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Research Article

# Critical success factors consistent with stakeholder engagement in construction equipment manufacturers (Case study in Tehran)

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## Abstract

In contemporary project management, stakeholders play a pivotal role in successful project implementation. Project outcomes are highly sensitive to stakeholder actions and decisions. Incorrect decisions, a lack of responsibility, and low-quality contributions from a wide range of stakeholders can significantly hinder project progress and lead to undesirable outcomes. Stakeholder theory identifies three key characteristics of stakeholders: power, legitimacy, and urgency. Notably, stakeholder satisfaction, particularly customer satisfaction, is widely recognized as a crucial indicator of organizational success and provides a significant competitive advantage. This research aims to identify and prioritize success factors associated with effective stakeholder engagement within the context of construction equipment manufacturers in Tehran. Utilizing factor analysis, the study will ultimately categorize these factors into a more concise framework. The research methodology encompasses a comprehensive literature review, in-depth face-to-face interviews, experimental research, and a thorough questionnaire survey. The Delphi technique is employed to screen sub-criteria, while the Analytical Network Process (ANP) and the DEMATEL method are utilized to determine the priority of sub-criteria and analyze the intricate interrelationships between criteria. Pairwise comparison matrices are utilized to ascertain the weight of each criterion. This research was conducted in a multi-phased approach, incorporating various research techniques. Findings indicate that the "project team" criterion exhibits the highest level of interaction with other studied criteria. Moreover, the "project team," "organization," and "external environment" criteria were identified as having the most significant impact. Based on the calculated results, the "organization," "external environment," and "sustainability" criteria were ranked first, second, and third in order of priority, with respective normal weights of 0.417, 0.264, and 0.181. Furthermore, the sub-criteria of "reaching the planned quality standard," "market availability," and "project size and complexity level" were ranked first, second, and third, with normal weights of 0.0525, 0.0454, and 0.044, respectively.

**Keywords:**
Success factors;
Stakeholder engagement;
Construction equipment manufacturers;
Delphi technique.

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## 1. Introduction

Iran's construction industry has a weak history of utilizing effective stakeholder engagement due to the complexity and uncertainty that characterized the past decade (Fathalizadeh et al., 2021). Many stakeholder engagement challenges arise from factors such as inappropriate stakeholder involvement, unclear project manager goals regarding stakeholder engagement, difficulty in identifying hidden stakeholders, and inadequate communication with stakeholders (Dansoh et al., 2020). To address these challenges, research teams must identify the critical elements for successful stakeholder engagement. In this context, it is crucial to determine the relative importance and classification of factors that significantly impact stakeholder engagement in the country's construction projects. To achieve this, success factors were presented to senior managers of construction projects in Tehran. Initially, these managers were invited to express their initial thoughts and ideas regarding the items listed in the questionnaire. Subsequently, they were asked to complete the questionnaire. The findings demonstrate that these senior managers possess a strong understanding of most project stakeholder management concepts. The interpretation of the obtained data accurately reflects the respondents' understanding and interpretation of the questionnaire items. Furthermore, the collected data accurately reflects the knowledge and skills of senior project managers regarding stakeholder engagement within their respective roles.

Based on these findings, the primary objective of this research is to identify success factors associated with effective stakeholder engagement in infrastructure projects within the country, utilizing factor analysis to ultimately categorize these factors into a more concise framework. The factors influencing the success of stakeholder engagement in construction equipment manufacturers were initially identified through a comprehensive literature review. Top-tier academic journals, including Elsevier, Taylor & Francis, ASCE, and Springer, as well as four major search engines, were systematically searched using keywords such as "stakeholders," "project partners," and "project environment." These publications were thoroughly reviewed to draw conclusions regarding the success factors of stakeholder engagement within the context of construction equipment manufacturers. Based on this comprehensive literature review, factors influencing the success of stakeholder engagement were proposed and subsequently hypothesized.

Table 1 presents the criteria, sub-criteria, and indices considered in this research.

