Contractor Ranking Model with Approach to Reduce Construction Project Delays and Optimization of Coefficients by Genetic Algorithm

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ABSTRACT: In Iran, the Management and Planning Organization is responsible for classifying and determining the qualifications of contractors and uses criteria to assess the ability and competence of contractors. One of the factors evaluating the productivity of a project is time and the impact of the contractor's performance on this index is undeniable. Therefore, in this study, a model for ranking contractors with the approach of reduction in delays in construction projects is presented. In this model, in addition to the criteria of the Regulations for Competence of Contractors of the Plan and Budget Organization, according to extensive research in previous studies and the opinion of relevant experts, using the FMEA method, four other criteria are identified as effective criteria for delay and severity to select a contractor. Eight criteria were modeled through genetic algorithm method so that the existing documents of contracting companies in the Isfahan Municipality Deputy for Urban Development were collected and considered as model input data. After analyzing them with the model and comparing the qualification score with the existing score of the Company, the final model was extracted. The average variable of the percentage of unauthorized delays for the contract period showed a correlation intensity of 0.712 with the relationship of the proposed qualification score. Finally, by calculating the qualification score and ranking in the proposed model, the relocation of a number of companies and the decline from the previous position was seen due to unauthorized delays, so that sometimes it even led to a change in the company's rating. Comparing the qualification score of the two models, a change in slope from 1.3% to 8.9% was also seen, which indicated the effect of the proposed criteria on the qualification score.

1- Introduction

The construction industry plays a role in the growth and development of countries. One of the factors of economic growth and development of any society is the success in the implementation of its construction projects. In the construction industry, completion in accordance with the time and cost considered is one of the common performance indicators [1]. Given that the bulk of the construction budget is allocated to executive operations and the key stage for any construction project is its implementation, the implementation of each project and its success requires the presence of a suitable contractor. Choosing the most suitable contractor can be very effective in the success of project implementation and completion [2]. Therefore, one of the most important reasons for delays in projects is the inability of the contractor as the executive arm of the employer [3]. Even in some cases, the contractor can have the highest impact on the delay [4]. Due to the fact that special criteria are considered to determine the qualifications and ratings of contractors in this study, the factors and parameters affecting the ranking of contractors with a focus on reducing delays and finally using mathematical modeling method through the genetic algorithm, the mathematical model of extracting contractors' qualification points has been implemented. In this regard, as an innovation, in addition to using a new formula to calculate the qualification score of contractors, four criteria with the approach of reducing delays in construction projects were added to the criteria of contractor qualification used in the formula of contractors' qualification regulations. Having this mathematical formula in applications such as Excel will be able to use this model.

2- Methodology

In this article, first, by reviewing the literature and research background, the factors affecting the ranking and selection of contractors have been identified and by considering these factors and their importance in causing the delay, the factors affecting the delay caused by the contractor in previous studies have been considered. In this regard, with extensive studies in the history of valid national and international research, out of 52 criteria that were used as criteria for ranking contractors, 23 criteria were identified as effective on delay, and among
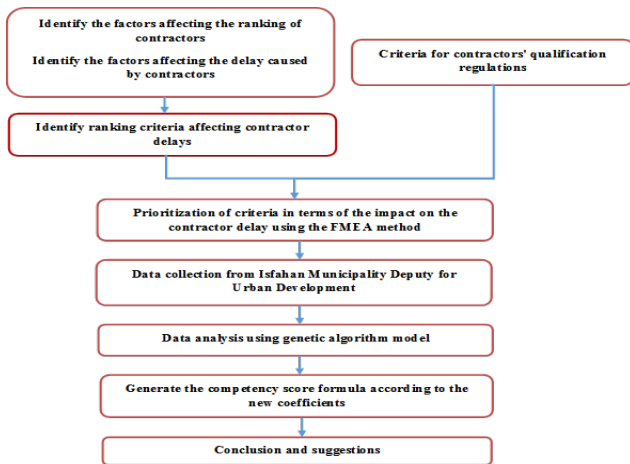
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Fig. 1. Research framework

Fig. 2. Comparison of the qualification score of some companies with a ranking of 5

them, ten criteria according to local conditions. As more effective criteria, it was provided to experts and experts in the field of contracts and the selection of contractors for the Telecommunication Company and the Electricity Distribution Office of Isfahan Province. The executive framework of the research is shown in Figure 1.

These criteria are presented to relevant and competent experts in the form of FMEA worksheets and after calculating the RPN, the severity of the delay effect, the probability of delay and the probability of detecting each of these criteria, finally, four factors of project management expertise, history of delays, quality of completed projects and experience of management personnel were identified as important and influential factors in the occurrence of delay and its severity. In MATLAB software, the logic of the genetic algorithm was implemented in such a way that these criteria combined with the criteria of the contractor qualification regulations create a mathematical model, then the existing documents of 115 contracting companies were collected in Isfahan Municipal Civil Deputy Organization and used as input for this model, after Analysis, the qualification score obtained is compared with the existing score for each company and after verification, the final model is extracted.

