կարող են սահմանվել առանց նախագծերի տեխնիկական բարդության և ինժեներական աշխատանքների իրական ծավալի համակարգված հաշվառման:

Սույն հետազոտության նպատակն է գնահատել Հայաստանի Հանրապետությունում ջրամատակարարման և ոռոգման ենթակառուցվածքների նախագծերի պետական գնումների ընթացակարգերում նախագծային ծառայությունների գնագոյացման համարժեքությունը: Հետազոտությունը հիմնված է ընտրված գնման ընթացակարգերի, նախագծերի բնութագրերի, պայմանագրային արժեքների և կիրառվող գնագոյացման մոտեցումների հիման վրա որոշված նախագծային հաշվարկային արժեքների համեմատական վերլուծության վրա: Նախագծերի տեխնիկական բարդությունը գնահատվում է Project Complexity Score (PCS) ցուցանիշի միջոցով, որը ներառում է ջրային ենթակառուցվածքների նախագծերի հիմնական ինժեներական բաղադրիչները՝ սպասարկվող բնակավայրերի թիվը, խողովակաշարերի երկարությունը, ջրընդունիչ կառուցվածքները, պոմպակայանները, կարգավորիչ ջրամբարները և ջրի մաքրման կառույցները:

Վերլուծության ընթացքում համեմատվում են նախագծերի բարդության մակարդակները և գնման ընթացակարգերով սահմանված նախագծային ծառայությունների արժեքները՝ գնահատելու համար, թե արդյոք տեխնիկական բարդության աճն ուղեկցվում է նախագծային աշխատանքների իրականացման համար հատկացվող ֆինանսական միջոցների համապատասխան աճով: Համեմատական գնահատումն իրականացնելու նպատակով առաջարկվում է Design Price Adequacy Ratio (DPAR) ցուցանիշը՝ որպես նախագծային ծառայությունների պայմանագրային արժեքի և հիմնավորված հաշվարկային արժեքի հարաբերակցություն:

Արդյունքները ցույց են տալիս նախագծերի տեխնիկական բարդության և նախագծային ծառայությունների գնագոյացման միջև էական անհամապատասխանություններ: Ինժեներական աշխատանքների ծավալով զգալիորեն տարբերվող նախագծերի համար կարող են սահմանվել նախագծային ֆինանսավորման համադրելի մակարդակներ, մինչդեռ մի շարք դեպքերում պայմանագրային արժեքները զգալիորեն ցածր են նախագծերի պատշաճ նախապատրաստման համար անհրաժեշտ հաշվարկային արժեքներից: Ստացված արդյունքները վկայում են, որ նախագծերի բարդությունը և ինժեներական աշխատանքների ծավալը համակարգված կերպով չեն ներառվում նախագծային ծառայությունների արժեքների որոշման գործընթացում:

Հետազոտությունը եզրակացնում է, որ նախագծերի բարդության չափանիշների և գնային համարժեքության քանակական ցուցանիշների ներառումը պետական գնումների պլանավորման գործընթացում կարող է բարձրացնել նախագծային ծառայությունների գնագոյացման թափանցիկությունն ու տեխնիկական հիմնավորվածությունը, նվազեցնել թերֆինանսավորված նախագծային աշխատանքների հետ կապված ռիսկերը և նպաստել ջրային ենթակառուցվածքների նախագծերի նախապատրաստման որակի ու արդյունավետության բարձրացմանը:

Բանալի բառեր՝ պետական գնումներ, նախագծային ծառայությունների գնագոյացում, նախագծերի բարդություն, Project Complexity Score (PCS), Design Price Adequacy Ratio (DPAR), ջրամատակարարման համակարգեր, ոռոգման համակարգեր, ինժեներական նախագծում:

СЛОЖНОСТЬ ПРОЕКТОВ И ЦЕНООБРАЗОВАНИЕ ПРОЕКТНЫХ УСЛУГ В ГОСУДАРСТВЕННЫХ ЗАКУПКАХ ПРОЕКТОВ ВОДНОЙ ИНФРАСТРУКТУРЫ

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Ценообразование инженерно-проектных услуг является важным компонентом подготовки инфраструктурных проектов и непосредственно влияет на способность проектных организаций выполнять изыскания, расчёты и технические работы, необходимые для разработки надёжной проектной документации. Однако в процедурах государственных закупок стоимость проектных услуг может определяться без систематического учёта технической сложности проектов и фактического объёма инженерных работ.

Целью настоящего исследования является оценка адекватности ценообразования проектных услуг в процедурах государственных закупок проектов инфраструктуры водоснабжения и орошения в Республике Армения. Исследование основано на сравнительном анализе выбранных процедур закупок, характеристик проектов, договорных цен и расчётной стоимости проектных работ, определённой на основе применяемых подходов к ценообразованию. Техническая сложность проектов оценивается с использованием показателя Project Complexity Score (PCS), который учитывает основные инженерные компоненты проектов водной инфраструктуры, включая количество обслуживаемых населённых пунктов, протяжённость трубопроводов, водозаборные сооружения, насосные станции, регулирующие резервуары и сооружения водоподготовки.

В ходе анализа сопоставляются уровни сложности проектов и стоимость проектных услуг, установленная в процедурах закупок, с целью определения того, сопровождается ли увеличение технической сложности соответствующим увеличением финансовых ресурсов, выделяемых на выполнение проектных работ. Для проведения сравнительной оценки предлагается показатель Design Price Adequacy Ratio (DPAR), определяемый как отношение договорной стоимости проектных услуг к расчётной обоснованной стоимости проектирования.

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PROJECT COMPLEXITY AND DESIGN SERVICE PRICING IN PUBLIC PROCUREMENT OF WATER INFRASTRUCTURE PROJECTS

Результаты исследования выявляют существенные несоответствия между технической сложностью проектов и ценообразованием проектных услуг. Проекты, значительно различающиеся по объёму и сложности инженерных работ, могут получать сопоставимые объёмы финансирования проектирования, тогда как в ряде случаев договорная стоимость проектных услуг значительно ниже расчётных значений, необходимых для надлежащей подготовки проектов. Полученные результаты свидетельствуют о том, что техническая сложность проектов и объём инженерных работ систематически не учитываются при определении стоимости проектных услуг.

В исследовании делается вывод о том, что включение критериев сложности проектов и количественных показателей адекватности стоимости в процесс планирования государственных закупок может повысить прозрачность и техническую обоснованность ценообразования проектных услуг, снизить риски, связанные с недостаточным финансированием проектных работ, и способствовать повышению качества и эффективности подготовки проектов водной инфраструктуры.

***Ключевые слова*:** государственные закупки; ценообразование проектных услуг; сложность проектов; Project Complexity Score (PCS); Design Price Adequacy Ratio (DPAR); системы водоснабжения; оросительные системы; инженерное проектирование.

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