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Analyzing selection criteria weight of exhibition contractors using analytic network process

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Abstract

Selecting exhibition contractors based solely on the lowest price often results in low-quality services and products due to unreasonably low bids. To address this issue, the Most Advantageous Bid (MAB) method is proposed, emphasizing comprehensive evaluation criteria such as technical capabilities, management systems, cost efficiency, collaborative abilities, past performance, delivery guarantees, and quality control. Implementing the MAB method involves allocating weights to evaluation criteria and sub-criteria, which is a significant challenge. This study utilized the Analytic Network Process (ANP) and expert interviews to identify and analyze the weights of suitable evaluation criteria and sub-criteria, establishing a systematic evaluation framework. The study formulated five main evaluation criteria and sixteen sub-criteria. The top criteria are professional competence and service quality (32.16%), technological capability and innovative solutions (23.65%), customer service and support (17.67%), cost efficiency and price competitiveness (14.93%), and risk management and compliance (11.60%). This shift indicates a greater emphasis on quality and technological capabilities over mere price competitiveness. The results provide a comprehensive MAB evaluation model and offer guidelines for enhancing the accuracy and fairness of supplier evaluations. These findings can help businesses and government agencies develop tailored MAB evaluation models, improving the efficiency and effectiveness of supplier selection.

Keywords: Lowest Price Bidding; Most Advantageous Bid; Analytic Network Process

1. Introduction

Many procurement organizations often use the lowest bid that meets specification requirements as the criterion for selecting winning bids. However, this approach often results in excessively low bid prices, with winning contractors unable to provide services and products that meet the needs of the inviting party during contract fulfillment. To address this issue, the most advantageous bid method has emerged [1, 2, 3]. The most advantageous bid method comprehensively evaluates bidders based on multiple factors such as technical capabilities, product quality, functionality, commercial terms, and price, according to predefined evaluation criteria to select the supplier most suitable for the needs of the inviting party or most advantageous to them [3-6].

The key distinction between the most advantageous bid method and the lowest price bidding method lies in the establishment of an evaluation committee to systematically score each evaluation criterion. This ensures that the selected supplier can genuinely fulfill the needs of the inviting party [2,6,7]. Therefore, establishing a fair evaluation committee, selecting appropriate criteria and sub-criteria, and determining accurate criterion weights are crucial preparatory steps before implementing most advantageous bid procurement [3,4,7]. A lack of proper evaluation criteria and their weights during the implementation of most advantageous bid procurement may lead to misjudgments in evaluation outcomes.

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This study reviews existing supplier evaluation theory research [8-16] and, through expert interviews, identifies evaluation criteria and sub-criteria suitable for most advantageous bid. Using analytic network process, the study analyzes the relative importance among various evaluation criteria and sub-criteria [17-20]. Unlike the analytic hierarchy process, analytic network process allows for the consideration of interdependencies among elements within complex dynamic systems, thus better addressing the complexity of real-world decision-making problems [17].

The results of this study provide specific reference guidelines for organizations wishing to adopt most advantageous bid for supplier selection, aiming to enhance the accuracy and fairness of the evaluation process while effectively safeguarding the interests and needs of the inviting party.

2. Literature Review

2.1. Most Advantageous Bid

Since 1993, the U.S. federal government has implemented procurement reforms aimed at enhancing openness and competitiveness in procurement through "source selection" as a core procurement procedure. this process essentially embodies the concept of the most advantageous bid [5-7]. The term "most advantageous bid" originates from article 13 of the agreement on government procurement and is also stipulated in Taiwan's government procurement laws [1-3,5]. Most advantageous bid refers to the procurement organization conducting a comprehensive evaluation of suppliers based on multiple criteria to determine the bidder most advantageous to itself. Evaluation criteria not only include price but also factors such as supplier reputation, innovation capability, planning capability, technical specifications, commercial terms, and experience. therefore, the winning bidder can provide high-quality, high-functionality products or comprehensive services within a reasonable price range [4,6,7].

This procurement decision-making system allows procurers to obtain the best products or services within a predetermined budget while encouraging suppliers to enhance non-price competitiveness (e.g., after-sales service, technical support) to avoid vicious price competition [3,6,]. The most advantageous bid method emphasizes balancing different evaluation factors and appropriately setting their weights to determine which bidder can bring the maximum overall benefit to the procurer [1,2,6,7]. Compared to bid methods based solely on the lowest price, the most advantageous bid method better ensures the maximization of overall procurement benefits. When using the most advantageous bid method, various evaluation criteria are usually explicitly defined, and bidders are evaluated based on these criteria to make the most informed procurement decisions [6,7].

