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Construction Project Contractors Management Using Analytic Network Process (ANP): A Case for Tehran City

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ARTICLE INFORMATION

ABSTRACT

As known the selecting the appropriate contractor is paramount importance to the success of civil projects which is even more important to urban construction projects in various cities. Thus, this study highlights the main criteria for selecting contractors for construction projects in urban area as cases study for Tehran city, Iran. The 19 criteria were identified based on field investigations and expert opinions which classified into six groups. The analytic network process (ANP) was applied on criterias to responses prioritization. According to the results of the assessment, the affordability with 0.0660 and compliance rate with 0.0599 importance score are ranked criteria for responses prioritization and selecting the appropriate contractor in Tehran city. The executive ability factor with 0.0144 score received the lowest attention in ANP model.

1. Introduction

Contractor evaluation and selection management is an essential part of the construction process because contractors are one of the basic pillars of construction projects and the main factor in converting resources into the final product, given that most of the construction projects budget is allocated to executive operations. Execution of any project requires the presence of a suitable contractor who has the necessary capabilities to carry out the project within the time and resources and with the desired quality (Gould and Joyce, 2013). The current method of selecting a contractor for construction projects is based on the lowest bid price, but it is clear that there are several quantitative and qualitative indicators with different degrees of importance in determining the qualification of a contractor and should be considered in decisions in

addition to identifying indicators (Dykstra, 2018). Effective on the contractors' selection is degree of importance and prioritization of these indicators using different methods is of particular importance (Allen and Lano, 2013). The most important indicators obtained based on previous research by experts are the technical and skill components of economic, financial and managerial ability; specialized staff of credit equipment and good record (Gould and Joyce, 2013). Thousands of billions of rials of our national capital are spent directly or indirectly on construction and infrastructure in the public and private sectors, according to Iran's economy, which is a single product and relies on oil revenues and the fact that the country's financial resources are limited. Since the bulk of the budget for construction projects is spent on executive costs, the implementation of each project requires a contractor with capabilities appropriate to the project to prevent the increase in the cost

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of executive costs and to complete the project within the time and resources to send (Daneshvar et al., 2019).

Many researchers and experts have defined management and decision making as equivalent and synonymous and do not consider management as anything but decision making and believe that the main focus of management is decision making and performing tasks such as organizational planning or control is in fact nothing but decision making. Not how to do these activities, so, wrong decisions and not paying attention to scientific methods and appropriate decision-making techniques in selecting contractors cause great losses to organizations and society. Therefore, scorpions of construction projects with problems such as increasing the cost of extending the implementation time or reducing the quality of not choosing the right contractor worthy to face the desired project (Laudon and Laudon, 2015).

Some contractors resort to all sorts of tricks to win tenders, including offering excessive and unreasonable discounts to the employer's estimate, usually due to weak rules and regulations for determining the winner of the tender and selecting the contractor. Many contractors in the project implementation process, and on the other hand, a number of contractors believe that the existing method of selecting a contractor in many cases does not lead to the actual selection of the main contractor. This has led to his strong motivation of qualified and capable contractors Construction projects should be reduced in view of the above and taking into account that the management of evaluation and contractor selection for the assignment of construction projects is an essential part of the construction process of conducting applied research to solve various problems of construction projects, including problems in the field of project management is to identify the dimensions and factors affecting the selection of the contractor and the use of scientific decision-making methods in the field of contractor selection and ultimately to prevent the waste of national resources of special importance (Gould and Joyce, 2013).

The process of selecting a contractor is complex due to the existence of criteria that may be inconsistent. Many researchers have tried to help managers make outsourcing decisions by identifying important tasks for selecting the right contractor. Criteria are in fact factors that evaluators consider. They can use them to examine contractors and their performance in various projects. Some companies and organizations use the criterion of lowest cost to select a contractor in tenders, but these criteria alone cannot guarantee the success and quality of the project. One of the most important reasons for the failure of outsourcing projects is the selection of an unsuitable contractor. A suitable contractor must be able to meet the current and future needs of the organization. Credit, technical competence, financial stability and the contractor's ability to build and produce affect the outsourcing process. Since wrong decisions about choosing the right contractors will have irreparable consequences for the organization, it is necessary to evaluate the management and better select the

best contractor from among the potential contractors. The amount of investment is done in the implementation phase of the project and the mistake in this stage is associated with the loss of a major share of this investment serum (Gould and Joyce, 2013). Therefore, one of the most important issues in the implementation of construction projects is the selection of the main contractor so as to ensure that by choosing the right, the risk of wasting resources is minimized in terms of cost and time, and also projects with the highest quality of execution and safety during or after implementation, according to the status of companies or contractors who are willing to undertake organizational and development projects, it is of special importance for organizations, including specialized development organizations, that they must submit part of their development projects. Therefore, considering that the management of evaluation and selection of contractors for the assignment of construction projects is an essential part of the work process of each complex, this study identifies the dimensions and factors affecting the selection of contractors and prioritization and selection of construction contractors. Thus, the main purpose of this study is to answer the question that what factors affect the selection of contractors for construction projects in Tehran and how is the prioritization and importance of each of these factors? (Allen and Lano, 2013).