Table 1
Success factors criteria and sub-criteria

| criterion | Sub-criterion | References |
|---|---|---|
| Project and project planning | Considering realistic goals | Mavi & Standing(2018); Mashwama et al. (2017); Inayat et al. (2015); Cserhati and Szabo (2014); Frinsdorf et al. (2014); Ihuah et al. (2014); Santos et al. (2014); Lester (2014); Ismail et al. (2014);Gudienė et al. (2013); Pandremmenou et al. (2013); The Standish Group (2010); Fortune and White (2006); Yu et al. (2006) |
| | Project size and complexity level | Mavi & Standing(2018); Inayat et al. (2015); Frinsdorf et al. (2014); Fortune and White (2006); Swink et al. (2006) |
| | Agile project processes | Mavi & Standing(2018); Yu and Kwon (2011); The Standish Group (2010) |
| | Change of minimum range | Mavi & Standing(2018); Joslin and Müller (2015); Frinsdorf et al. (2014); Lester (2014) |
| | Project level with company strategy | Mavi & Standing(2018); Mashwama et al. (2017); Joslin and Müller (2015); Pandremmenou et al. (2013) |
| | urgency | Mavi & Standing(2018); Santos et al. (2014); Pandremmenou et al. (2013) |
| | Labor cost effectiveness and cash flow planning | Mavi & Standing(2018); Mashwama et al. (2017); Das et al. (2017); Joslin and Müller (2015); Frinsdorf et al. (2014); Ribeiro et al. (2013); Le-Hoai et al., (2008); Sambasivan & Soon, (2007); Long et al., (2004); Frimpong et al. (2003) |
| | Achieving the planned quality standard | Mavi & Standing (2018); Das et al. (2017); Joslin and Müller (2015); Frinsdorf et al. (2014); Lester (2014); Ismail et al. (2014); Ribeiro et al. (2013); Aksorn & Hadikusumo (2008) |
| | Design complexity | Das et al. (2017); Alwaer and Clements-Croome (2010); Aksorn & Hadikusumo (2008); Jha and Iyer (2006); Abudayyeh et al. (2006); Zhang (2005); Chan et al. (2001) |
| Project team | Competent and effective project management | Mavi & Standing(2018); Mashwama et al. (2017); Inayat et al. (2015); Cserhati and Szabo (2014); Frinsdorf et al. (2014); Alias et al. (2014); Mir and Pinnington (2014); Ihuah et al. (2014); Santos et al. (2014); Lester (2014); Gudienė et al. (2013); Pandremmenou et al. (2013); Fortune and White (2006); Kendra and Taplin (2004) |
| | Risk management and project responsibility | Mavi & Standing(2018); Inayat et al. (2015); Frinsdorf et al. (2014); Ihuah et al. (2014); Fortune and White (2006); Chan et al. (2002); Amani and Safarzadeh (2022) |
| | Teamwork development | Mashwama et al. (2017) |
| | Team development and establishment of skilled personnel | Mashwama et al. (2017) |
| | planning and good planning methods | Mavi & Standing(2018); Das et al. (2017); Joslin and Müller (2015); Todorovic et al. (2015); Frinsdorf et al. (2014); Ihuah et al. (2014); Santos et al. (2014); Lester (2014); Ismail et al. (2014); Ribeiro et al. (2013); Pandremmenou et al. (2013); Yu and Kwon (2011); Yung & Yip |

| criterion | Sub-criterion | References |
|---|---|---|
| | | (2010); Sambasivan & Soon, (2007); Fortune and White (2006); Yu et al. (2006); Long et al. (2004) |
| | A motivated and integrated team | Mavi & Standing(2018); Joslin and Müller (2015); Frinsdorf et al. (2014); Alias et al. (2014); Lester (2014); Ismail et al.(2014); Swink et al. (2006) |
| | Training, development, and awareness-raising of human resources | Mashwama et al. (2017) |
| | Fulfilling the project team obligations | Mavi & Standing(2018); Mashwama et al. (2017); Das et al. (2017); Cserhati and Szabo (2014); Alias et al. (2014); Pandremmenou et al. (2013); Yu et al. (2006) |
| | Effective consultation with main stakeholders and stakeholder trust | Mavi & Standing(2018); Joslin and Müller (2015); Frinsdorf et al. (2014); Ihuah et al. (2014); Santos et al. (2014); Ismail et al. (2014) |
| | Project life cycle management processes | Mavi & Standing(2018); Frinsdorf et al. (2014); Mir and Pinnington (2014) |
| | Sufficient experience in project execution | Das et al. (2017); Gudienė et al. (2013); Sambasivan & Sam (2007); Koushki et al. (2005); Long et al. (2004); |
| | Information sharing and collaboration between project participants | Das et al. (2017); Aksorn & Hadikusumo (2008); Sambasivan & Soon (2007); Jha and Iyer (2006); Long et al. (2004) |
| organization | Organizational structure of the project | Mavi & Standing(2018); Mashwama et al. (2017); Cserhati and Szabo (2014); Yu and Kwon (2011); Fortune and White (2006); Kendra and Taplin (2004) |
| | Availability of sufficient resources (finances, labor, factories, materials) | Mavi & Standing(2018); Mashwama et al. (2017); Frinsdorf et al. (2014); Mir and Pinnington (2014); Ihuah et al. (2014); Lester (2014); Ismail et al. (2014); Ribeiro et al. (2013); Pandremmenou et al. (2013); Le-Hoai et al. (2008); Fortune and White (2006); Long et al. (2004); Sambasivan & Soon, (2007) |
| | Proper management, organization, support and advocacy | Mavi & Standing(2018); Mashwama et al. (2017); Alias et al. (2014); Ihuah et al. (2014); Santos et al. (2014); Lester (2014); Pandremmenou et al. (2013); The Standish Group (2010); Fortune and White (2006); Swink et al. (2006) |
| | Continuous performance measurement | Mavi & Standing(2018); Alias et al. (2014); Lester (2014); Ismail et al. (2014); Fortune and White (2006); Kendra and Taplin (2004). |
| | Maintaining skills over time (staff maintenance) | Mavi & Standing(2018); Frinsdorf et al. (2014); Gudienė et al. (2013); Pandremmenou et al. (2013). |
| | Good relationship with stakeholders | Mavi & Standing(2018); Todorovic et al. (2015); Frinsdorf et al. (2014); Alias et al. (2014); Lester (2014); Pandremmenou et al. (2013); Yu and Kwon (2011). |
| | exact technical understanding/project capability | Mavi & Standing(2018); Frinsdorf et al. (2014); Ismail et al. (2014); Ribeiro et al. (2013); Fortune and White (2006). |
| | use of lessons learned from previous projects and applied to future projects | Mavi & Standing(2018); Joslin and Müller (2015); Todorovic et al. (2015); Cserhati and Szabo (2014); Frinsdorf et al. (2014); Fortune and White (2006) |
| | Organizational maturity level | Mavi & Standing(2018); Frinsdorf et al. (2014); The Standish Group (2010) |
| | Induction of appropriate technology | Das et al. (2017); Mashwama et al. (2017) |
| | Accurate time control system and quality feedback | Mavi & Standing(2018); Mashwama et al. (2017); Das et al. (2017); Inayat et al. (2015); Frinsdorf et al. (2014); Ihuah et al. (2014); Santos et al. (2014); Lester (2014); Pandremmenou et al. (2013); Le-Hoai, Lee, and Lee (2008); Sambasivan & Soon, (2007); Fortune and White (2006); Long, Ogunlana, Quang, and Lam (2004); Frimpong et al. (2003) |
| External environment | Restrictions imposed on the end user | Mavi & Standing(2018); Joslin and Müller (2015); Cserhati and zabo (2014); Frinsdorf et al. (2014); Khan and Rasheed (2015); Ribeiro et al. (2013); Pandremmenou et al. (2013); Fortune and White (2006); Chan et al. (2002). |
| | Policy stability | Mavi & Standing(2018); Das et al. (2017); Santos et al. (2014); Lester (2014); Gudienė et al. (2013); Pandremmenou et al. (2013); Fortune and White (2006); Chan et al. (2002) |
| | Knowledge of environmental issues and related rules | Mavi & Standing(2018); Joslin and Müller (2015); Santos et al. (2014); Lester (2014); Pandremmenou et al. (2013); Yu and Kwon (2011); Fortune and White (2006) |
| | Access to national information | Mavi & Standing(2018); Joslin and Müller (2015); Cserhati and Szabo (2014) |
| | Stakeholder expectations | Mavi & Standing(2018); Joslin and Müller (2015); Cserhati and Szabo (2014); Ihuah et al. (2014); Ismail et al. (2014); Ribeiro et al. (2013); Pandremmenou et al. (2013). |
| | Stability of financial and economic conditions at the macro level | Mavi & Standing(2018); Das et al. (2017); Cserhati and Szabo (2014); Lester (2014); Gudienė et al. (2013); Ameh et al. (2010); Le-Hoai et al. (2008); Fortune and White (2006); Kendra and Taplin (2004); Frimpong et al. (2003); Chan et al. (2002) |
| | Market availability | Mavi & Standing(2018); Pandremmenou et al. (2013) |
| | Issuance of construction permit | Gudienė et al. (2013); |

