

Evaluating Contractors in Construction Projects by Multi-Criteria Decision Making and Supply Chain Approach

Sara Najiazarpour, Mahsa Najiazarpour

Abstract—There are many problems in contracting projects and their performance. At each project stage and due to different reasons, these problems affect cost, time, and quality. Hence, in order to increase the efficiency and performance in all levels of the chain and with supply chain management approach, there will be a coordination from the beginning of a project to the end of project (handover of project). Contractor selection is the foremost part of construction projects which in this multi-criteria decision-making, the best contractor is determined by expert judgment, different variables, and their priorities. In this paper for selecting the best contractor, numerous criteria were collected by asking from adept experts and then among them, 16 criteria with highest frequency were considered for questionnaire. This questionnaire was distributed between experts. Cronbach's alpha coefficient was used and then based on Borda function important criteria were selected which was categorized in four main criteria as follows: Environmental factors and physical equipment, past performance and technical expertise, affordability and standards. Then with PROMTHEE method, the criteria were normalized and monitored, finally the best alternative was selected. A case study had been done, and the best contractor was selected based on all criteria and their priorities.

Keywords—Evaluation and selecting contractors, project development, supply chain management, multi-criteria decision-making.

I. INTRODUCTION

THE supply chain is a topic that occupies the minds of all societies today, and according to Chapra and Meindl, the supply chain is dynamic, including the constant flow of information, products, and budgets among different stages [1]. Also, its concept is briefly stated in Ghazanfari and Fathalah 's book as follows: This approach is based on the attitude of integrating different stages and units of activity and information (construction and installation, service, production and distribution, etc.) in order to achieve a specific goal and in parallel with it, reducing cost and time and increasing quality and productivity along with customer satisfaction (real or legal) came into existence [2]. Waters sees supply chain management as the integration of chain activities and related information flows by improving chain relationships to achieve a reliable and sustainable competitive advantage [3]. Today, with a scientific and academic attitude, it has brought many efforts to improve its application in various operational processes, including

construction projects.

Managing an organization and solving its various problems requires management, organization, policy making and realistic planning. An acceptable and desirable combination of human power and material facilities provides an answer to the needs and solutions to such problems [4]. The implementation of construction projects by contractors is also one of the cases that requires proper and logical coordination and planning. The implementation of projects spends billions of rials from the capitals of the public and private sectors of the country for the construction and creation of infrastructure facilities [5].

In the implementation of each project from the beginning to the delivery of the work and the completion of the project, several factors such as the choice of contractor, supplier, economic and political conditions governing each country, etc., play a role. It is important to note that mistakes in each part and lack of integration in different parts of the project overshadow the entire chain and have negative effects on all project activities and of course on the society and create a heavy financial burden. The structure of construction projects is generally the same. Also, considering that the optimal implementation of any construction project is a new infrastructure in a society to increase the economic development of that society, double attention should be paid to this class.

For this purpose, in order to prevent problems during the implementation, this article seeks to use an optimal, efficient and at the same time simple method for selecting a contractor (taking into account all the effective indicators in the assessment) so that with a better selection, a large amount of material capital and the spirituality of the communities should be kept safe during the implementation of the project in this turbulent society. Also, considering the importance of construction projects to developing a nation, to maintain the mentioned conditions, in construction projects, there is a need for a contractor whose ability to perform the contract in the best possible way and by spending the least amount of material and spiritual capital, to share in this progress in the best way.

Another goal of the research is to determine the difference between the selection of a contractor and a supplier and to explain that conditions and methods of selecting a supplier cannot be completely the same as selection of a contractor.

Sara Najiazarpour is with Master of Economic and Social Systems Engineering, Iran University of Science and Technology, Iran (e-mail: Saraasfat@yahoo.com).

Mahsa Najiazarpour is with Master of Mathematics, University of Damghan (e-mail: mahsanaji@ymail.com).

Also, this similarity has caused less research to be carried out in this field, which is another reason for doing this article, and it is an effort to, in addition to the previous works and reviews in the field of suppliers, the cases related to contractors are also fully and accurately presented by providing technical suitable and efficient and at the same time usable, be examined and researched.

This article includes the following parts: The next part is a definition of the process of holding tenders and stating the problem in this class. In the second part, there is a review of past articles in the field of supplier selection and the difference between supplier selection and contractor selection. In the third part, important criteria and how to collect them are presented. The fourth part of the proposed method for optimal evaluation and selection is given along with an example of the evaluation of several companies. Finally, the fifth section is the conclusion of the article.