The presented study identifies the dimensions and factors affecting the selection of contractors and prioritization and selection of construction contractors using ANP network analysis of construction projects in Tehran.

2. Materials

2.1. Effective indicators in construction project contractors' selection

One of the important issues that was reviewed while reviewing the theoretical foundations and background and the indicators affecting the competence of the contractor, as studies have shown, various parameters are involved in determining the desired indicators and their importance so That indicators or their importance may change in different projects because organizations are looking for contractors whose final products with green time and less cost to have more durability and better quality. According to the issues related to competency assessment and factors affecting the selection of the contractor, the indicators that are effective in the competence of contractors in most construction projects were extracted by library studies and reviewed by field methods and questionnaire distribution (Levy, 2017).

Technical index: This index examines the technical and technological capabilities of contractors to carry out the project. After conducting interviews and consulting experts, 5 sub-technical categories were identified (Dykstra, 2018):

- Having a comprehensive project planning and control system,

- How to comply with standards and technical specifications in previous projects,
- How to implement previous projects in terms of quality, cost and schedule,
- Observance of relevant current laws such as environmental, labor and social security laws,
- Observing the safety and protection instructions of the workshop.

Skills-ability index: Skills index evaluates the ability of successful backgrounds and records of contractors, considered effective. These records are effective in the successful implementation of construction projects. The experimental index group has 6 sub-indices (Dykstra, 2018):

- Executive history in the desired field and field of work,
- Being a local contractor or having experience at the project site,
- Creativity and innovation in previous projects,
- Application of appropriate methods and executive organization and order in the affairs of the workshop,
- Classification of workshop documents and documentation of previous work done,
- Continuous communication and coordination with the employer and the monitoring device.

Economic-financial index: The financial ability of a contractor to complete the project and bear the costs during the project is an important indicator in the evaluation of contractors. The five economic and financial indicators are as follows (Dykstra, 2018):

- Financial capacity and support,
- Proposed price,
- How to price analysis,
- Timely payment of salaries of workshop agents and contractors except,
- Insuring all facilities of equipment and personnel against possible accidents.

Management index and specialized staff: It is obvious that efficient management and the presence of specialized personnel are the basic and basic conditions for the success of any organization in project organizations that act as contractors for various projects. The need to benefit from strong management staff is vital. Contractors' management capabilities address (Dykstra, 2018):

- Efficient management and proper management system,
- Stability of board members and expert staff,
- The level of education in the field of study and the executive experience of the expert staff and key elements,
- Presenting articles in conferences, conferences and specialized journals,
- Works of scientific and technical writings and researches,
- Continuous staff training.

Equipment index: Having suitable and sufficient equipment and machinery in civil works is also an important indicator to check the contractor's capabilities. Therefore, along with other factors affecting the decision, the availability of machinery should also be considered. The following 2 indicators of this group are (Dykstra, 2018):

- Having equipment and machinery ready or available,
- Complete and timely equipment of the workshop.

Goodwill index and Credibility index: The last effective indicator on decision making based on review and evaluation of previous research in this field is the existence of a good record in previous projects and the satisfaction of past employers, which can actually facilitate decision making. This group has 4 sub-indicators (Dykstra, 2018):

- Accreditation of various qualifications from official and reputable organizations and organs,
- Receive awards and official letters of appreciation,
- Good record in previous works,
- Credibility and reputation of the company and key personnel.

As can be seen, a number of criteria mentioned in the research literature, such as work capacity and number of works in progress, do not fit into the above category because it is assumed that contractors participate in the tender who have the minimum requirements and based on the dimensions And the size of the project in question have also been ranked according to the project. It should be noted that there is a general consensus on these categories, although other projects or categories may be proposed in different projects based on the specific requirements and conditions of the project, for example, an index is removed or more weight is added to it. Therefore, it does not matter whether the classification performed or the weights obtained for the indicators are suitable for all types of projects or not, because in each project, the project management team and relevant officials, based on the terms and specifications of the project, they make group decisions according to the proposed method (Levy, 2017).

