Evaluation Of Priority Criteria for Selecting Subcontractors in Highway Construction Projects in Nusantara Capital City (Ikn) Project

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ABSTRACT

The selection of appropriate subcontractors plays a critical role in the success of construction projects, particularly in strategic infrastructure projects such as Section 6B of the Highway Construction Project in Nusantara Capital City. This project experienced delays and cost deviations of 4.43% due to subcontractor selection based solely on two common criteria—experience and lowest price—while neglecting additional important criteria such as technical qualifications and managerial capabilities, which could mitigate project risks. This study aims to identify and analyze subcontractor selection criteria to enhance project success and reduce delays and cost overruns based on the experience and assessments of stakeholders. Previous research indicates that commonly used methods have not sufficiently addressed issues of delays and cost deviations. Therefore, this study explores more effective methods, employing the Delphi, DEMATEL, and ANP methodologies. The Delphi method, through three survey rounds, identified seven criteria and sub-criteria. DEMATEL was then applied to assess relationships among these criteria, identifying dominant causal or effect factors. Finally, the ANP method determined priority criteria and sub-criteria. The results revealed that Price held the highest priority weight (23%), followed by Quality (21%), Technical (18%), Delivery (13%), Organization (8%), and Internal (6.5%). Among sub-criteria, Bid Price had the highest weight (16%), followed by Standard Quality (8%) and others with similar significance

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1. INTRODUCTION

Large-scale infrastructure projects play a strategic role in driving economic growth and enhancing inter-regional connectivity [1]. In the current administration, Indonesia's capital city was officially relocated from Jakarta to Nusantara in East Kalimantan Province, as mandated by Law No. 3 of 2022 on the National Capital. This strategic policy, ratified by the House of Representatives on January 18, 2022 [2], aims to distribute development more evenly, alleviate Jakarta's burdens, and foster growth outside Java. To realize infrastructure development in Nusantara, project success depends

not only on robust planning but also on execution quality involving multiple stakeholders. However, inadequate infrastructure has hindered mobility and the construction supply chain. Addressing these challenges, the Directorate General of Highways initiated Section 6B of the Outer Ring Road – SP. 3 ITCI Highway Project to enhance mobility and transport efficiency in Nusantara. The project execution encountered issues in finding competent subcontractors, who are pivotal for specialized technical tasks [3]. Proper subcontractor selection is critical for project success [4], as poor choices can lead to delays, cost overruns, and substandard work quality [5]. PT XYZ, the state-owned contractor leading the project, collaborated with private companies PT DEF and PT JKL under a joint operation structure. Subcontractors were selected through an open tender process based on relationships and price. The initial stage involved explaining project details and presenting the Bill of Quantity (BOQ), followed by formal instructions (Aanwijzing), and price negotiation.

While the open tender method is common, it often lacks comprehensive evaluation criteria. Subcontractor performance, especially deviations in project costs [6], highlighted weaknesses in the current approach. For instance, cost deviations of 4.4% were observed in the Section 6B project, indicating suboptimal subcontractor performance, which could delay completion, inflate costs, and reduce quality. This calls for reevaluating the selection criteria beyond price and relationships. Previous studies by Abedin et al. [7] utilized AHP-ANP approaches focusing on past performance and commercial and technical bids, identifying commercial bids as the most influential factor. Similarly, Kishore et al. [8] employed AHP and Simple Additive Weighting (SAW) methods, emphasizing price and additional criteria like human resources and compliance with safety standards. Building on these insights, this study proposes an integrated framework using Delphi, DEMATEL, and ANP methods for the Section 6B project. The framework identifies determinants for improving selection quality and minimizing risks of cost deviations and delays. This study's novelty lies in the integrative application of Delphi, DEMATEL, and ANP methods, rarely implemented in large-scale construction projects. The Delphi method gathers expert opinions to identify relevant criteria, DEMATEL maps relationships and influences among criteria, and ANP determines priority weights. Unlike previous research focusing solely on basic criteria, this study incorporates additional factors such as quality, technical capabilities, organizational strength, and safety compliance. The proposed framework aims to enhance efficiency, reduce deviations, and ensure project success. Hence this study aims to analyze relationships and influences among criteria to improve subcontractor selection and project efficiency, identify and prioritize key criteria to reduce cost deviations and project delays, as well as develop an optimized subcontractor selection framework for the Section 6B Highway Project.