| criterion | Sub-criterion | References |
|---|---|---|
| | Level of risk and profitability | Gudienė et al. (2013); Amani and Safarzadeh (2022) |
| sustainability | energy consumption | Amani (2024); Amani et al., (2021); Mavi & Standing(2018); Heravi et al. (2015); S anchez (2015); Yilmaz and Bakis (2015); Zhong and Wu (2015); Wang et al. (2015); O'Brien and Sarkis (2014); Tsai and Chang (2012); Fern andez-S anchez and Rodríguez-L opez (2010). |
| | Water protection | Mavi & Standing(2018); Heravi et al. (2015); S anchez (2015); Yilmaz and Bakis (2015); Wang et al. (2015); Zhong and Wu (2015); O'Brien and Sarkis (2014); Fern andez-S anchez and Rodríguez-L opez (2010) |
| | Recycling and waste management | Mavi & Standing(2018); Heravi et al. (2015); Zhong and Wu (2015); O'Brien and Sarkis (2014); Tsai and Chang (2012); Fern andez-S anchez and Rodríguez-L opez (2010) |
| | Recycling / reuse of materials | Mavi & Standing(2018); Heravi et al. (2015); Yilmaz and Bakis (2015); Zhong and Wu (2015); Tsai and Chang (2012); Fern andez-S anchez and Rodríguez-L opez (2010) |
| | Construction cost | Mavi & Standing(2018); Das et al. (2017); Heravi et al. (2015); S anchez (2015); Zhong and Wu (2015); Fernandez-Sanchez & Rodríguez- Lopez (2010); Aksorn & Hadikusumo (2008); Koushki et al. (2005); Frimpong et al. (2003) |
| | Public comfort and health and safety | Mavi & Standing (2018); Das et al. (2017); Mashwama et al. (2017); Heravi et al. (2015); Wang et al. (2015); Fern andez-S anchez and Rodríguez-L opez (2010);Le-Hoai, Lee, and Lee (2008); Sambasivan & Soon, (2007); Long, Ogunlana, Quang, and Lam (2004); Frimpong et al. (2003) |
| | User security | Mavi & Standing(2018); Heravi et al. (2015); Fern andez-S anchez and Rodríguez-L opez (2010) |
| | General tool | Mavi & Standing(2018); Heravi et al. (2015); Wang et al. (2015); Fern andez-S anchez and Rodríguez-L opez (2010) |
| | Noise pollution during construction | Mavi & Standing(2018); Heravi et al. (2015); Zhong and Wu (2015); Fern andez-S anchez and Rodríguez-L opez (2010) |
| | Environmental Protection | Das et al. (2017); Gudienė et al. (2013); Le-Hoai, Lee, and Lee (2008); Sambasivan & Soon, (2007); Long, Ogunlana, Quang, and Lam (2004); Frimpong et al. (2003) |