2.2. Construction Management

Construction management (CM) is a legal entity that, on behalf of the project manager, is responsible for managing the control and coordination of projects and implementation stages. Management of the project and its duties within the methods, rules and instructions that have reached the contractor and by applying direct and daily management in the shadow of executive agents to the executor is responsible for the accuracy of qualitative and quantitative approval of the work according to the specifications of the initial estimates and plans and its possible changes is responsible for providing continuous reports. In addition to the three common and well-known factors of the employer, the consultant and contractor also play a role in project management. This method of implementation is a kind of conventional operating system in which the employer manages another external organization called project management or the fourth factor

to manage the project is used. The task of this institution is to manage and control the project and coordinate between the design and construction. Using this institution reduces the responsibility and risk of the employer (Gould and Joyce, 2013). Therefore, the project manager performs his duties within the framework of methods and instructions that have either been prepared or approved by the employer or have been determined and communicated to him by the employer and are performed through the application of superior quantitative and qualitative management (Levy, 2017). Approves the status of contractors and builders or the accounts of consulting engineers and has no financial or legal responsibility to contractors, builders and consultants in terms of supply and payment of their claims and does not respond to claims of possible damages. The main purpose of this method is to use project management skills and knowledge to optimally use resources so that the demands of the employer in terms of performance, time, cost, quality and operation are met. In the classification of types of contracts, contract management is in the line of management contracts This means that the CM is not of the same type but is considered to be of the service of consulting engineers and is included in that group. Also, some employers may not have the internal resources to plan and execute complex projects to plan the design and construction of that project. To cover this field, construction management services can be provided in two different ways (Rumane, 2014).

2.3. Steps for selecting construction project contractors

Selection is one of the important tasks of managers in operational processes and the correct choice in the project management process has a great impact on efficiency and productivity in operations (Allen and Lano, 2013). High performance and effectiveness of projects is guaranteed when managers and project managers by recognizing and benefiting from decision-making techniques and tools remove obstacles and problems inside and outside the organization as well as executive affairs and pave the way for the correct implementation of project activities (Kar and Jha, 2020). One of the most important decisions in the project management process is choosing the right system in the early stages of the project. It is that over the past decades, methods of project implementation and management have undergone significant changes and development (Daneshvar et al., 2019). In fact, it was in the years after 1950 that systematic methods and tools for project management were invented and used (Allen and Lano, 2013). Gradually, issues such as cost and time management of the project were considered and systems such as three-factor and four-factor methods were formed for the implementation of construction projects which explains the different forms and shapes that are all used to complete the successful design and construction of the project. As mentioned before, the difference between the propulsion systems is due to the difference in the performance of their components and in addition the

difference in the scope of responsibility (Zavadacaz and Vilittine, 2006). Also, risk distribution causes differences between these systems. In the trust system, all responsibilities are the responsibility of the employer and are done within the organization. In the conventional system, the responsibility for design and construction is assigned to separate resources outside the organization and the responsibility for financing is assumed and the employer is placed. In the construction management system, the construction manager is responsible for managing and coordinating the design and construction, which in the conventional system is the responsibility of the employer. The difference between the two types of construction management system as a representative of the employer and structural management and the construction responsibility for the design and construction of the project is entrusted to the construction designer (Allen and Lano, 2013). It should be noted that the rotary switch method can be called a modified state of the design and construction system that performs design and construction services and the task of short-term financing. Of course, part of the responsibility for feasibility studies and initial design is also included in the rotary switch system. Construction method exploitation the transfer of the entire construction process from the definition and basic studies stage to long-term financing in all stages of the project is done by a single source of responsibility. However, this method also has no place in the category of project advancement systems (Shive et al., 2007).

2.4. Hierarchical method in selecting contractors

The decision-making process is finding the best option among the possible options evaluation and selection of contractors which considered as an important decision factor that plays a major role in the success of construction projects, therefore for the success of the construction industry, which in practice as an important element in the economy where that directly leads to employment and economic growth (Sahni and Yang, 2016). The contractor selection is a critical decision in the project decision that affects the success of the project which is done through measurements and evaluation of the characteristics of the contractor (Allen and Lano, 2013). It is now common to evaluate and select the contractor on the tender and low price which the highest bid price is emphasized (Gould and Joyce, 2013). While different factors and criteria are effective in determining the weight of the evaluation and selecting the best contractor, the decision is complicated by considering different factors and the weighting of the criteria is through expert judgment and concerns about the inaccuracy of judges and ambiguities in evaluation (Dadashi and Mohammadi, 2019). One cannot expect definite judgments and accept uncertainty in judgments (Saaty, 1997).

Multi-criteria decision making is a complex process for decision makers and managers. In the classical method, the weight of criteria is precisely defined but due to the human

judgments in determination, the superiority of options is often ambiguous and one cannot accurately estimate the value of one criterion from boundary distance data (Sirin et al., 2019). Multi-criteria decision making is a complex and dynamic process for decision makers and analysts. The decision maker sets the goals and also chooses the final option (Gunduz and Khader, 2020). The nature of multi-criteria decision making is such that the decision maker has the ability to accept or reject the analyst's proposed solution. Using different techniques often produces contradictory results for similar problems, or in other words the results of ranking the options depend on the technique used to solve the problem and choosing a valid and appropriate technique is very important (Kheybari et al., 2020). Analytical Network Process or ANP technique is a new approach to multi-criteria group decision making (Saaty, 2013). Human judgments are always involved in ambiguity and uncertainty, and sometimes the high number of criteria and factors make decision-making difficult for managers, so tools are used for decision-making (Lio et al., 2000).