2.2. Supplier Selection

The Most Advantageous bid selection system aims to identify suppliers that can best meet procurers' needs through comprehensive consideration of multiple factors [4]. In addition to price and product quality, considerations include technical capabilities, delivery commitments, and after-sales services. while price remains an important consideration factor, most advantageous bid emphasizes selecting suppliers who can best meet additional requirements while ensuring product or service quality [5-7].

According to relevant literature [8-16], most advantageous bid evaluation criteria cover a broad scope, including supplier service capabilities, technological innovation, past performance records, legal compliance, and corporate social responsibility. These factors not only ensure fairness and transparency in the procurement process but also help procurers make comprehensive decisions.

This selection method based on multiple criteria helps avoid over-reliance on single factors (such as price) and maximizes the overall benefits of procurement outcomes. Therefore, the most advantageous bid selection system plays a crucial role in modern procurement management, providing a comprehensive and flexible framework for procurement activities in both public and private sectors [3, 5].

To determine appropriate evaluation criteria and sub-criteria, this study designed closed and open-ended questionnaires, evaluated by 7 experts based on their extensive experience and knowledge. Through cross-discussion among experts, evaluation criteria and sub-criteria were refined step by step until consensus was reached among all experts. The diversity of expertise and perspectives among experts ensures that the final evaluation criteria comprehensively cover all aspects, effectively supporting scientific and rational procurement decisions.

2.3. Analytic Network Process

Analytic Network Process is a multi-criteria decision-making method proposed by American operations research expert Thomas L. Saaty in 1996 [17,18], designed to address the complexity and interdependencies of elements in decision-making processes. Unlike traditional Analytic Hierarchy Process, analytic network process not only considers the hierarchical structure of decision elements but also incorporates their mutual influences and feedback effects, making it more suitable for complex decision-making scenarios in the real world [18-20].

The basic concepts and steps of analytic network process are as follows [17,18]:

- Constructing a decision network model: Determine the overall framework of the decision problem, including identifying decision goals, criteria, sub-criteria, and alternative solutions, and establish the corresponding network structure diagram.
- Establishing pairwise comparison matrices: Determine the relative importance between each pair of elements through pairwise comparisons and fill in the comparison matrices.
- Computing the supermatrix: Compile weight values from the comparison matrices to form a supermatrix reflecting the interrelationships among all decision elements.
- Solving for weight vectors: Normalize the supermatrix and iteratively calculate stable weight vectors.
- Integrative weight assessment: Based on the weight vectors, conduct comprehensive assessments of alternative solutions to determine the optimal solution.
- Analytic network process is widely applied in various fields such as business management, policy-making, technology selection, risk assessment, and resource allocation. Its primary advantage lies in its ability to comprehensively consider the interdependencies among decision elements, thereby effectively addressing decision problems in complex systems. The adoption of analytic network process helps enhances the scientific nature of decision-making processes and the rationality of decision outcomes, thus playing an important role in modern multi-criteria decision analysis.

3. Research Methodology

This study aims to develop a Most Advantageous Bid evaluation model for service suppliers. Initially, evaluation criteria and sub-criteria were drafted based on a literature review [8-16], and a hierarchical framework for the evaluation model was established using the Delphi Method. The framework consists of three levels: the first level being the objective layer, the second level comprising evaluation criteria such as professional competence and service quality, cost-effectiveness and price competitiveness, customer service and support, technical capabilities and innovative solutions, risk management and compliance, among others. The third level involves evaluation sub-criteria, totaling 16 indicators (see Table 1).

To better address the essence of decision-making problems, this study conducted a second-stage expert questionnaire to perform structural model interpretation analysis, aiming to structure the interdependencies and feedback among the criteria. subsequently, surveys and telephone interviews were conducted with executives from private enterprises and government agencies in Taiwan who had been responsible for most advantageous bid evaluations of service suppliers. a total of 22 questionnaires were collected, with 17 valid responses used to calculate the weights of each evaluation criterion and sub-criterion.

Table 1 Evaluation Criteria and Sub-criteria for Most Advantageous Bid Evaluation of Service Suppliers.