3- Results and Discussion

First, before performing statistical analyzes by software, the criterion of delays of the studied companies in relation to their rank was compared. Companies were seen that had high delays despite having a high ranking, or companies with a ranking of 5 did not have much delay. In statistical analysis, due to the abnormality of the data, the Friedman test was used to evaluate the rank of the model verification criteria. This test showed that the new criteria are more important than the 4 criteria in the contractors' qualification regulations. The Spearman correlation coefficient was used to examine the correlation between the data. The results showed that all variables had a significant effect on the output of the model, the qualification score of contracting companies.
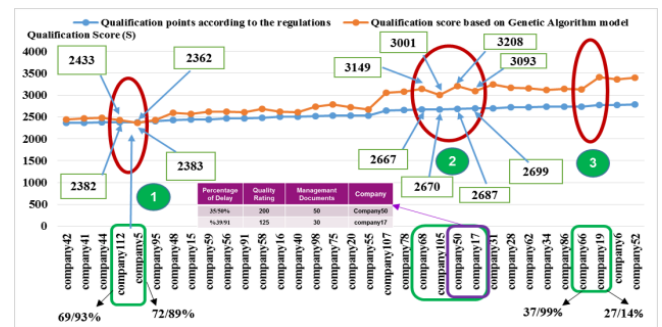
3- 1- Presenting a mathematical model for ranking contractors with a delay reduction approach

In the method used in the qualification regulations, a linear equation is used to calculate the number S (qualification score). But in this study, in order to achieve a more accurate qualification score, the quadratic equation "$ax2 + bx + c$" was used for each of the criteria. In this equation, x is the symbol of the criteria and the coefficients a, b and c are the coefficients generated and optimized by the model in the genetic algorithm

$$\min f = \left(\sum_{i=1}^{t} \left(a_i x_i^2 + b_i x_i + c_i \right) \right) - v, \quad t=1,2,...,8 \qquad (1)$$

The condition for optimal response is that the objective function in formula (1) is minimal. The values of the variable v were the previous ranks of the contractors.

3- 2- Evaluating the results of the model

Figure 2 compares the qualification scores of several companies with a rank of 5 determined by the method of regulations, with the qualification scores of the same companies resulting from the developed model of genetic algorithm.

There are ups and downs in the qualification curve of the proposed model. For example, in the area marked with the number 1, the qualification score of company 112 and company5 is increasing according to the regulations, but according to the proposed model, it is decreasing. Also in area 2, the points of the companies specified in Figure2 are in ascending order. While the qualification score of the mentioned companies varies according to the proposed model. These ups and downs are due to the use of new criteria in the proposed model. In the area marked with the number 3, mutations are seen. These jumps indicate that some companies, such as company19, have been more successful in scoring out of the four proposed new criteria. It was also found that companies that climbed their position due to higher scores in the proposed model, had a lower percentage of delays.
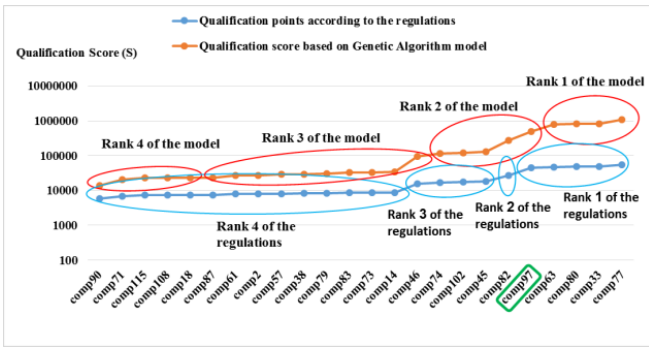
Fig. 3. Comparison of the qualification score of ranked companies 1,2,3,4

In Figure 3, the qualification scores of companies with a rank of one to four are compared by the rules method and the proposed model method. Some companies have changed their position and eventually changed their ranking. On the other hand, company97, which has a rank of 1 in the regulation method, has been reduced to a rank of 2. 4 years of tenure of the board of directors, a quality score of 30 out of 200, the score of management documents is zero and more importantly, the average percentage of unauthorized delays of this company is 117.54%.

4- Conclusions

In this study, first, the criteria for determining the competence affecting the delay were identified. With these criteria and the existing criteria of the regulation, 115 companies that had a contract with the Isfahan Municipality Deputy Civil Engineering Organization were re-ranked. The ranking was modeled using a genetic algorithm. Statistical analysis showed that the proposed criteria are more important than the other criteria and there was a significant relationship with delays. Model analysis showed that the decrease in the new competency score was due to the increase in the latency of companies, while this was not the case in the previous ranking. Also, the promotion or downgrading of some companies was seen, which indicated the exact effect of the proposed criteria on the qualification score and, consequently, the impact on the ranking and optimization of the previous ranking system.

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