3. Methods

Research can be defined as the analysis of an objective and systematic record of controlled observations that leads to the development of general rules of theories as well as to the prediction or possibly eventual control of events. Achieving research goals will not be possible unless the search for knowledge is done with methodology two (Saaty, 2013). In this article, by specifying the research process, introducing the statistical community, the method of data collection, the method of data analysis and the methodology used are described. The purpose of selecting and prioritizing contractors is based on the indicators identified in construction projects. In this regard, ANP network process has been used. ANP method is a generalization of AHP, was first proposed by Saaty in 1996 (Saaty, 2013). In cases where the lower levels affect the upper levels or the elements that are on the same level are not independent of each other, the AHP method can no longer be used. For this reason, Saaty introduced the ANP method. ANP is a more general form of AHP but does not require a hierarchical structure and therefore shows more complex relationships between different levels of decision networking and considers interactions and feedback between criteria and alternatives (Saaty, 2013). In the ANP method, the dependencies must be linear, from top to bottom or vice versa, if the dependence is two-sided, the weight of the criteria depends on the weight of the options and the weight of the options depends on the weight of the criteria. The hierarchical mode exits and forms a nonlinear network or system, in which case hierarchical rules and formulas cannot be used to calculate the weight of the elements. Instead, we need to use network theory to calculate the weight of the elements. The simplest grid is made up of a number of clusters with elements inside them. The ANP network structure is presented in Fig. 1. Mainly,

ANP is another series of multi-criteria decision making techniques that is very similar to AHP hierarchical analysis process. Each method is based on a series of hypotheses. For example, if the criteria are independent of each other and pairwise comparisons are possible, the appropriate decision model is the AHP model, but if the criteria are not independent, the ANP method is better (Lio et al., 2000).

Thomas L. Saaty plotted the extended ANP process method for solving complex decision-making problems in which the nodes in this network are equivalent to our needs, criteria, and options, and the directional vectors that connect these nodes which are also equivalent to the direction and the effect of nodes on each other (Saaty and Vargas, 2013). Like the AHP method in the ANP method, the weight of the criteria and the desirability of the options are obtained directly by receiving individual judgments and using pairwise comparisons (Saaty, 2013). One way to perform calculations in the ANP method is to place the weights obtained by performing pairwise comparisons in a matrix called the supermatrix (Sirin et al., 2019). A supermatrix is a matrix of relationships between network components that is obtained from the special vectors of these relationships. Supermatrix can be divided into different blocks. Each block represents the weight obtained from a pairwise comparison of rows (e.g., indices) with respect to columns (e.g., options or indicators) which is capable to multi-active decision process (Kulakowski, 2020). In fact, the ANP method uses a supermatrix instead of the research matrix, which is common in AHP. The analytical structure of this network is presented in Fig. 2 (Karamoozian et al., 2019).

The supermatrix is used to represent the flow of influence from one cluster to other clusters (external communications) or to the elements within itself (internal communications), which is obtained by empowering the super matrix, the weight vector. In the following, we will explain the same issue in another expression. Imagine that the problem has N clusters called C_1, C_2,… C_N and there are Ni elements in the i cluster. Now if you select clusters i and j and select all the elements i in pairs relative to the first element j compared; the matrix of the pair shown below is obtained. This matrix is a pairwise comparison of all the elements of branch i with respect to the first element of branch j (Karamoozian et al., 2019).

$$W_{ij} = \begin{bmatrix} i_1 \\ i_2 \\ \vdots \\ i_{ni} \end{bmatrix} \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \vdots & \vdots & \cdots & \vdots \\ a_{ni1} & a_{ni2} & \cdots & a_{nin} \end{bmatrix} = \begin{bmatrix} W_{i1}^{j1} \\ W_{i2}^{j1} \\ \vdots \\ W_{in}^{j1} \end{bmatrix} \quad (1)$$