## 2. Methodology

The methodology of this research will be based on a comprehensive review of previous articles and research, complemented by a series of face-to-face interviews, experimental research, and questionnaire-based research (Amani, 2022). To ensure validity, success factors identified through the literature review (as presented in Table 1) will be validated by a panel of experts prior to questionnaire development. Initial success factors will be presented to a group of experienced professionals during face-to-face interviews. These specialists, selected based on their expertise in stakeholder engagement within the Iranian construction equipment manufacturing sector, possess over 10 years of experience and hold diverse roles and positions within relevant projects. Interviews will be conducted at the interviewees' offices, with an estimated duration of 1 to 2 hours, depending on the available time and the depth of information provided. Given the utilization of industrial engineering and operations research approaches, the study population comprises experts and senior experts in the relevant field. In this study, the Network Analysis Process technique is employed to prioritize the identified criteria. Saati (2002) suggests that a sample size of ten experts is sufficient for studies utilizing pairwise comparisons. Similarly, Riza and Vasilis (1988) propose a sample size of 5 to 15 experts, emphasizing that the number of interviewees should be kept within a manageable range. Given the importance of expert opinions and discussions, the questionnaire was distributed to ten experts and specialists in the Iranian construction equipment manufacturing sector. Prior to questionnaire distribution, a pilot study was conducted. Two project managers, one representing clients and the other a contractor, were selected to answer the questionnaire. The primary objective of this pilot study was to preliminarily evaluate the questionnaire's completeness and clarity, ensuring the absence of any inconsistencies. The final questionnaire, mirroring the structure of the pilot version, incorporates the identified improvements. The questionnaire comprises four sections: 1) respondent background information, 2) opinions and reactions regarding stakeholder management, 3) key issues related to stakeholder engagement, and 4) statements about the questionnaire itself. The target population for this study consists of project managers from various organizations within the Tehran construction industry. A total of 100 to 300 questionnaires will be electronically distributed via email to potential respondents.Respondents were instructed to rate their degree of agreement with each identified success factor on a five-point Likert scale (1 = Strongly Disagree to 5 = Strongly Agree), providing a specific example from a relevant project they had been involved in. After a five-week period, the completed questionnaires were returned via email or fax.

The collected raw data was subsequently entered into SPSS for analysis. To assess the internal consistency of the research variables, Cronbach's alpha was employed. A Cronbach's alpha value exceeding 0.7 was considered acceptable. The final section of the methodology outlines the data analysis approach. Multi-criteria decision-making (MCDM) techniques, including the Delphi process, network analysis (specifically the Analytic Hierarchy Process – AHP), and the DEMATEL technique, were selected as the most suitable data analysis methods for this research (Saaty, 1980; Saaty, 2002).

## 3. Data Analysis

In this research, the Delphi technique was employed to screen sub-criteria. Subsequently, the Analytical Network Process (ANP) and the DEMATEL method were utilized to determine and prioritize sub-criteria, as well as to measure the internal relationships between criteria (Powell, 2003). Pairwise comparison matrices were utilized to determine the weight of each criterion. This research was conducted in several stages, employing a range of methodologies. To facilitate the calculations associated with the Delphi technique, the ANP technique was implemented using the Super Decision software.

### *3.2. Delphi technique of sub-criteria*

The Delphi technique was employed to screen the sub-criteria. A panel of ten experts, selected for their in-depth knowledge of the subject matter, evaluated each sub-criterion. An initial screening process involved assigning scores between 1 and 10 to each sub-criterion. Sub-criteria with scores below 7 were eliminated. Expert analysis revealed that most of the removed sub-criteria exhibited semantic overlap with other sub-criteria. The Delphi process proceeded through two rounds, concluding when a consensus among experts was achieved. To assess the consistency of expert opinions, the Kendall Delphi agreement coefficient was calculated for each sub-criterion (Table 2).

Table 2
Kendall Delphi agreement coefficient of sub-criteria

| | The number of subcriteria | Number of experts | Degrees of freedom | Kendall coefficient | A significant amount |
|---|---|---|---|---|---|
| Round 1 | 51 | 10 | 50 | 0/315 | 0/000 |
| Round 2 | 44 | 10 | 43 | 0/321 | 0/000 |

### *3.1. Designing the Analytical Network Process (ANP) model*

According to the objective of the research, first, based on the identified criteria and sub-criteria, a suitable model of network analysis has been designed in the Super Decision software. Based on this model, the diagram of the Analytical Network Process (ANP) will be in the form of Figure 1.