Criteria	Sub-Criteria
Professional Competence and Service Quality(A)	Industry Experience and Expertise: Whether the supplier possesses relevant industry experience and expertise. (A1)
	Qualification Certification and Licensing: Whether the supplier holds necessary qualification certifications and appropriate licenses. (A2)
	Service Quality Assurance: Whether the supplier can guarantee high-quality service. (A3)
	Effectiveness Assessment and Customer Feedback: How the supplier evaluates its service effectiveness and gathers customer feedback. (A4)

Cost-effectiveness and Price Competitiveness(B)	Reasonableness of Pricing: Whether the pricing offered by the supplier is reasonable and competitive. (B1)
	Cost-benefit Analysis: Whether the supplier can clearly analyze the cost-effectiveness of its offerings.(B2)
	Market Positioning and Value Proposition: The supplier's positioning in the market and its value propositions.(B3)
Customer Service and Support(C)	Response Speed and Efficiency: How promptly and efficiently the supplier responds to customer inquiries or requests. (C1)
	Post-Sales Service Level: The quality of service provided by the supplier after a transaction is completed. (C2)
	Customer Satisfaction and Long-term Relationships: The level of customer satisfaction with the supplier's service and the supplier's ability to establish long-term partnerships. (C3)
Technical Capability and Innovative Solutions(D)	Technological Advancement and Reliability: Whether the supplier's technological capabilities are advanced and reliable. (D1)
	Innovative Solutions: Whether the supplier can offer innovative solutions to meet customer needs. (D2)
	Research and Development Capability and Technical Support: The supplier's capabilities in research and development and the technical support it provides. (D3)
Risk Management and Compliance(E)	Risk Management Strategy: How the supplier manages and responds to potential risks. (E1)
	Legal Compliance: Whether the supplier adheres to relevant laws, regulations, and compliance standards. (E2)
	Environmental and Social Responsibility: The supplier's performance in environmental protection and social responsibility aspects. (E3)

4. Empirical Results

This study aims to identify and prioritize the key factors of travel website service quality using the ANP model for validation. Through Interpretive Structural Modeling (ISM) and expert interviews, critical dimensions and criteria were identified, and the ANP was utilized to calculate the priority of service quality dimensions and criteria. The steps are as follows:

4.1. Analytic network process calculation [17,18]

4.1.1. Step One: Construct Hierarchy and Dependency Model

- Establish the Structural Self-Interaction Matrix.
- Transform the Structural Self-Interaction Matrix to create the Initial Reachability Matrix, considering the transitive relationships between criteria, to form the Final Reachability Matrix (RM) that reveals the interdependencies and feedback relationships among criteria.

4.1.2. Step Two: Establish Pairwise Comparison Matrices and Calculate Eigenvalues and Eigenvectors

- Values in the pairwise comparison matrices are filled by decision-makers based on subjective judgments. Due to the complexity of the hierarchy and numerous factors, achieving consistency among decision-makers through multiple comparisons may be challenging. Saaty [17] recommends using the Consistency Index (C.I.) and Consistency Ratio (C.R.) to assess the consistency and reliability of the comparison matrices.
- **Consistency Index (C.I.)**: $C.I. = \frac{\lambda_{max} - n}{n-1}$, where λ_{max} is the maximum eigenvalue and n is the order of the matrix. C.I. = 0 indicates complete consistency, C.I. > 0.10 indicates inconsistency, and C.I. ≤ 0.10 is recommended as an acceptable level of consistency.
- **Consistency Ratio (C.R.)**: $C.R. = \frac{C.I.}{R.I.}$, where R.I. is the Random Index, varying with the order of the matrix. Saaty suggests that if C.R. ≤ 0.1, the pairwise comparisons in the matrix exhibit acceptable consistency.

- This study conducted evaluations in the pairwise comparison matrix of criteria for selecting service providers (Table 2) and in the relative weight comparison matrices among sub-criteria (Tables 3 to 7).

Table 2 Pairwise Comparison Matrix of Criteria for Selecting Service Providers

Criteria	**Professional Competence and Service Quality(A)**	**Cost-effectiveness and Price Competitiveness(B)**	**Customer Service and Support(C)**	**Technical Capability and Innovative Solutions(D)**	**Risk Management and Compliance(E)**	**Description**
Professional Competence and Service Quality(A)	1	2.5833	3.0333	1.0556	2.1944	λ_{max} =5.3622 C.I.= 0.0906 C.R.= 0.0809 n=5 R.I.=1.12
Cost-effectiveness and Price Competitiveness(B)	0.3871	1	0.4500	0.8349	2.0571	
Customer Service and Support(C)	0.3297	2.2223	1	1.0278	0.8167	
Technical Capability and Innovative Solutions(D)	0.9474	1.1977	0.9730	1	3.0889	
Risk Management and Compliance(E)	0.4557	0.4861	1.2245	0.3237	1	