2. METHODS

This study employs an exploratory approach with a mixed-methods design, combining both qualitative and quantitative methods, aimed at investigating the causal relationships between the variables under study. The qualitative method is utilized to gain a deep understanding of the phenomena, through descriptive data collection techniques such as in-depth interviews and observations. Meanwhile, the quantitative method is used to test the formulated hypotheses by collecting numerical data through surveys or experiments. The integration of these two methods offers advantages in data analysis by combining the strengths of each method to provide a more comprehensive understanding of the issues at hand, as explained by Creswell & Clark [9].

The data collection methods used in this study include literature review and questionnaires. The literature review is conducted to acquire theories and concepts from previous studies, which serve as the theoretical foundation for this research, providing a strong basis for the validity of the research findings. The questionnaire, as the primary data collection instrument, was developed based on insights from expert judgment to identify relevant variables in the subcontractor selection process.

This questionnaire was then used to gather data from respondents with specialized knowledge and experience in subcontractor selection, with answer choices systematically structured [10]. Data analysis in this study utilizes the Delphi-DEMATEL-ANP methods, as the combination of these three approaches is considered more effective in addressing the limitations of previous research methods. The criteria used in this study are presented in Table 1.

Table 1. Research Instrument

No	Criteria	Sub-criteria	Definition	Measurement Scale	Reference
1	**Price**	a. Bid Price	Price offered by the subcontractor to the contractor during the tender process	1. Comparison scale to calculate weights of criteria and sub-criteria. 2. Likert scale for obtaining subcontractor scores	[11]
		b. Payment Method	Flexibility in the payment method offered by the subcontractor, e.g., down payment (DP), delayed payment, or progress-based payment		
2	**Quality**	a. Standard Quality	Recognized quality standards by the subcontractor		[12]
		b. Quality Control Program	Presence of quality control supervisors during project execution		
		c. Specification Quality	Ability of the subcontractor to meet job specifications		
3	**Technical**	a. Material Specification	Specification and quality of materials offered by the subcontractor (brand, thickness, etc.)		[12]
		b. Execution Method	Method planned by the subcontractor for carrying out the work, including steps, tools, and techniques		
		c. Execution Timeframe	Planned project completion target		
		d. Equipment Type & Capacity	Types of equipment to be used and the subcontractor's capacity to provide the necessary tools		

4	**Internal**	a. Location of the company/branch	Location of the company or branch near the project site		[11]
		b. Previous Project Performance	Evaluation of previous projects to demonstrate subcontractor track record		
		c. Management Capability	Subcontractor's management capabilities to support project execution		
		d. Number of Projects Completed	Portfolio of completed projects		
		e. Financial Capability	Financial strength of the subcontractor to assure the contractor of their ability to finish the work without financial issues		
5	**Health, Safety & Environment**	a. Safety Standards (K3)	Subcontractor's adherence to health and safety standards		[12]
		b. Safety Program (K3)	Presence of a safety supervisor during project execution		
		c. Waste Management	Subcontractor's waste management during construction		
6	**Organization**	a. Worker Qualifications	Quality of the subcontractor's workforce		[12]
		b. Commitment to Completion	Subcontractor's commitment to completing the work until the handover stage		
		c. Company Management	Professionalism in managing the company		
7	**Delivery**	a. Delivery Method for Materials & Equipment	Ability to deliver tools and materials to the site, especially for off-island projects		[11]

	b. Worker Placement Strategy	Subcontractor's strategy for providing labor, including housing for workers or utilizing local labor

Source: Primary Data Processed, 2025

3. RESULTS AND DISCUSSION

3.1 Analysis of Delphi Method

Table 2. The Result of Delphi Method Analysis for Criteria

No.	Criteria	Round 1 (%)	Round 2 (%)	Round 3 (%)
1	**Price**	92%	96%	96%
2	**Quality**	98%	98%	100%
3	**Technical**	90%	92%	94%
4	**Internal**	74%	74%	72%
5	**Health, Safety & Environment (K3L)**	84%	86%	86%
6	**Organization**	74%	74%	72%
7	**Delivery**	84%	78%	82%