The eigenvector obtained from this pairwise comparison is defined as follows. If this pairwise comparison is not significant, the corresponding eigenvector will be zero. If all the elements i is compared to each other in pairs relative to all the elements j and we get its special vectors, the following matrix will be obtained:
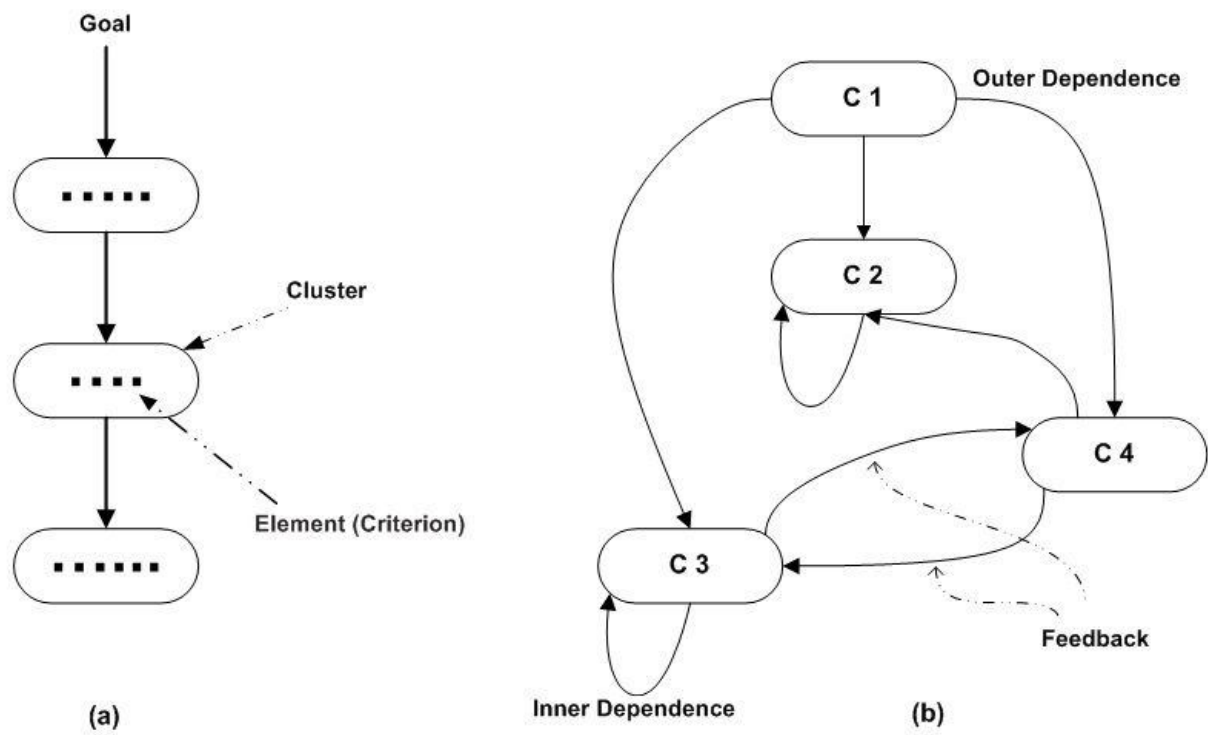
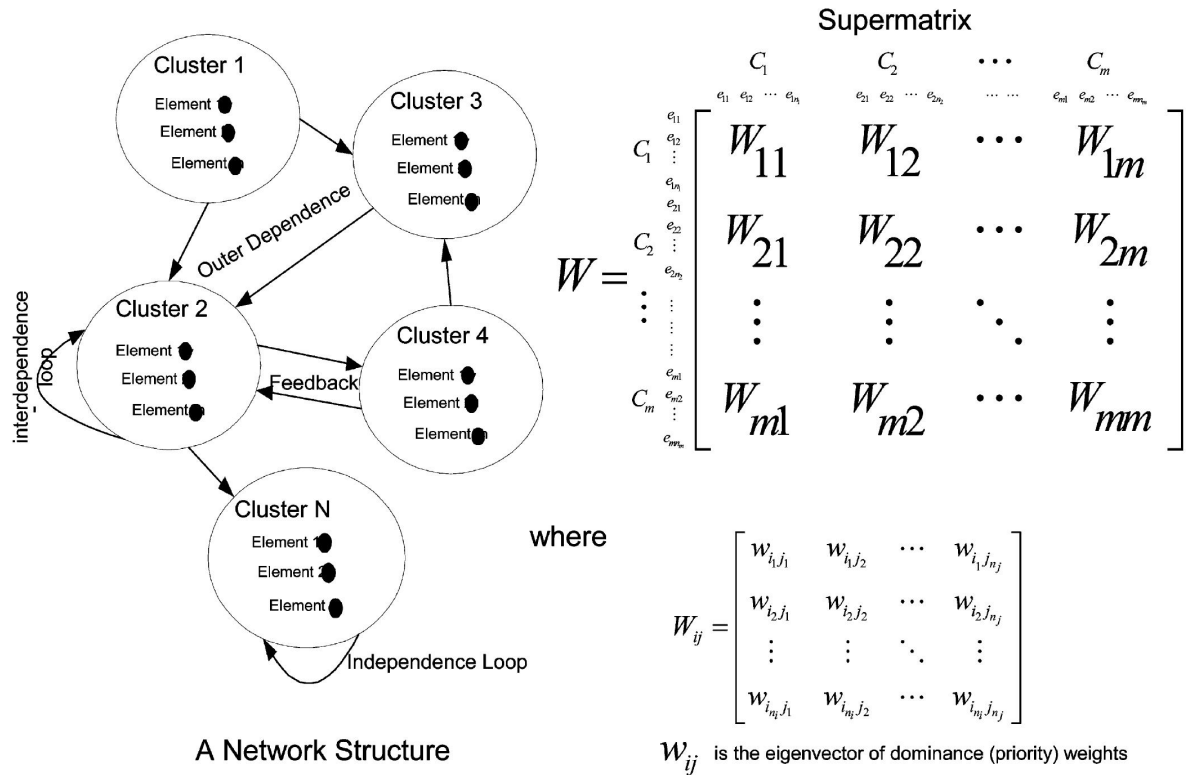**Figure 1.** Network structure based on (a) AHP and (b) ANP (Gunduz and Khader, 2020)