The Process of Holding a Tender and Stating the Issue

Each project is implemented according to its own conditions. According to the type and conditions of the project, the tender is held and after the winner is determined, the mentioned company equips the workshop at the project site, provides consumables and all the necessary basic activities. After equipping the workshop, the project starts, and until its end, at specific and specified times, the employer's supervisor visits the project site to check the work process and the correct implementation of the plans, so that the steps proceed in an accelerated manner. This process continues until the completion of the project and final delivery for operation.

Contracting tenders is a process among bidders (contractors) to select the best bidder (contractor) in terms of quality and quantity in order to ensure the desired quality according to the obligations of the tendered transaction. In this process, after securing the required financial resources from the bidder (employer), the type of bidding is determined in transactions. In the general research and surveys conducted in this field, conducting tenders, and selecting contractors in most countries of the world; Iran, America, Canada, etc. are done in a similar way and based on the same process, and there are only differences in some parts. But in general, tenders are held with private or government employers and sub-branches in terms of the types of tenders held.

Also, the criteria and items that are used to carry out initial and final evaluations and checks in the process of a tender in order to select a contractor who has the ability to carry out the desired project in all respects, are similar to a large extent in different countries under review and with Paying attention to the laws and policies of each country, differences can be seen in it. For example, this process in some countries includes these steps: 1. Tender request - 2. Proposal submission - 3. Proposal selection - 4. Contract formation - 5. Project delivery [6].

Also, the criteria that are evaluated for this selection in some countries include: work experience, expertise in the relevant field, having the necessary certificates, complying with regulations, and the ability to manage possible risks [7].

In this article, according to the complete information that is

available in the process of holding tenders in Iran, its process is given in the following algorithm. After choosing the type of tender, the tender documents are prepared and given to the contractors so that at the end of the process of concluding the contract with the selected contractor (Fig. 1).

It is worth mentioning that this article is about choosing a contractor in holding a tender; and it is important to note that choosing a contractor is the most important step is in this process and the optimal impact of the criteria in the selection stage improves the quality in other stages of the work process.

Different types of projects are carried out based on the needs of each society and different social- economic-political-cultural conditions, etc., which despite the difference in the form and type of their holding, are in accordance with the specific characteristics of each project at the time of each project at the time of implementation (building-road and transportation-oil and gas, etc.) as well as the needs of each geographical region, all face a similar and identical overall structure. Carrying out projects by spending governmental or non-governmental budgets in any country requires economic justification as well. It is also important that construction projects affect the development of a nation over the years. Therefore, in order to maintain the mentioned conditions, in construction projects, there is a need for a contractor who has the ability to carry out the project in the best possible way and by spending the least amount of material and spiritual capital of a country, this progress can be made efficiently.

Unfortunately, there are many problems in the contracting process and choosing the wrong contractor as the first step is an effective factor in these problems. Incorrect selection of the contractor based on relationships more than criteria causes projects to be assigned to companies that do not have sufficient power (in any respect) and are unable to perform the work due to various difficulties. Unfinished projects are classified as a delayed and half-finished project and induces many subsequent issues to the society. Another problem during the execution of the work is the selection of the wrong supplier, who is unable to prepare the required materials and deliver them on time at a certain time and place, which causes a delay in the completion of the project. Time delay increases the costs, and less profit is obtained in the whole chain.

Also, not paying attention to other criteria when choosing a contractor, inability to participate in the payment of project costs or possible damages, the inconsistency of the work process with the expressed plans of the project, the repetition of a part of the work, the inexperience of people in coordinating the project stages and so on will be happened. A high percentage of these challenges during the implementation of the project for reasons such as the lack of knowledge of the evaluators - ignoring the conditions, criteria and all the criteria required at the time of evaluation - and sometimes the lack of a suitable and integrated way to check the indicators, in the initial stage of the tendering process of construction projects That is, it is the choice of the contractor that brings inconsistencies, repetitions and future losses in a country. Such wrong actions are seemingly small, but they greatly overshadow the huge capitals of a society, including time, government budget,

superior national positions in terms of economic-social-cultural-political, etc.