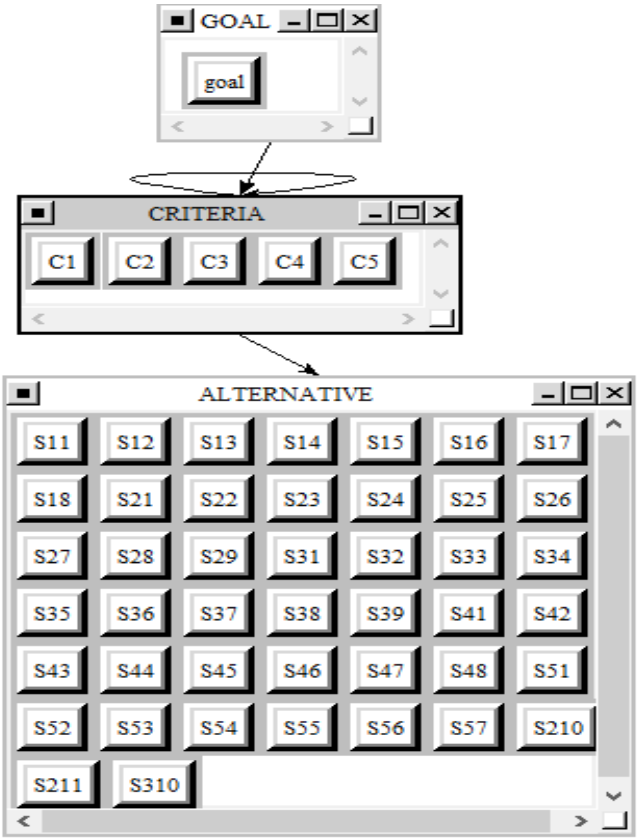


Fig. 1. ANP diagram of sub-criteria priority in Super decision software

Table 3
Symbols used in sub-criteria

| criterion | Criterion symbol | Sub-criterion | Sub-criterion symbol |
|---|---|---|---|
| Project and project planning | C1 | Considering the realistic goals | S11 |
| | | Project size and level of complexity | S12 |
| | | Agile project processes | S13 |
| | | Achieving the planned quality standard | S14 |
| | | Project level with the company's strategy | S15 |
| | | Urgency | S16 |
| | | Labor cost effectiveness and cash flow planning | S17 |
| | | Change the minimum range | S18 |
| Project team | C2 | Competent and effective project management | S21 |
| | | Risk management and project responsibility | S22 |
| | | Teamwork development | S23 |
| | | Team development and establishment of skilled personnel | S24 |
| | | planning and good planning methods | S25 |
| | | Training, development, and awareness-raising of human resources | S26 |
| | | Fulfilling the project team obligations | S27 |
| | | Effective consultation with main stakeholders and stakeholder trust | S28 |
| | | Project life cycle management processes | S29 |
| | | enough experience in project implementation | S210 |
| | | Information sharing and collaboration between project participants | S211 |
| organization | C3 | Organizational structure of the project | S31 |
| | | Availability of sufficient resources (finances, labor, factories, materials) | S32 |
| | | Proper management, organization, support and advocacy | S33 |
| | | Continuous performance measurement | S34 |
| | | Maintaining skills over time (staff maintenance) | S35 |
| | | Good relationship with stakeholders | S36 |
| | | exact technical understanding/project capability | S37 |
| | | use of lessons learned from previous projects and applied to future projects | S38 |
| | | Organizational maturity level | S39 |
| | | Induction of appropriate technology | S310 |
| External environment | C4 | Restrictions applied to the end user | S41 |
| | | Knowledge of environmental issues and related rules | S42 |
| | | Achieving national specifications | S43 |
| | | Stakeholder expectations | S44 |
| | | Stability of financial and economic conditions at the macro level | S45 |
| | | Market availability | S46 |
| | | Issuance of construction permit | S47 |
| | | Level of risk and profitability | S48 |
| sustainability | C5 | energy consumption | S51 |
| | | Recycling and waste management | S52 |
| | | Construction cost | S53 |
| | | Public comfort and health and safety | S54 |
| | | Users' security | S55 |
| | | Noise pollution during construction | S56 |
| | | Environmental Protection | S57 |

### *3.3. Identification and comparison of the main criteria*

In the first step, the main decision-making criteria should be identified. For this purpose, research literature and specialized interviews or things like brainstorming techniques and nominal groups are used. Then, the set of identified criteria is selected using the screened Delphi technique and the final criteria. After selecting the main criteria based on the main objective of the research, the criteria are compared in pairs and the priority is determined by calculating the eigenvector. The calculations performed are presented in Table 4 and the eigenvector is also shown in Figure 2.

Table 4
Determining the priority of the main criteria based on the purpose

| | Project And Project Planning | Project Team | Organization | External Environment | Sustainability | Geometric Mean | Eigenvector | Ranking |
|---|---|---|---|---|---|---|---|---|
| Project and project planning | 1 | 0.709 | 0.264 | 0.221 | 0.326 | 0.422 | 0.066 | 5 |
| Project team | 1.410 | 1 | 0.234 | 0.256 | 0.228 | 0.454 | 0.071 | 4 |
| organization | 3.794 | 4.274 | 1 | 3.538 | 2.346 | 2.665 | 0.417 | 1 |
| external environment | 4.529 | 3.901 | 0.283 | 1 | 2.748 | 1.688 | 0.264 | 2 |
| sustainability | 3.067 | 4.382 | 0.426 | 0.364 | 1 | 1.158 | 0.181 | 3 |

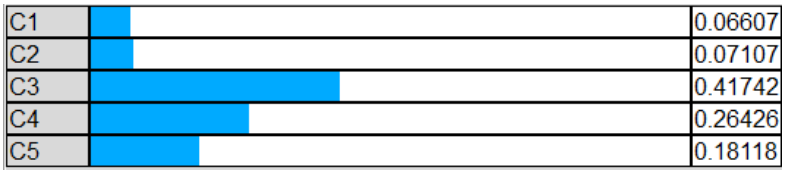


Fig. 2. The output of the Super Decision software based on the purpose

Based on the eigenvector obtained:
The "Organization" criterion with a normalized weight of 0.417 is the first priority.
The "external environment" criterion with a normalized weight of 0.264 is the second priority.
The "sustainability" criterion with a normalized weight of 0.181 is the third priority.
The "project team" criterion with a normalized weight of 0.071 is the fourth priority.
The "project and project planning" criterion with a normalized weight of 0.066 is the last priority.