Table 3 Pairwise Comparison Matrix of Professional Capability and Service Quality (A) Criteria

Sub-Criteria	**Industry Experience and Expertise(A1)**	**Qualification Certification and Licensing(A2)**	**Service Quality Assurance(A3)**	**Effectiveness Assessment and Customer Feedback(A4)**	**Description**
Industry Experience and Expertise(A1)	1	1.6389	1.5417	2.5000	λ_{max}=4.214 C.I.=0.0713 C.R.=0.0793 n=4 R.I.=0.9
Qualification Certification and Licensing(A2)	0.6102	1	0.5611	0.4266	
Service Quality Assurance(A3)	0.6486	1.7822	1	2.3333	
Effectiveness Assessment and Customer Feedback(A4)	0.4000	2.3442	0.4286	1	

Table 4 Pairwise Comparison Matrix of Cost Efficiency and Price Competitiveness (B) Criteria

Sub-Criteria	**Reasonableness of Pricing(B1)**	**Cost-benefit Analysis(B2)**	**Market Positioning and Value Proposition(B3)**	**Description**
Reasonableness of Pricing(B1)	1	1.1667	1.3056	λ_{max} =3.0969 C.I.=0.0485 C.R.=0.0835 n=3 R.I.=0.58
Cost-benefit Analysis(B2)	0.8572	1	2.8333	
Market Positioning and Value Proposition(B3)	0.7660	0.3529	1	

Table 5 Pairwise Comparison Matrix of Customer Service and Support (C) Criteria

Sub-Criteria	**Response Speed and Efficiency(C1)**	**Post-Sales Service Level(C2)**	**Customer Satisfaction and Long-term Relationships(C3)**	**Description**
Response Speed and Efficiency(C1)	1	2.1389	0.7500	λ_{max}=3.0211 C.I.=0.0105 C.R.=0.0182 n=3 R.I.=0.58
Post-Sales Service Level(C2)	0.4675	1	0.5418	
Customer Satisfaction and Long-term Relationships(C3)	1.3334	1.8456	1	

Table 6 Pairwise Comparison Matrix of Technical Capability and Innovative Solutions (D) Criteria

Sub-Criteria	**Technological Advancement and Reliability(D1)**	**Innovative Solutions(D2)**	**Research and Development Capability and Technical Support(D3)**	**Description**
Technological Advancement and Reliability(D1)	1	1.7685	1.7000	λ_{max} =3.0444 C.I.=0.0222 C.R.=0.0382 n=3 R.I.=0.58
Innovative Solutions(D2)	0.5654	1	1.8056	
Research and Development Capability and Technical Support(D3)	0.5882	0.5538	1	

Table 7 Pairwise Comparison Matrix of Risk Management and Compliance (E) Criteria

Sub-Criteria	Risk Management Strategy(E1)	Legal Compliance (E2)	Environmental and Social Responsibility(E3)	Description
Risk Management Strategy(E1)	1	0.8556	1.8611	λ_{max} =3.0019
Legal Compliance(E2)	1.1688	1	2.3576	C.I.=0.0009
Environmental and Social Responsibility(E3)	0.5373	0.4242	1	C.R.=0.0016 n=3 R.I.=0.58

4.1.3. Step Three: Constructing the Supermatrix and Calculating Criterion Weights

The analytic network process method involves three matrices in its calculation process: the unweighted supermatrix, the weighted supermatrix, and the limit supermatrix. Through the process of limit supermatrix convergence, integrated values are derived which represent the weights corresponding to each criterion. The weight table for dimensions and criteria in this study is presented in Table 8.