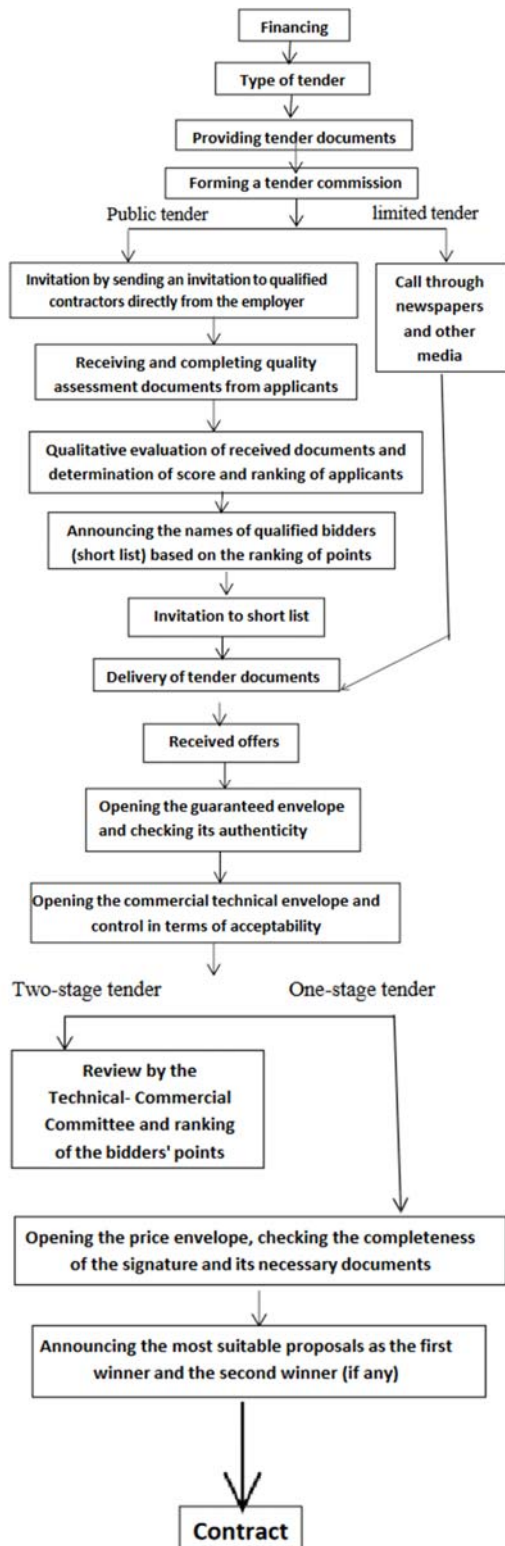


Fig. 1 Algorithm of contractor selection tenders in Iran

II. LITERATURE REVIEW

Selection of the contractor in construction projects, and not

paying attention to the determining criteria, subjective judgments, the absence of a logical and integrated technique during the selection, creates shortcomings and disturbances during the implementation. Also, because the choice of contractor and supplier are similar, very limited studies have been done to solve this problem. In most cases, the selection of the contractor is considered the same as the selection of the supplier, but it should be noted that the supplier in construction projects is a subset of the selection of the contractor, and in other cases, it has a different function from the contractor.

Shaw and his coworkers, in 2012, used fuzzy AHP and fuzzy multi-objective linear programming and according to the criteria of quality, cost, percentage of delivery delay and demand, firstly have analyzed the weights of items and then selected the best supplier by the chosen items [8].

In 2011, Chen analyzed the data of supplier companies with SWOT (Strength-Weakness-Opportunity-Threat) and defined the criteria in a framework. Then, the author ranked potential companies by analyzing the data coverage and TOPSIS and MADM techniques. The attention of this article is on quality criteria and product development and cost reduction and product life cycle [9].

In 2011, Liu and Zhang chose suppliers according to economic globalization and competition between companies. In this article, they proposed a new method by combining entropy weight and ELECTRE III. First, the threshold value is confirmed, and valid or invalid indicators are specified. Finally, the ranking of the companies is done according to the profit criterion of the network of each project [10].

Kanan and Khodavardi, in 2013, have proceeded the existing qualitative and quantitative problems in supplier selection and used the integrated approach of fuzzy multi-objective utility theory and multi-objective planning to rank suppliers by different criteria [11].

Shen and his coworkers, in 2013, have published an article by aim of more profit according to the international business environment and considering traditional criteria such as quality, price, time and environmental criteria preferences. They proposed green supply chain management, using a multi-phase approach [12].