Source: Primary Data Processed, 2024

Based on Table 2, the Quality criterion received the highest score compared to the other criteria, with 98% in the first round, 98% in the second round, and reaching 100% in the third round. The Price criterion ranked second with 92% in the first round, increasing to 96% in both the second and third rounds. Meanwhile, there was a decline in the Internal criterion, with a score of 72% in the third round, down 2% from the previous round. A similar decline was observed in the Organization criterion, which recorded a final score of 72% in the third round, lower than the previous rounds. The Delivery criterion experienced a score decrease in the second round but increased in the third round, reaching 82%.

Table 3. The Result of Delphi Method Analysis for Sub-Criteria

No.	Criteria	Sub-criteria	Round 1 (%)	Round 2 (%)	Round 3 (%)
1	**Price**	Tender Price	94%	96%	98%
		Payment Method	80%	88%	88%
2	**Quality**	Quality Standards	98%	100%	100%
		Quality Control Program	90%	92%	94%
		Specification Quality	94%	96%	94%
3	**Technical**	Material Specification	92%	96%	94%
		Execution Method	88%	92%	94%

		Execution Timeframe	82%	88%	88%
		Equipment Type & Capacity	74%	76%	78%
4	**Internal**	Company/Branch Location	62%	62%	64%
		Previous Project Performance	66%	64%	64%
		Management Capability	72%	76%	80%
		Number of Completed Projects	64%	64%	64%
		Financial Capability	90%	86%	86%
5	**Health, Safety & Environment (K3L)**	Safety Standards (K3L)	86%	86%	86%
		K3 Program	84%	84%	86%
		Waste Management	74%	74%	80%
6	**Organization**	Worker Qualifications	78%	76%	78%
		Commitment to Work	90%	88%	88%
		Company Management	78%	80%	80%
7	**Delivery**	Material & Equipment Delivery Method	78%	80%	80%
		Worker Placement Strategy	72%	70%	76%

Source: Primary Data Processed, 2024

Referring to Table 3, the sub-criterion Quality Standards representing the Quality criterion obtained the highest final score. Next in rank are the sub-criterion Tender Price from the Price criterion, Specification Quality from the Quality criterion, Material Specification from the Technical criterion, Quality Control Program from the Quality criterion, and Execution Method from the Technical criterion. All these sub-criteria have average scores ranging from 90% to 100%.

After the score calculations for the main criteria and sub-criteria were performed using the Dickenson method within the Delphi approach and followed by a Focus Group Discussion (FGD) involving 10 respondents, it was agreed that there are 7 main criteria and 23 sub-criteria to be used in the next stage of analysis. These criteria and sub-criteria will not undergo changes, either by reduction or addition. Therefore, the agreed-upon structure of criteria will serve as the foundation for further analysis in this study. The focus on this agreement is expected to provide consistency and objectivity in evaluation and decision-making. The analysis will proceed with the DEMATEL method to identify the relationships between criteria and sub-criteria in subcontractor selection for the highway project in the National Capital (IKN).

3.2 Analysis of DEMATEL Method

The next step in the DEMATEL method involves calculating the D (Dispatcher) and R (Receiver) values. Criteria that fall into the D group are categorized as those that have an impact (influence other criteria). Data regarding the Dispatcher and Receiver values are obtained from the processing of the Total-Influence Matrix. The value of each criterion must be calculated based on its row and column. The Total Influence Strength Index (D+R), which represents the sum of the influence given and received by a criterion or sub-criterion, as well as the Degree of Influence Trend (D-R), which indicates the tendency of each criterion or sub-criterion to influence or be influenced, need to be computed. If the value of (D-R) is positive, the criterion or sub-criterion tends to have more influence. If the value of (D-R) is negative, the criterion or sub-criterion tends to be more influenced by others. The (D+R) and (D-R) values can be seen in Table 4 below.