Pairwise comparison of sub-criteria: In the next step, the sub-criteria of the study are compared in pairs. In this step, pairwise comparisons have been made in five steps (number of criteria). In each step, sub-criteria related to each main criterion has been compared in pairs. The performed calculations to determine the priority of project sub-criteria and project planning; project team; Organization; The external environment and sustainability are shown in Figure 3 (a, b, c, d, e).

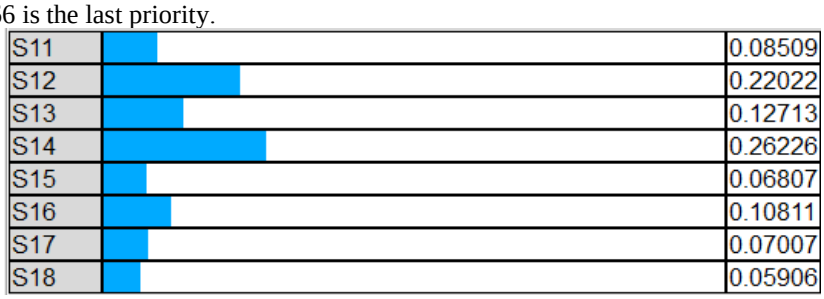


Fig. 3(a). Output of Super Decision software of project and project planning


Fig. 3(b). Output of Super Decision software project team criteria

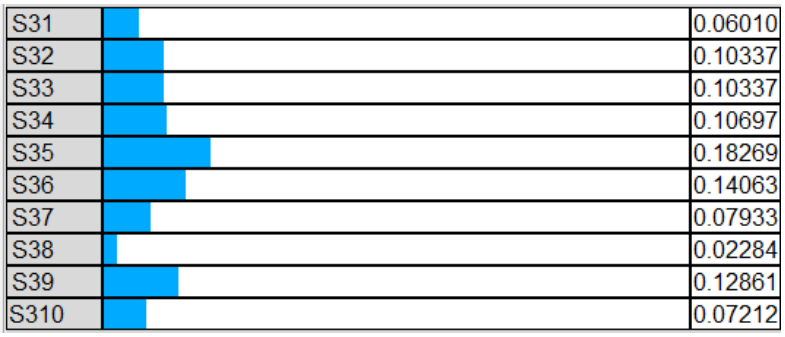


Fig. 3(c). The output of the Super Decision software of the "organization" criterion

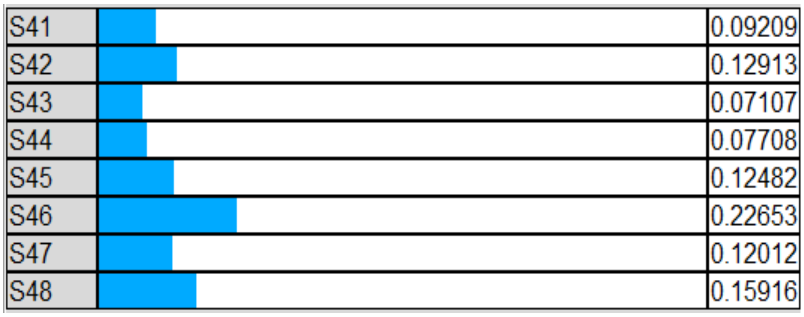


Fig. 3(d). Output of Super Decision software of the external environment criterion

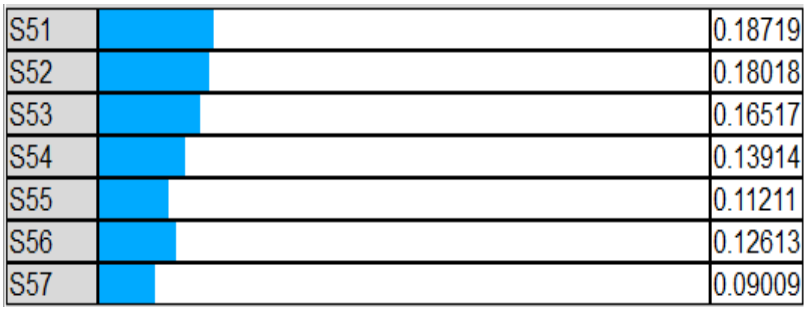


Fig. 3(e). Output of the Super Decision software for sustainability criteria

## 4. Result and Discussion

### *4.1. The pattern of relationships between the main criteria with the DEMATEL technique*

With the pre-assumption of internal relationships between the main criteria of the research and to reflect the cross relationships between the criteria, the DEMATEL technique has been used. So that experts are able to express their opinions regarding the effects (direction and intensity of effects) between factors with more mastery. It is necessary to mention that the matrix obtained from the DEMATEL technique (internal relationships matrix) shows both the cause-and-effect relationship between the factors and the effectiveness of the variables. In this study, the threshold intensity is equal to 1.440. The pattern of significant relationships is shown in Table 5 and Figure 4:

Table 5
The pattern of significant relationships of the main criteria

| | C1 | C2 | C3 | C4 | C5 |
|---|---|---|---|---|---|
| C1 | * | 1.719 | 1.622 | 1.611 | * |
| C2 | * | * | 1.550 | 1.567 | * |
| C3 | 1.463 | 1.690 | * | 1.671 | * |
| C4 | * | 1.618 | 1.509 | * | * |
| C5 | * | 1.548 | * | 1.533 | * |