Figure 2. ANP Supermatrix Analysis Structure (Promentilla et al., 2006)

$$W_{ij} = \begin{bmatrix} W_{i1}^{j1} & W_{i1}^{j2} & W_{i1}^{j3} & \dots & W_{i1}^{jn} \\ W_{i2}^{j1} & W_{i2}^{j2} & W_{i2}^{j3} & \dots & W_{i2}^{jn} \\ \vdots & \vdots & \vdots & \dots & \vdots \\ W_{in}^{j1} & W_{in}^{j2} & W_{in}^{j3} & \dots & W_{in}^{jn} \end{bmatrix} \quad (2)$$

If we obtain the above matrix for all indices, the following matrix is obtained, which is called a supermatrix:

$$D = \begin{array}{c} \\ C_1 \\ \vdots \\ C_n \\ A_1 \\ \vdots \\ A_n \end{array} \begin{bmatrix} C_1 & \cdots & C_n & A_1 & \cdots & A_n \\ 0 & \cdots & 0 & w_{1,n+1} & \cdots & w_{1,n+m} \\ \vdots & & \vdots & \vdots & & \vdots \\ 0 & \cdots & 0 & w_{n,n+1} & \cdots & w_{n,n+m} \\ w_{n+1,1} & \cdots & w_{n+1,n} & 0 & \cdots & 0 \\ \vdots & & \vdots & \vdots & & \vdots \\ w_{n+m,1} & \cdots & w_{n+m,n} & 0 & \cdots & 0 \end{bmatrix} \quad (3)$$

The research method is a set of rules, tools and valid and systematic ways to investigate the reality of discovery of unknowns and achieve solutions to problems. Given that in this study, the purpose of selecting and prioritizing contractors based on indicators identified in construction projects using ANP technique can be promoted in task as:

- A review of past research,
- Selecting the appropriate index for selecting contractors for construction projects,
- Selecting the appropriate time variable to identify construction project contractors,
- Preparing a questionnaire,
- Evaluating the importance and performance of performance indicators of construction project contractors through a questionnaire,
- Integrating the importance and performance of selecting and ranking contractors for construction projects.

Step 1: Selecting a criterion of the most suitable contractors for construction projects which in the first step, which is selecting a suitable criterion for evaluation, using the screening method, we will achieve criteria and indicators that many researchers and thinkers use as a criterion for selecting the most appropriate Contractors have named construction projects. The most important criteria for selecting the most suitable contractors for construction projects can be stated in Table 1.

Step 2: Determining an appropriate cognitive scale to evaluate the performance rank and importance of criteria weights that led to the selection of the most suitable contractors for construction projects and in the second step, determining an appropriate linguistic scale to evaluate the performance rank and importance of criteria for selecting the most appropriate project contractors It is a productive development. In many cases, it is practically impossible to determine the scores of ambiguous indicators, such as the best grade of the information system, the way in which the requested information is received, the transfer of compatibility, and the cases that are impossible for experts. Therefore, in this approach, linguistic words are used to evaluate the performance rank and the importance of the criteria weights, selecting the most appropriate type of contractors for construction projects. The use of linguistic words and the functions of the corresponding members

have always been criticized. In order to convince and instead of inferring from experts the linguistic words and the functions of the corresponding members can be used from past data or as a basis and adjusted to the unique situations and needs of users. In general, it is suggested that linguistic levels do not exceed 9 levels. Based on the main data of the study, which were selected by Yang Wali and due to different human perceptions, the linguistic variables excellent, very good, good, average, poor, very poor were selected to evaluate the criteria for selecting the most suitable contractors for construction projects. Linguistic variables very high, high, relatively high, medium, relatively low, low, very low, have been selected to measure the importance of the weights of the selection criteria for the most suitable type of contractors.

Step 3: The third step is to measure the performance and importance of the selection capacities of the contractors of the construction projects using linguistic methods. Experts can make the relative importance of each of the capabilities of the criteria for selecting the most suitable contractors for construction projects by comparing based on the strategy and policy of the organization, competitive market orientation, technology development orientation, expertise and knowledge of professionals. This measurement is through the distribution of questionnaires among professors and elites of the civil engineering system and civil engineers in this field.

Step 4: In this step, according to the questionnaire related to the importance of indicators for selecting the most suitable contractors for construction projects that were collected, using the weights obtained and with the help of ANP technique, we will rank these indicators.