Tabel 4. The Result of DEMATEL Method Analysis

Criteria	Code	Sub-criteria	D	R	D+R	D-R
Price	C1	Tender Price	5.7149757	5.8059559	11.520932	-0.09098
	C2	Payment Method	4.9148304	5.0884912	10.003322	-0.17366
Quality	C3	Quality Standards	5.5667091	5.8770161	11.443725	-0.31031
	C4	Quality Control Program	5.4695467	5.7424419	11.211989	-0.2729
	C5	Specification Quality	5.7889261	6.0598596	11.848786	-0.27093
Technical	C6	Material Specification	5.7868615	5.876529	11.663391	-0.08967
	C7	Execution Method	6.3393537	6.1682289	12.507583	0.17112
	C8	Execution Timeframe	6.3890654	5.8054547	12.19452	0.58361
	C9	Equipment Type & Capacity	5.8381765	5.5444112	11.382588	0.29377
Internal	C10	Company/Branch Location	4.3976882	4.07004	8.467728	0.32765
	C11	Previous Project Performance	4.5157755	4.6935807	9.209356	-0.17781
	C12	Management Capability	5.4889064	5.1927624	10.681669	0.29614
	C13	Number of Projects Completed	4.5331941	4.3833493	8.916543	0.14984
	C14	Financial Capability	5.7874333	5.3203763	11.10781	0.46706
K3L	C15	Safety Standards (K3L)	5.1064498	5.3222569	10.428707	-0.21581
	C16	K3 Program	5.0769907	5.3800785	10.457069	-0.30309

	C17	Waste Management	4.7341035	4.80709	9.541194	-0.07299
Organization	C18	Worker Qualifications	5.6646381	5.509812	11.17445	0.15483
	C19	Commitment to Work	5.5555346	5.8669424	11.422477	-0.31141
	C20	Company Management	5.5187325	5.7750287	11.293761	-0.2563
Delivery	C21	Material & Equipment Delivery Method	5.2399181	5.2093579	10.449276	0.03056
	C22	Worker Placement Strategy	4.7801028	4.7088488	9.488952	0.07125

Source: Primary Data Processed, 2024

3.3 Analysis of ANP Method

Based on the results from data processing using the Analytic Network Process (AHP) with the Superdecision software, the priority weights for the main criteria in subcontractor selection for the Highway Project in the National Capital (IKN) were obtained, as shown in Table 5.

Table 5. The Result of ANP Method Analysis for Criteria

Criteria	Limiting	Weight
Delivery	0.125993	13%
Price	0.230277	23%
Internal	0.05942	6%
Health, Safety & Environment (K3L)	0.117144	12%
Quality	0.207555	21%
Organization	0.08186	8%
Technical	0.177749	18%

Sumber: Data diolah peneliti, 2024

Table 5 provides a clear overview of the priority results for the criteria in subcontractor selection for the Highway Project in the National Capital (IKN). Several criteria serve as the basis for determining the most suitable subcontractor, with the Price criterion having the highest weight at 23%, indicating that price is the most considered factor in the evaluation. This is followed by the Quality criterion, which receives a weight of 21%, highlighting its significant role in the assessment. Technical ranks third with a weight of 18%, signifying the importance of technical factors in the evaluation. Delivery (timing and speed of delivery) receives a weight of 13%, suggesting that while delivery is important, it is not as critical as the other criteria. The Health, Safety, and Environmental criterion holds a weight of 12%, reflecting that safety and environmental aspects remain a significant concern. Organization is assigned a weight of 8%, indicating the importance of organizational structure and efficiency, while the Internal criterion receives the lowest weight at 6%, suggesting that internal factors are considered less relevant compared to the other criteria in this context.