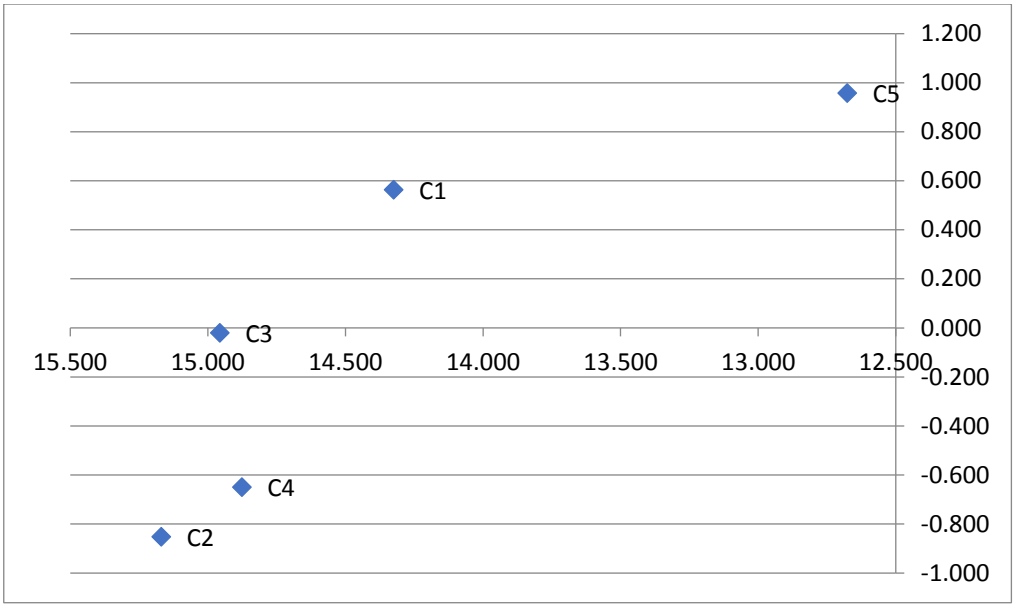


Fig. 4. Cartesian coordinate diagram of the output of DEMATEL method for criteria

Table 6

The pattern of causal relationships based on the main criteria

| Criterion | Criterion symbol | D | R | D+R | D-R |
|---|---|---|---|---|---|
| Project and project planning | C1 | 7.444 | 6.881 | 14.325 | 0.563 |
| Project team | C2 | 7.159 | 8.011 | 15.170 | -0.852 |
| Organization | C3 | 7.468 | 7.488 | 14.956 | -0.020 |
| External environment | C4 | 7.114 | 7.763 | 14.876 | -0.649 |
| sustainability | C5 | 6.818 | 5.859 | 12.677 | 0.958 |

In Table 6, the sum of the elements of each row (D) indicates the degree of influence of that criterion on other criteria of the model. Therefore, the criterion of the organization is the most effective. The sum of column elements (R) for each factor indicates the influence of that factor on other factors of the system. Therefore, the criterion of the project team is the most effective. The horizontal vector (D + R) is the degree of influence of the desired factor in the system. In other words, the higher the (D + R) value of a factor, the more interaction that factor has with other factors of the system. Therefore, the project team criterion has the most interaction with other studied criteria. The vertical vector (D - R) shows the power of the influence of each factor. In general, if (D – R) is positive, the variable is considered a causal variable, and if it is negative, it is considered an effect. In this model, the criteria of the project team, the organization, and the external environment are the effect.

### *4.2. The final priority of sub-criteria of the model with the ANP technique*

In order to determine the final priority of the model's criteria with the ANP technique, the initial (unweighted) supermatrix, the weighted supermatrix, and finally the limit supermatrix must be calculated. Each of the elements of this diagram has been calculated in different stages of the paired comparison and DEMATEL technique. Therefore, the structure of the unweighted supermatrix can be seen by entering these data in the final structure of the model designed with Super Decision software. Based on the calculations and the limit supermatrix, and the output of the Super Decision software, it is possible to determine the final priority of the sub-criteria. The final priority of the sub-criteria by adapting the limit supermatrix is shown in Table 7 and Figure 5.

Table 7

The final priority of the sub-criteria

| Sub-criterion | Sub-criterion symbol | Normal weight | rank |
|---|---|---|---|
| Considering realistic goals | S11 | 0.017 | 30 |
| Project size and complexity level | S12 | 0.044 | 3 |
| Agile project processes | S13 | 0.0254 | 15 |
| Achieving the planned quality standard | S14 | 0.0525 | 1 |
| Project level with company strategy | S15 | 0.0136 | 37 |