Wang and his colleagues, in 2004, used PGP (preemptive goal programming) and AHP methods to determine the result to design an effective supply chain among the performance of suppliers by considering two general quantitative and qualitative criteria in supplier selection [13].

In 2005, Chen et al. considered criteria such as price, quality, flexibility, and transportation, weighting the factors by the MCDM model, the set of triangular and trapezoidal fuzzy numbers and TOPSIS, they reached a suitable conclusion in the ranking [14].

Nydic and Hill evaluated the selection of suppliers by criteria such as price, quality, transportation, and service, then analyzed them with the AHP method [15].

Xia and Wu have chosen supplier according to time of decrease in business volume. AHP method and multiple sourcing criteria, multiple products, capacity limitation have been considered for this allocation [16].

In 2009, an article was presented by Boran and others, based on which the criteria of price, time, quality, as well as decision opinions receiver and TOPSIS have rated the suppliers [17].

Heng and his colleagues, in 2004, presented a model of supplier selection with mathematical programming and believe that choosing a good supplier is not enough, but the continuity of the supply relationship is the goal [18].

Swift has evaluated the criteria of price, total cost, product flexibility and available techniques for evaluating and selecting company suppliers at the time of product purchase by managers with different preferences [19].

Differences between Contractor Selection and Supplier Selection

By reviewing articles, a similarity between contractor selection and supplier selection will be fined, but it is not completely. Despite the similar appearance, the details of these functions are different. The working relationship of the contractor with the supplier during the implementation of the project is different from the characteristics related to the relationship between the buyer and the seller. Therefore, all the examined criteria are also different due to the difference in the type of relationship and performance.

In terms of performance, many of the activities and operations assigned to a contractor during the execution of the project are different from the operations performed by a supplier in the performance of the assigned contract. Therefore, it is natural that the way they are selected, and the criteria measured in the selection are different.

The criteria and conditions that are used and evaluated in the selection of suppliers are price, delivery time, quality, transportation conditions, finance, cooperation, etc. (which are reviewed in the above articles). Some of these criteria are like the contractor selection criteria in this article and approved by experts, but the nature of their use is different from its form and application in a contracting tender process. Therefore, the difference in the nature of the criteria create a distinction between the choice of the contractor and the choice of the supplier. The difference in criteria is explained at the end of the article. Therefore, despite the difference in criteria and performance, there are necessarily differences in the selection.

III. CONTRACTOR SELECTION CRITERIA

After studying the past research and considering the differences between the two choices (contractor and supplier), as well as collecting information and data through interviews with knowledgeable people in this field and many surveys, the research criteria were determined. Some of these criteria are similar to supplier selection criteria and some are different from them. Of course, it was stated in the previous section that the nature of using the same criteria is also different in the two choices.

Obtained criteria in project are: locality of the contractor, familiarity with the location of the region, value engineering, circulation of tax declarations, bank financial circulation, project timing, ability to pay damages in case of delays, basis and field of qualification recognition certificate, empty rial

capacity of the company, membership in associations, environmental conditions, technical and expert personnel, supply of equipment and materials, company machinery, employer's satisfaction, previous work done, ISO, similar work done. Some of these criteria become important during the implementation of the project or are used in specific projects and are not related to the selection of the contractor in general. Also, some criteria were obtained in the research that are not related to the topic and refrain from expressing them in this article. Therefore, among all the collected criteria, less important criteria were removed, and then a questionnaire was prepared according to a five-point Likert scale and distributed among experts, who are 10 decision-makers, including the employer and law decision-makers, to measure its validity and reliability (Table I).

In the distributed questionnaire, according to the approval of the experts, its validity and reliability were measured by calculating the Cronbach's alpha coefficient. According to experts, criteria should be used that are more important in selecting a contractor and their impact is visible and tangible in different stages of the project, explaining that all criteria can be positive items for each contractor, but they are not effective in the project process. For example, environmental conditions (economic-political-social), value engineering, ISO, membership of relevant associations, etc., have no effect on the evaluation, and in other words, they have zero importance. Finally, from the obtained results, consultation of experts from mentioned statistical community and by the Borda test, 12 important criteria are selected and the second questionnaire was prepared for distribution to the public. The selected criteria are grouped into main criteria (general criteria) and sub-criteria (according to the proximity of the criteria in the same group) and are listed separately in the Table II.