Table 8 Weight Table for Evaluation Criteria and Sub-criteria

Criterion	Criterion Weight	Rank	Sub-criterion	Sub-criterion Weight	Total Weight	Rank
Professional Competence and Service Quality	0.3216	1	Industry Experience and Expertise	0.3636	0.1169	1
			Qualification Certification and Licensing	0.1511	0.0486	12
			Service Quality Assurance	0.2908	0.0935	3
			Effectiveness Assessment and Customer Feedback	0.1945	0.0626	8
Cost-effectiveness and Price Competitiveness	0.1493	4	Reasonableness of Pricing	0.3661	0.0547	9
			Cost-benefit Analysis	0.4250	0.0634	7
			Market Positioning and Value Proposition	0.2089	0.0312	15
Customer Service and Support	0.1767	3	Response Speed and Efficiency	0.3711	0.0656	6
			Post-Sales Service Level	0.2013	0.0356	14
			Customer Satisfaction and Long-term Relationships	0.4275	0.0756	5
Technical Capability and Innovative Solutions	0.2365	2	Technological Advancement and Reliability	0.4580	0.1083	2
			Innovative Solutions	0.3214	0.0760	4
			Research and Development Capability and Technical Support	0.2206	0.0522	10
Risk Management and Compliance	0.1160	5	Risk Management Strategy	0.3671	0.0426	13
			Legal Compliance	0.4408	0.0511	11

			Environmental and Social Responsibility	0.1921	0.0223	16

4.2. Evaluation of Criterion and Sub-Criterion Weight Calculation Results

According to the results in Table 8, the importance of each evaluation criterion is as follows:

- **Professional Competence and Service Quality (32.16%)** is the most important criterion, emphasizing suppliers' capabilities in technical expertise and service quality.
- **Technological Capability and Innovative Solutions (23.65%)** closely follows, highlighting suppliers' technological advancement and innovation capabilities.
- **Customer Service and Support (17.67%)** places importance on suppliers' performance in post-sales service and customer support.
- **Cost Efficiency and Price Competitiveness (14.93%)** considers the impact of pricing relative to other criteria.
- **Risk Management and Compliance (11.60%)** emphasizes suppliers' capabilities in risk management and regulatory compliance.

These results indicate that the Most Advantageous Bid procurement system no longer relies solely on lowest price bidding but focuses on high-quality products and services, technological capabilities, problem-solving abilities, and quality post-sales support. This approach allows procurers to obtain the most value within predefined budgets.

Regarding sub-criteria, the top six sub-criteria (Industry Experience and Professional Knowledge, Technological Advancement and Reliability, Service Quality Assurance, Innovative Solutions, Customer Satisfaction and Long-term Relationships, Response Speed and Efficiency) together account for 53.59% of the total weight, demonstrating the importance of suppliers' industry experience, technological leadership, service reliability, innovation capability, customer relationships, and responsiveness. In contrast, the last three sub-criteria (Post-Sales Service Level, Market Positioning and Value Proposition, Environmental and Social Responsibility) collectively hold only 8.9% of the total weight, with Corporate Social Responsibility (Environmental and Social Responsibility) contributing 2.23%. Despite their lower importance, businesses should prioritize their role and responsibility in social welfare and environmental protection, aligning with the United Nations' and Taiwan government's initiatives on corporate social responsibility.

These results underscore the importance of the most advantageous bid method in modern procurement management, which comprehensively considers multiple factors to support scientific and rational procurement decisions.

5. Conclusion

Based on supplier selection theory, this study formulated evaluation criteria and sub-criteria for the most advantageous bid method through expert interviews. the derived 5 evaluation criteria and 16 sub-criteria provide crucial reference points for companies or government agencies engaged in most advantageous bid. analytic network process was employed in this research to determine the weights of most advantageous bid evaluation criteria and sub-criteria. the study results reveal that the weights of the evaluation criteria are as follows: professional competence and service quality (32.16%), technological capability and innovative solutions (23.65%), customer service and support (17.67%), cost efficiency and price competitiveness (14.93%), and risk management and compliance (11.60%). this indicates that the most advantageous bid procurement system has shifted from the past emphasis solely on lowest price bidding to now focusing on quality, emphasizing supplier technological capabilities, requiring problem-solving abilities, and providing high-quality services and warranties. Price is no longer the sole decision-making factor.

The top six sub-criteria account for a total weight of 53.59%, highlighting once again the importance of industry experience, technological leadership, service reliability, innovation capability, customer relationships, and responsiveness in the supplier selection process. In contrast, the total weight of the last three sub-criteria (Post-Sales Service Level, Market Positioning and Value Proposition, Environmental and Social Responsibility) is only 8.9%, with Corporate Social Responsibility contributing only 2.23%. Nevertheless, given the current emphasis by the United Nations and the Taiwan government on promoting corporate social responsibility initiatives, these criteria should not be overlooked in procurement evaluations. Therefore, businesses or government agencies can refer to the results of this study when formulating most advantageous bid evaluation criteria and sub-criteria, or utilize the methods proposed in this study to construct a most advantageous bid evaluation model that suits their specific needs. This approach can enhance the accuracy and efficiency of supplier selection.

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