Table 6. The Result of ANPMethod Analysis for Sub-Criteria

Sub-criterion	Normalized by Cluster	Limiting	Sub-criterion Weight	Priority
Material & Equipment Delivery Method	0.58506	0.073714	7%	3
Worker Placement Strategy	0.41494	0.052279	5%	5
Tender Price	0.71182	0.163915	16%	1
Payment Method	0.28818	0.066362	7%	3
Number of Projects Completed	0.10118	0.006012	1%	8
Financial Capability	0.26102	0.01551	2%	7
Management Capability	0.24147	0.014348	1%	8
Previous Project Performance	0.3242	0.019264	2%	7
Company/Branch Location	0.07213	0.004286	0%	9
Waste Management	0.59475	0.069671	7%	3
K3 Program	0.19585	0.022943	2%	7
K3 Standard	0.2094	0.02453	2%	7
Specification Quality	0.32585	0.067631	7%	3
Quality Control Program	0.29569	0.061372	6%	4
Quality Standards	0.37846	0.078552	8%	2
Commitment to Work	0.34801	0.028488	3%	6
Worker Qualifications	0.37662	0.03083	3%	6
Company Management	0.27537	0.022542	2%	7
Execution Timeframe	0.26212	0.046592	5%	5
Equipment Type & Capacity	0.11595	0.02061	2%	7
Execution Method	0.28436	0.050545	5%	5
Material Specification	0.33757	0.060002	6%	4

Source: Primary Data Processed, 2024

Based on Table 6, the sub-criterion Tender Price ranks first with a priority weight of 16%, followed by Standard Quality with 8%. The third rank includes sub-criteria such as Material & Equipment Delivery Method, Equipment Type & Capacity, Payment Method, Specification Quality, and Waste Management, all with a priority weight of 7%. In the fourth rank, we have Quality Control Program and Material Specification, each with a weight of 6%. The fifth rank includes Worker Placement Strategy and Execution Timeframe, both with a weight of 5%. In the sixth rank, Commitment to Work and Worker Qualifications are both given a weight of 3%. The seventh rank includes K3 Program, K3 Standard, Financial Capability, and Equipment Type & Capacity, each with a weight of 2%. The eighth rank contains Number of Projects Completed and Management Capability, both

with a weight of 1%, and lastly, Company/Branch Location holds the ninth rank with a weight of 0%.

3.4 Discussion of The Result of Delphi Method

The results of the Delphi survey indicate that although Execution Timeframe is important in subcontractor selection, it is considered "influential" rather than "highly influential," despite PT XYZ facing delays. This is attributed to the higher priority given to Quality and Price. Quality received the highest score, 98% in the first and second rounds, rising to 100% in the third round, signaling that quality is the main factor in subcontractor selection. Price ranked second, with its score increasing from 92% in the first round to 96% in both the second and third rounds.

The perception of delays suggests that time-related issues are often influenced by overall project management rather than just subcontractor performance. Effective coordination between the main contractor and subcontractors can mitigate delays, indicating that time is not the sole determining factor for project success. Meanwhile, the Internal and Organization criteria saw a decrease in scores, suggesting that both are viewed as less essential compared to Quality and Price. The Delivery criterion, while important, also showed score fluctuations and was deemed less critical than Quality and Price in subcontractor selection. Overall, Quality and Price are more influential than Execution Timeframe in the subcontractor selection process.

3.5 Disscusion of The Result of DEMATEL Method

The analysis using the DEMATEL method reveals that the Execution Timeframe sub-criterion has the greatest influence on other sub-criteria, with the highest (D+R) and (D-R) values, 0.58361. This indicates that the execution timeframe plays a dominant role in affecting the success or failure of the decisions made. A longer timeframe allows for gradual improvement in work quality, which also leads to higher operational costs. Conversely, the Commitment to Work sub-criterion has a lower influence, with a (D-R) value of -0.31141, indicating that external factors play a larger role in determining commitment. A longer timeframe enhances commitment to the work, while a shorter timeframe may reduce commitment due to greater pressure.

In subcontractor selection for the highway project, the relationships between sub-criteria show that the Execution Timeframe directly affects work quality. Limited time tends to accelerate the work, sacrificing quality. Price also influences quality, where a lower price may risk reducing the quality standard. More experienced subcontractors are likely to demonstrate a higher commitment to the project, understanding the importance of completing the work according to specifications and within the allotted time. Additionally, good management within the subcontractor's organization affects Delivery capability, ensuring timely delivery that supports project smoothness. The interaction among these sub-criteria illustrates the complexity of decision-making, which requires thorough planning, effective time management, and proper risk management.