| Sub-criterion | Sub-criterion symbol | Normal weight | rank |
|---|---|---|---|
| Urgency | S16 | 0.0216 | 23 |
| Labor cost effectiveness and cash flow planning | S17 | 0.014 | 36 |
| Change of minimum range | S18 | 0.0118 | 40 |
| Competent and effective project management | S21 | 0.019 | 27 |
| Risk management and project responsibility | S22 | 0.0184 | 29 |
| Teamwork development | S23 | 0.0234 | 22 |
| Team development and establishment of skilled personnel | S24 | 0.0242 | 19 |
| planning and good planning methods | S25 | 0.0246 | 18 |
| Training, development, and awareness-raising of human resources | S26 | 0.0251 | 16 |
| Fulfilling the project team obligations | S27 | 0.0152 | 34 |
| Effective consultation with main stakeholders and stakeholder trust | S28 | 0.0158 | 32 |
| Project life cycle management processes | S29 | 0.0116 | 42 |
| Sufficient experience in project execution | S210 | 0.0116 | 41 |
| Information sharing and collaboration between project participants | S211 | 0.011 | 43 |
| Organizational structure of the project | S31 | 0.0121 | 39 |
| Availability of sufficient resources (finances, labor, factories, materials) | S32 | 0.0208 | 25 |
| Proper management, organization, support and advocacy | S33 | 0.0208 | 26 |
| Continuous performance measurement | S34 | 0.0215 | 24 |
| Maintaining skills over time (staff maintenance) | S35 | 0.0367 | 5 |
| Good relationship with stakeholders | S36 | 0.0283 | 7 |
| exact technical understanding/project capability | S37 | 0.016 | 31 |
| use of lessons learned from previous projects and applied to future projects | S38 | 0.0046 | 44 |
| Organizational maturity level | S39 | 0.0259 | 13 |
| Induction of appropriate technology | S310 | 0.0135 | 38 |
| Restrictions imposed on the end user | S41 | 0.0185 | 28 |
| Knowledge of environmental issues and related rules | S42 | 0.0259 | 12 |
| Achieving national specifications | S43 | 0.0142 | 35 |
| Stakeholder expectations | S44 | 0.0154 | 33 |
| Stability of financial and economic conditions at the macro level | S45 | 0.025 | 17 |
| Market availability | S46 | 0.0454 | 2 |
| Issuance of construction permit | S47 | 0.0241 | 20 |
| Level of risk and profitability | S48 | 0.0319 | 6 |
| Energy consumption | S51 | 0.0255 | 14 |
| Recycling and waste management | S52 | 0.0408 | 4 |
| Construction cost | S53 | 0.0237 | 21 |
| Public comfort and health and safety | S54 | 0.0261 | 11 |
| User security | S55 | 0.0277 | 8 |
| Noise pollution during construction | S56 | 0.0277 | 9 |
| Environmental Protection | S57 | 0.0277 | 10 |

*4.3. Findings*

Therefore, according to the calculations, the final weight of each sub-criteria of the model has been calculated with the ANP technique. According to this:
The sub-criterion "Achieving the planned quality standard" with a normalized weight of 0.0525 is the first priority.
The sub-criterion "market availability" with a normalized weight of 0.0454 is the second priority.
The "project size and complexity level" sub-criterion with a normalized weight of 0.044 is the third priority.
The "recycling and waste management" sub-criterion with a normalized weight of 0.0408 is the fourth priority.
The sub-criterion "maintaining skills over time (maintaining personnel)" with a normalized weight of 0.0367 is the fifth priority.
The sub-criterion "level of risk and profitability" with a normalized weight of 0.0319 is the sixth priority.
The sub-criterion "good relationship with stakeholders" with a normalized weight of 0.0283 is the seventh priority.
The "user security" sub-criterion with a normalized weight of 0.0277 is the eighth priority.
The sub-criterion "noise pollution during construction" with a normalized weight of 0.0277 is the ninth priority.
The sub-criterion of "Environmental protection" with a normalized weight of 0.0277 is in the tenth priority.

*4.4. Implications of the study*

The study highlights the critical role of stakeholders in project success, especially in the construction equipment manufacturing sector**.** The analysis reveals the interrelationships between different factors, emphasizing the need for a holistic approach to stakeholder management. The study pinpoints specific sub-criteria like reaching planned quality standards and market availability as crucial for project success.

## 5. Conclusions

In contemporary project management, stakeholders play a pivotal role in the successful implementation of project activities. Projects are highly sensitive to the actions and decisions made by stakeholders. Incorrect decisions, a lack of responsibility, and low-quality contributions from various stakeholder groups can significantly hinder project progress and lead to undesirable outcomes. Stakeholder theory identifies three key characteristics of stakeholders: power, legitimacy, and urgency. Notably, stakeholder satisfaction, particularly customer satisfaction, is widely recognized as a crucial indicator of organizational success and provides a significant competitive advantage. This research employed the Delphi technique to screen sub-criteria. Subsequently, the Analytical Network Process (ANP) and the DEMATEL method were utilized to determine and prioritize sub-criteria, as well as to measure the internal relationships between criteria. Pairwise comparison matrices were utilized to determine the weight of each criterion. This research was conducted in several stages, employing a range of methodologies. To facilitate the calculations associated with the Delphi technique, the ANP technique was implemented using the Super Decision software. The research methodology involved the development of a conceptual model, followed by a five-step process:

Identifying the main criteria: This step involved identifying the key factors that influence stakeholder engagement.

Identifying the options: This step involved defining the specific options or alternatives within each criterion.

Identification of internal relationships: This step involved analyzing the interdependencies and interactions between the identified criteria and options.

Determining general priorities: This step involved determining the overall priorities of the criteria and options based on the analysis conducted in the previous steps.

Compatibility test: This step involved conducting a compatibility test to ensure the consistency and validity of the results obtained in the previous steps.

Based on the analysis results, the "project team" criterion exhibited the highest level of interaction with other studied criteria. Moreover, the "project team," "organization," and "external environment" criteria were identified as having the most significant impact.

Based on the calculated results, the "organization," "external environment," and "sustainability" criteria were ranked first, second, and third in order of priority, with respective normal weights of 0.417, 0.264, and 0.181. Furthermore, the sub-criteria of "reaching the planned quality standard," "market availability," and "project size and complexity level" were ranked first, second, and third, with normal weights of 0.0525, 0.0454, and 0.044, respectively.

The study focuses on construction equipment manufacturers in Tehran. The findings might not be directly applicable to other industries, project types, or geographical locations.

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