The Difference in Evaluation Criteria

The criterion of time in choosing a supplier is an important indicator in the timely delivery of materials and consumables; However, in the selection of the contractor, this indicator is not directly important in the selection, and it becomes important during the project implementation, this means, after the selection, and it is mandatory to perform each stage and phase in the specified time to enter the next stages of the project.

The criterion of past performance and experience and technical expertise is a criterion that is used in the selection of supplier by considering delivery time and providing a suitable and high-quality product. But this criterion in choosing a contractor can be an important criterion in measuring the condition and efficiency. The satisfaction or non-satisfaction of the employers in the past contracts, the history and experience in the previous works, to be on time, complying with the project criteria, the presence of expertise people and past of the contractor. This item is very important to perform well in next projects. It is worth mentioning that the existence of a good supplier is an effective factor in the optimization of the above cases directly or indirectly in the performance of a contractor.

The criterion of environmental factors and physical equipment is not important in choosing a supplier. Because the

supplier does not need physical machinery and does not seek to supply them or consumables but is the supplier of these tools for the contractor, but this part is effective in choosing the contractor.

A contractor needs to provide the above items to complete the project. Also, the correct estimate of the contractor's proposed price is effective during the bidding, but the price estimate is not in supplier contracts, and only an agreed amount is transferred during the exchange of the product. Also, another point in the difference between these two choices is to note that in contracting projects, the right supplier is a subset of the contractor's performance and is considered as a criterion for selecting the contractor. In this way, a good supplier with proper performance becomes one of the positive points in choosing a contractor, and the continuation of this relationship and cooperation should not be forgotten.

Financial ability is another criterion that is very important in choosing a contractor. The fact that the contractor can advance

the stages of the project before the employer's financing or be responsible in the event of possible problems and damages and not have to keep the progress of the project is one of the things that can be determined based on the circulation of the tax declaration of previous years, the circulation of the bank and how it worked in the past was examined, but in the selection of the supplier, the financial discussion is in the field of reducing transportation costs and related matters.

In the criteria of standards, there are legal approvals to recognize the contractor's qualification in the desired field and field, but there is no such approval in the case of the supplier, and this shows the importance of choosing a contractor. The measure of empty capacity or the number of projects is also to inform about the works in progress of the company so that the financial capacity and technical people are not engaged in a project and do not cause problems; However, such criteria are not required in supplier contracts.

TABLE I
 EXPERTS' ANSWERS TO THE QUESTIONNAIRE

	Criteria	Very high (9)	High (7)	Middle (5)	Low (3)	Very low (1)	sum
Bank turnover	1	7	3				84
Environmental conditions (economic-political-social)	2			3		7	22
Payment of damages or charity	3	8		2			82
Personnel and technical and expert people	4	8	1	1			84
Empty Rial ceiling	5		6	3	1		60
Providing equipment and materials (supplier)	6	2	7	1			72
Machinery	7	3	6	1			74
Estimated price	8	5	4	1			78
Declaration income	9	5	5				80
Membership in forums	10			1	2	7	18
Satisfaction of past employers	11	1	5	4			64
Similar work as before	12		6	3	1		60
Ranking (Standards)	13		6	3	1		60
Value Engineering	14				2	8	14
ISO	15				1	9	12
Past experiences	16		7	3			64

TABLE II
 MAIN CRITERIA AND SUB-CRITERIA FOR CONTRACTOR SELECTION

Sub-criteria	Main criteria
Providing equipment and consumables (supplier) - Company's machinery - Contractor's cost estimate proposal	Environmental factors and physical equipment
Bank turnover and company capital - Declaration income in the previous year - The ability to pay damages or compensation to charity	Affordability
Expert and experienced people - Past experiences and technical records - Employer satisfaction in past contracts - The number of similar jobs done before	Past performance and technical expertise and experience
Field of qualification (ranking) and validity period - Empty capacity and the number of authorized projects	Standards

IV. STEPS OF THE PROPOSED METHOD

PROMTHEE is an outranking technique, a multi-criteria decision-making method presented by Burns and Marschal in the decade 1980 [20]. It is used in evaluating a number of options based on different criteria. The reason of this essay is the possibility of measuring all criteria which is one of the most important points in evaluating contractors. In this way, the entire chain of a contract tender is largely immune from subsequent problems. The normalization of all options in this method sets the values of all criteria at the same level, and after

completing steps, selecting the best contractor in result (Fig. 2).