3.5 Discussion of The Result of ANP Method

The weighting results for criteria and sub-criteria in decision-making through the ANP method in this study indicate that Price is the most important criterion, with the highest priority weight of 23%, and the sub-criterion Tender Price at 16%. This finding aligns with Zainal Abedin et al. (2021), who identified Tender Price as a dominant factor in subcontractor selection. Quality ranks second with a weight of 21%, consistent with the research by Caesarani Gloria Putri and Dewi Nusraningrum (2022), who also emphasized the importance of quality in subcontractor selection, although in their study, price did not dominate as it did in this study.

The Technical criterion ranks third with a weight of 18%, indicating that although technical capabilities of subcontractors are not the primary factor, they still play a significant role in the selection decision, in line with the findings of Zainal Abedin et al. (2021) and Naghizadeh Vardin et al. (2021). Additionally, the Delivery criterion ranks fourth with a weight of 13%, which is consistent with the research by Prayogi and Suparno (2023), who emphasized the importance of managing material and equipment delivery in large projects to avoid delays. The Health, Safety, and Environment (K3) criterion receives a weight of 12%, with the sub-criterion Waste Management at 7%, aligning with the findings of Basaran et al. (2023), which highlighted the importance of compliance with OHS requirements. The Organization and Internal criteria each receive weights of 8% and 6%, respectively, indicating that while these factors are important, they do not dominate the decision-making process compared to other criteria such as quality, price, and technical aspects. This suggests that although Organization and Internal factors play a role, other criteria have a more substantial influence on the final subcontractor selection outcome.

3.6 The Comparisson of The Result and Project's Actual Condition

Based on the analysis, Price emerges as the primary criterion in subcontractor selection for the highway project in the National Capital (IKN). Price has a significant impact on budget efficiency and the smooth financing of the project, leading stakeholders to prefer subcontractors offering competitive prices without compromising on quality. This is particularly relevant given the logistical challenges and accessibility issues in IKN, which necessitate tight budget management. Keeping costs under control allows for optimal fund usage without diminishing the quality of work, which is crucial for the project's sustainability.

Quality ranks second with the highest score in the survey, indicating that while price is prioritized, the quality of work remains a critical factor. Good quality ensures that the project is durable and meets safety and comfort standards. In IKN, with its challenging geographical conditions, quality cannot be compromised, as poor quality could jeopardize the project's sustainability. The Technical criterion ranks third, as the technical skills of subcontractors are vital for overcoming project challenges and minimizing the risk of errors that could affect both cost and completion time. Delivery ranks fourth, related to the logistical challenges in IKN that require timely delivery of materials, equipment, and labor. Health, Safety, and Environment (K3L) ranks fifth, ensuring worker safety and minimizing environmental impact. Meanwhile, Internal and Organization criteria are ranked last, though still important for the smooth operation of the project. Overall, although price is the top priority, subcontractor selection must balance price, quality, technical skills, delivery, and K3L to ensure the success of the project.

4. CONCLUSION

This study aims to address three main research questions: first, to identify the relationships and influences among criteria in subcontractor selection to improve project quality and efficiency; second, to find the key criteria that need to be considered to reduce the risk of project delays; and third, to develop a more precise subcontractor selection framework for the Section 6B Highway Construction Project. Based on the results of a literature review validated through the Delphi method and the examination of relationships between criteria using the DEMATEL method, seven main criteria were identified: price, quality, technical, internal, health, safety, and environment (K3L), organization, and delivery. Technical criteria, such as execution method, execution timeframe, and equipment type and capacity, play a dominant role in determining project success, while price and quality are more influenced by external policies.

The prioritization in subcontractor selection for this project shows that price is the most important criterion, with a weight of 23%, followed by quality (21%), and technical (18%), while delivery, K3L, organization, and internal factors each received smaller weights. The careful subcontractor selection framework emphasizes the balance between price, quality, and technical capabilities, with particular attention to K3L aspects and delivery efficiency to ensure smooth project execution despite geographic and operational challenges. Recommendations for PT XYZ include adopting the Delphi-DEMATEL-ANP evaluation model, strengthening risk mitigation in evaluations, and developing a flexible information technology-based evaluation system. Furthermore, further research is recommended to explore innovation and sustainability aspects in subcontractor selection, as well as considering the application of alternative methods like PROMETHEE or TOPSIS to reduce subjectivity in decision-making

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