Table 1. The most important criteria involved in Tehran construction projects

Parameters	Criterion
Obligation	Timely response to customer needs
	Post-operation services
	Timely delivery
Compliance rate	Compliance with the employer and consultants opinions
	Having close relationships with consultants
	Contractor executive flexibility
Resources	Technical and technological skills
	Intellectual capital and expertise
	Physical capacity
Affordability	Financial stability
	Financial power
	Outsourcing costs
Executive ability	Optimal performance of units
	Application of new technologies
	Contractor experience
	Innovation in implementation
Managerial acts	Human resource management skills
	Concluding various contracts
	Ability to manage relationships in outsourcing

Step 5: In this step, according to the questionnaires related to the most appropriate selection of contractors for construction projects that were distributed and collected, and using the obtained data, we will evaluate the level of each of the indicators.

Step 6: Finally, according to the importance and ranking of indicators, which was done with the help of ANP technique and using the results obtained from the questionnaire of each of the indicators to select the most suitable contractors for construction projects to evaluate these contractors and their performance.

4. Results and Discussions

In this section, the collected data is used to confirm or refute the research hypotheses. To analyze the findings, first the research data collected by experts and specialists of construction projects in Tehran and academic experts and university professors in the field of project management are collected through a questionnaire, extracted and arranged in tables. Then all data were analyzed using software at both descriptive and inferential levels. To analyze the collected data, first, descriptive statistics are examined which examines the research variables in terms of central statistics and describes the status of the statistical sample and members' then analytical statistics are presented.

In the analytical statistics of this study, the SPSS software was used. In order to investigate the relationship between the effective components in the optimal selection of contractors for construction projects and identify the relationships between the components in order to analyze the model components and predetermined relationships of the correlation test research and alignment status of these variables will be used. Also, in order to estimate the collected data distribution (in terms of the normality of the variables); the non-parametric Kolmogorov-Smirnov test is used.

Finally, for investigate the presence or absence of significant differences among the effective components in the optimal construction project contractor's selection in the present case study, the non-parametric ANP test was used which is applied in Super-decision sofware. The evaluation results are as follows:

Table 2. Kolmogorov-Smirnov test for obligation group in Tehran project

Criteria	Test Num.	Max	Min	Mean	St.Dev.
Timely response	15	7.021	1.331	4.176	1.163
Post-operation	15	7.220	2.211	4.715	0.887
Timely delivery	15	7.144	2.289	4.716	1.012

Table 3. Kolmogorov-Smirnov test for compliance rate group in Tehran project

Criteria	Test Num.	Max	Min	Mean	St.Dev.
Employer-consultant opinions	15	4.214	1.881	3.047	1.015
Relationships with consultants	15	3.986	2.321	3.153	0.912
Contractor flexibility	15	4.535	2.049	3.292	1.126

Table 4. Kolmogorov-Smirnov test for resources group in Tehran project

Criteria	Test Num.	Max	Min	Mean	St.Dev.
Technical / technological skills	15	4.231	1.710	2.970	0.987
Intellectual capital/expertise	15	3.880	2.102	2.991	1.363
Physical capacity	15	3.633	2.096	2.864	1.141

Table 5. Kolmogorov-Smirnov test for affordability group in Tehran project

Criteria	Test Num.	Max	Min	Mean	St.Dev.
Financial stability	15	4.633	2.363	3.498	1.033
Financial power	15	4.288	2.770	3.529	0.888
Outsourcing costs	15	4.07	2.144	3.107	1.643

Table 6. Kolmogorov-Smirnov test for executive ability group in Tehran project

Criteria	Test Num.	Max	Min	Mean	St.Dev.
Optimal performance	15	4.476	2.211	3.343	0.976
New technologies	15	3.882	2.636	3.259	0.918
Experience	15	4.500	2.335	3.417	1.674
Innovations	15	4.343	1.988	3.165	1.099

Table 7. Kolmogorov-Smirnov test for managerial acts group in Tehran project

Criteria	Test Num.	Max	Min	Mean	St.Dev.
Human resource	15	3.456	2.289	2.872	1.077
Contracts	15	3.055	1.554	2.304	0.798
Outsourcing management	15	3.412	1.188	2.300	1.344

Table 8. Statistical relationship between the effective components in Tehran project

Parameters		Obligation	Compliance rate	Resources	Affordability	Executive ability	Managerial acts
Obligation	Coefficient	1					
	Variation	0.00					
Compliance rate	Coefficient	0.721	1				
	Variation	0.03	0.00				
Resources	Coefficient	0.333	0.556	1			
	Variation	0.125	0.277	0.00			
Affordability	Coefficient	0.645	0.871	0.917	1		
	Variation	0.122	0.239	0.311	0.00		
Executive ability	Coefficient	0.486	0.576	0.886	0.925	1	
	Variation	0.188	0.255	0.309	0.423	0.00	
Managerial acts	Coefficient	0.319	0.454	0.611	0.721	0.836	1
	Variation	0.121	0.212	0.346	0.457	0.533	0.00