It is worth mentioning that all the presented numbers and figures related to quantitative criteria are directly placed in the table for normalization and this prevents disagreements in entering the figures in the initial table. The existing quality criteria are each converted in the following way and are placed on the table in order to normalize and continue the work. This conversion is obtained from the same information mentioned by the contractor, and it also reduces the difference of opinions:

- The criterion of ability to pay damages or compensation to

charity:

$$\text{ability to pay damages} = \text{declaration income} + \text{company capital}$$

- Rating criteria (basis and field)-Validity time: If the validity of the rating has ended, the number will be zero, otherwise, according to the provided base, 1-5 should be entered in order of priority.
- Riyal ceiling criteria or the number of vacancy: If there is no vacancy, no Riyal ceiling or this criterion (Riyal ceiling) is less than estimated amount of project, the privilege will be zero and otherwise, 2 should be entered in the table.
- The criterion of how to provide equipment and consumables (supplier selection): Based on the level of employer experience and good reputation, according to the priority, number 5 up 1 should be included in the table otherwise should be zero.

Note 1: For each project, it is better employers to prepare a list of suppliers based on the quality and quantity of the services. This preparation will make suppliers with poor performance unable to participate in projects and will not cause financial losses or time delay in a project. In addition, this list creates competition among suppliers to do professionally. Also, priority of each criterion will be determined by experts' opinions and brainstorm.

Level1. Calculate the deviation range of alternatives (criteria) (A: set of alternatives). D_j values are the distance between the values (V_j) of criteria a and b in set A:

$$D_j(a, b) = V_j(a) - V_j(b) \quad \forall (a, b) \in A \quad (1)$$

Level2. Create the preference function of each criterion based on DM opinion and normalization. F_j is a function defined by the method, which is used to normalize values of the previous step and make them between zero and one, and the values of P_j is obtained:

$$P_j(a, b) = F_j[D_j(a, b)] \quad \forall (a, b) \in A \quad (2)$$

Level3. Create multi-criteria preference index based on weighted average of preference functions. P which is normalized values, is multiplied by w_j that is determined weights of each criterion. In this step, standardized values

(between zero and one) are taken as a weighted average and π is obtained:

$$\pi(a, b) = \sum_{j=1}^n P(a, b) * w_j \quad (3)$$

Level4. Determination of incoming and output and net flow. Φ function gives the number of flows related to a node, which calculates input flow (sum of rows), output flow (sum of columns). m is the number of alternatives:

Incoming flow:

$$\Phi^+(a) = 1/(m-1) \sum_{x \in A} \pi(a, x) \quad (4)$$

Output flow:

$$\Phi^-(a) = 1/(m-1) \sum_{x \in A} \pi(x, a) \quad (5)$$

Net flow:

$$\Phi(a) = \Phi^+(a) + \Phi^-(a) \quad (6)$$

Level5. Apply partial order. In this sorting, the criteria are prioritized:

- Sort the alternatives based on the descending order of the output stream.
- Sort the alternatives based on the ascending order of the incoming flow.
- Create a subscription of two orders.

Evaluation of Contractors in a Tender

By PROMTHEE method, the best contractor has been examined and selected. We have weighted the given information and prepared normalization. Final result of evaluation is shown in Table III. In addition, functions by DM's opinion are as follows: u and l are limitation of, and d is the values of each criterion:

$$F_1(d) = \begin{cases} 0, & d \leq 0 \\ 1, & d > 0 \end{cases}$$

$$F_2(d) = \begin{cases} 0, & d \leq l \\ 1, & d > l \end{cases} \quad l = 2$$

$$F_3(d) = \begin{cases} 0, & d \leq 0 \\ \frac{d}{u}, & 0 < d \leq u \\ 1, & d > u \end{cases}$$

TABLE III
FINAL RESULT OF EVALUATION

f^+	sum	6	5	4	3	2	1		
3.464	17.32	4.78	3.42	3.45	0.92	4.75		1	A
1.072	5.36	3.12	0	1.54	0		0.7	2	B
5.146	25.73	7.06	5.12	3.45		6.86	3.24	3	C
2.034	10.17	3.92	1.59		0	3.86	0.8	4	D
2.872	14.36	5.65		3.42	0.8	2.99	1.5	5	E
0.984	4.92		0.44	1.92	0	1.86	0.7	6	F
		24.5	10.57	13.78	1.72	20.32	6.94	sum	
		4.91	2.114	2.756	0.344	4.064	1.38	f^-	

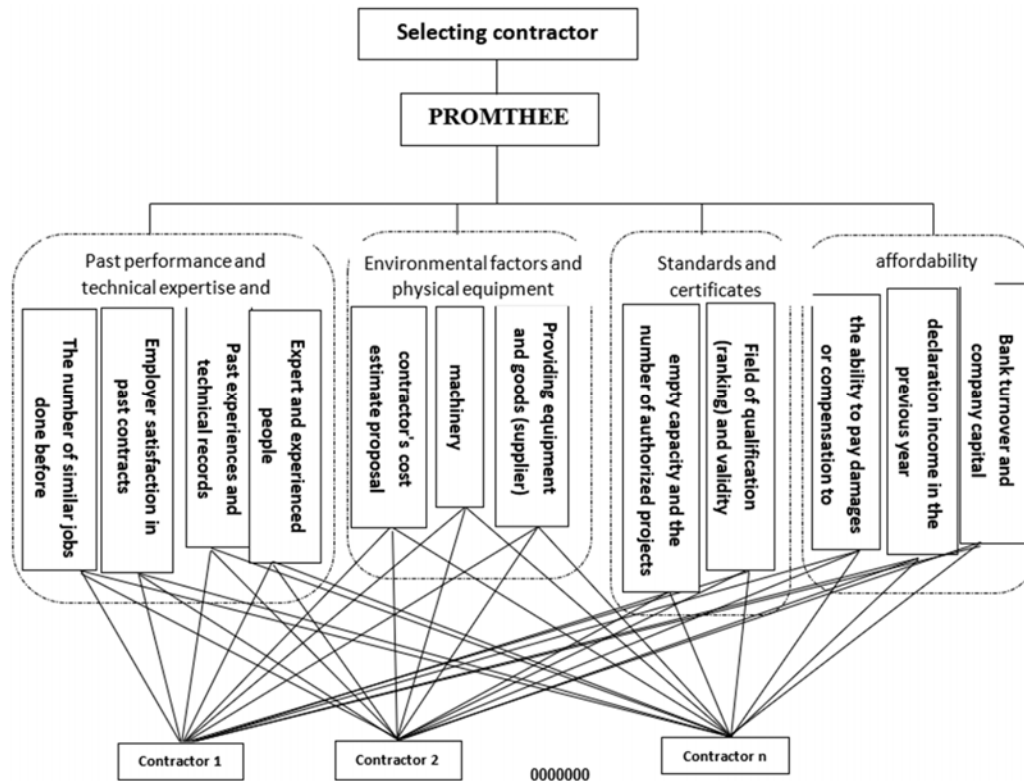


Fig. 2 Hierarchical structure of the model

Based on the final table, the following conclusion was obtained:

$$C \succ A \succ E \succ D \succ B \succ F$$

Company C was the best choice of this tender and priorities were also determined. Also, the information of these companies was measured with AHP and TOPSIS methods. From the AHP method, a very different result was obtained, which can be attributed to use of experts' opinions more in process and possibility of differences in opinions. But the results of the TOPSIS method were slightly different from the measurement. Failure to use decision-making methods has created problems in this choice. This method provides the employer with a better choice by evaluating all criteria simultaneously and then making the final selection.

V. CONCLUSION

A chain is harmonious if the decisions taken will maximize the profit of the entire chain. There is integration in a chain. Contracting tenders are not exempted from and choosing a contractor is the first stage of tenders, which is the first stage of a chain too in construction projects in a country. The optimal selection of the contractor in a tender prevents the loss of material and spiritual capital of a society. Also, distinction between choosing a contractor and a supplier is one of the other reasons for conducting this research.

With PROMTHEE method and evaluating sufficient criteria in the project, problems such as the lack of financial ability to

support the project or the lack of enough experts to be continuously present in, will be removed. The criterion of environmental factors and its sub-criteria indicate the physical and experimental facilities of the contractor. In this item, supplier selection is very important, and supplier selection articles in construction projects can be considered a subset of contractor selection articles. The past performance measure reveals the company's technical experiences which is overriding in troublesome projects. After determining the criteria, converting them (weighting) and calculating, Company C was selected as the best contractor in this tender.