Table 9. Inter-dependencies between clusters with respect to obligation

Parameter	A	B	C
Timely response to customer needs (A)	-	2	3
Post-operation services (B)	1/2	-	1/2
Timely delivery (C)	1/3	2	-

Table 10. Inter-dependencies between clusters with respect to compliance rate

Parameter	A	B	C
Compliance with the employer and consultants opinions (A)	-	2	5
Having close relationships with consultants (B)	1/2	-	1/3
Contractor executive flexibility (C)	1/5	3	-

Table 11. Inter-dependencies between clusters with respect to resources

Parameter	A	B	C
Technical and technological skills (A)	-	2	4
Intellectual capital and expertise (B)	1/2	-	1/3
Physical capacity (C)	1/4	3	-

Table 12. Inter-dependencies between clusters with respect to affordability

Parameter	A	B	C
Financial stability (A)	-	3	5
Financial power (B)	1/3	-	4
Outsourcing costs (C)	1/5	1/4	-

Table 13. Inter-dependencies between clusters with respect to executive ability

Parameter	A	B	C	D
Optimal performance of units (A)	-	2	3	6
Application of new technologies (B)	1/2	-	2	4
Contractor experience (C)	1/3	1/2	-	1/3
Innovation in implementation (D)	1/6	1/4	3	-

Table 14. Inter-dependencies between clusters with respect to Managerial acts

Parameter	A	B	C
Human resource management skills (A)	-	2	3
Concluding various contracts (B)	1/2	-	1/2
Ability to manage relationships in outsourcing (C)	1/3	2	-

Table 15. Importance weight nodes and limitations for criterions

Criterion	Limitation	Importance weight	Criterion	Limitation	Importance weight
Obligation	0.1280	0.0345	Timely response	0.0775	0.0222
			Post-operation services	0.1120	0.0309
			Timely delivery	0.0991	0.0455
Compliance rate	0.1134	0.0599	Employer /consultants opinions	0.0852	0.0366
			Relationships with consultants	0.0666	0.0187
			Contractor executive flexibility	0.1733	0.0672
Resources	0.0873	0.0363	Technical/technological skills	0.1020	0.0277
			Intellectual capital and expertise	0.1644	0.0150
			Physical capacity	0.1108	0.0500
Affordability	0.0628	0.0660	Financial stability	0.0933	0.0644
			Financial power	0.0819	0.0187
			Outsourcing costs	0.1003	0.0721
Executive ability	0.1209	0.0144	Optimal performance of units	0.0675	0.0190
			Application of new technologies	0.0344	0.0432
			Contractor experience	0.0425	0.0125
			Innovation in implementation	0.0555	0.0331
Managerial acts	0.0765	0.0282	Human resource management skills	0.0434	0.0159
			Concluding various contracts	0.1022	0.0333
			Outsourcing management	0.0900	0.0145

The importance weights of clusters and nodes are given in Table 15. The analysis shows that as effectiveness of strategies is the most influential cluster that contributes to the competitiveness of the contractors. Effective strategy enables construction firms to match their activities to the changing environment and achieve superior performance in competition. Therefore, there is a need for studying contractors' competitive strategies. Effectiveness of strategies is followed by organizational capabilities and managerial capabilities (Ozorhon et al., 2020).

According to the results of the assessment, the affordability with 0.0660 and compliance rate with 0.0599 importance score are ranked criteria for responses prioritization and selecting the appropriate contractor in Tehran city. The executive ability factor with 0.0144 score received the lowest attention in ANP model.

5. Conclusion

Selecting the appropriate contractor is of paramount importance to the success of civil projects especially urban constructions in mega-cities which construction projects such circumstances require contractors with special capabilities in addition to the traditional capabilities. The selection of the sustainable contractor for city projects is a very difficult and need to applying comprehensive project management with high quality decision process where considered as critical task to assure the success. In this regard, the multi-criteria decision-making procedures like AHP and ANP were conducted to provide high accuracy results in management levels. The presented study used the ANP model for providing the highlights in appropriate contractors' selection in urban area's construction projects for Tehran city, Iran. The 19 criteria (concluded timely response to customer needs, post-operation services, timely delivery, compliance with the employer and consultants opinions, having close relationships with consultants, contractor executive flexibility, technical and technological skills, intellectual capital and expertise, physical capacity, financial stability, financial power, outsourcing costs, optimal performance of units, application of new technologies, contractor experience, innovation in implementation, human resource management skills, concluding various contracts, ability to manage relationships in outsourcing) were identified based on field investigations and expert opinions which classified into six groups (concluded obligation, compliance rate, resources, affordability, executive ability, managerial acts). According to the results of the assessment, the affordability with 0.0660 and compliance rate with 0.0599 importance score are ranked criteria for responses prioritization and

selecting the appropriate contractor in Tehran city. The executive ability factor with 0.0144 score received the lowest attention in ANP model

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