Considering today's scientific advances, the existence of new techniques such as machine learning (ML) can be used to improve the above process and achieve faster optimization. The technique of unsupervised learning and clustering is a solving method, using neural network, a fast and efficient method for the above calculations. Also, another thing that can be considered with new methods, in addition to the high speed and accuracy of calculations and reaching the result, in future research, in addition to the presence of domestic companies, international companies can be used to carry out construction projects in a non-native country. This could be by using new items with appropriate weights. The advantage of this work, in addition to increasing competition among companies in order to increase optimality, efficiency and cost reduction, in the entire supply chain, will make economic relations between countries, and in other way to increase the marginal profit of each country.

REFERENCES

- [1] S. Chapra and P. -Meindl, *Supply chain management*. Pearson Education, 2001.
- [2] M. Ghazanfari and M. Fathalah, *Comprehensive approach to supply chain management*. University of Science and Technology - Publications Center, 1386.
- [3] D. Waters, *Logistics: an introduction to supply chain management*. Palgrave Macmillan, 2003.
- [4] Y. Zare Mehrjardi -H.Momeni-Sh.Barghi, "Evaluation and selection of contractors in petrochemical projects" *journal of business administration research*, vol. 2, no. 3 pp. 32– 59, 2010.
- [5] Y. M.-Z. N. Azimi-A.Pouya, "Identify and evaluate the effective indicators in Choose a Contractor to finance water and wastewater company Mashhad," *Sixth Int. Conf. Iran. Oper. Res. Soc.*, 2013.
- [6] Benarroche, *The Construction Bidding Process Explained*, 2023
- [7] Selection Criteria for Contractors, 2018, <https://ask-ehs.com/blog/selection-criteria-for-contractors/>
- [8] K. Shaw, R. Shankar, S. S. Yadav, and L. S. Thakur, "Supplier selection using fuzzy AHP and fuzzy multi-objective linear programming for developing low carbon supply chain," *Expert Syst. Appl.*, vol. 39, no. 9, pp. 8182–8192, 2012.
- [9] Y.-J. Chen, "Structured methodology for supplier selection and evaluation in a supply chain," *Inf. Sci. (Ny)*, vol. 181, no. 9, pp. 1651–1670, 2011.
- [10] P. Liu and X. Zhang, "Research on the supplier selection of a supply chain based on entropy weight and improved ELECTRE-III method," *Int. J. Prod. Res.*, vol. 49, no. 3, pp. 637–646, 2011.
- [11] D. Kannan, R. Khodaverdi, L. Olfat, A. Jafarian, and A. Diabat, "Integrated fuzzy multi criteria decision making method and multi-objective programming approach for supplier selection and order allocation in a green supply chain," *J. Clean. Prod.*, vol. 47, pp. 355– 367, 2013.
- [12] L. Shen, L. Olfat, K. Govindan, R. Khodaverdi, and A. Diabat, "A fuzzy multi criteria approach for evaluating green supplier's performance in green supply chain with linguistic preferences," *Resour. Conserv. Recycl.*, vol. 74, pp. 170–179, 2013.
- [13] G. Wang, S. H. Huang, and J. P. Dismukes, "Product-driven supply chain selection using integrated multi-criteria decision-making methodology," *Int. J. Prod. Econ.*, vol. 91, no. 1, pp. 1–15, Sep. 2004.
- [14] C.-T. Chen, C.-T. Lin, and S.-F. Huang, "A fuzzy approach for supplier evaluation and selection in supply chain management," *Int. J. Prod. Econ.*, vol. 102, no. 2, pp. 289–301, Aug. 2006.
- [15] R. P. Nydick, Robert L.Hill, "Using the Analytic Hierarchy Process to Structure the Supplier Selection Proc ...," *Int. J. Purch. Mater. Manag.*, vol. 28, no. 2, p. pg. 31-36, 1992.
- [16] W. Xia and Z. Wu, "Supplier selection with multiple criteria in volume discount environments," *Omega*, vol. 35, no. 5, pp. 494–504, 2007.
- [17] F. E. Boran, S. Genç, M. Kurt, and D. Akay, "A multi-criteria intuitionistic fuzzy group decision making for supplier selection with {TOPSIS} method," *Expert Syst. Appl.*, vol. 36, no. 8, pp. 11363–11368, 2009.
- [18] G. H. Hong, S. C. Park, D. S. Jang, and H. M. Rho, "An effective supplier selection method for constructing a competitive supply-relationship," *Expert Syst. Appl.*, vol. 28, no. 4, pp. 629–639, 2005.
- [19] C. O. Swift, "Preferences for single sourcing and supplier selection criteria," *J. Bus. Res.*, vol. 32, no. 2, pp. 105–111, 1995.