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Profitability Estimation Model of Egyptian Construction Projects Using Artificial Neural Network

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Abstract: The profit ratio is important for any construction project. There is a high need to determine the profit ratio in the tendering stage. This paper investigates the factors affecting the determination of the profit ratio in the tendering stage for Egyptian construction projects. The effect of the characteristics of the project, contractor, owner, tender, and external condition on the profit ratio was studied to determine the significant factors affecting the determination of the profit ratio. A questionnaire was designed to determine the importance of 35 factors affecting the profit ratio decision and 267 responses were studied. The results indicated that most companies did not rely on any equations or analyses to determine the profit ratio for construction projects in Egypt. Employing the Relative Importance Index, the most important factors for profit ratio determination were economic stability, cash flow, degree of difficulty, size of the contract, and type of contract. The least important factors for profit ratio determination were delay penalties, safety rules, and the experience of the client. Pareto analysis was employed, and the 35 factors influencing the profit ratio were reduced to 12 significant factors. A second questionnaire was designed to identify the profit ratio for construction projects and responses were studied. An Artificial Neural Network model was developed to determine the profit ratio. Validation tests were conducted using six construction projects in Egypt. The absolute differences between actual and predicted profit ratios ranged between -0.0315% and 0.043%. This model will help to determine the profit ratio easily.

Keywords: Profit; Markup; Margin size; Tendering; and Artificial Neural Network modeling.

1. INTRODUCTION

Low or high profits in construction projects could be a significant loss to the construction project, where it causes low or high bidding unit prices. A high bidding price means being out of the bidding and a low bidding price means low profit. The lower the bidding price, the higher the risks faced by the project, the lower the availability of resources, and the overtime to complete the project. Low profits in construction projects may decrease the quality or cut the scope of the work by the contractor to overcome the loss in profit. Most companies did not use any mathematical or statistical techniques for making profit and markup percentages. The only tools that were being used in bid decision-making were experience and subjective evaluation [1]. This study aims to determine the most important factors influencing profitability in construction projects in Egypt. These considerations should be considered when determining the net profit ratio for any upcoming project. A comprehensive literature has been conducted to review the most common factors affecting the determination of profit ratio. A model was proposed for the determination of the profit ratio.

2. LITERATURE REVIEW

Many studies have been conducted to explore the factors that influence the bidding price, cost, profit, and markup of construction projects. Profitability is defined as the residual sales income after all expenditures [2]. In Saudi Arabia, 37 factors affecting the markup ratio were determined. The main important factors were the size of the contract, availability of required cash, and contract type [3]. In Australian projects, the main factors influencing the decisions on margin size

were determined as the desire to take the project, the need for work, and the contingency amount [4]. In Singapore, 40 factors influencing the markup margin decisions of large and medium-sized contractors were determined. The main factors affecting the decisions of bid markup for medium-size contractors were work availability, work needing, and making a relationship with the owner. On the other hand, the main factors affecting the decisions of bid mark-up for large-size contractors were difficulty degree, work availability, competitiveness, the risks involved in investing, and contract Size. When deciding on a bid markup, large contractors considered the difficulty of the construction task more than medium-sized contractors [5]. In Singapore, 21 important factors influencing markup size were determined and the three most essential elements were customer attributes, client size, and client type [6].

In Egypt, the main factors that influence the site overhead ratio were the duration of the project and the amount of the bill of quantities. A model was proposed using the artificial neural network (ANN) approach. The model was developed using N-Connection 2.0 Professional [7]. In Korea, 93 variables impacting the profit were classified into 5 categories: characteristics of the project, country condition, organization characteristics, the ability of the contractor, and conditions of the contract. The study employed multiple regression analysis on 126 projects from global construction to investigate the causal link between the project profit level and the degree of exposure of each risk variable and to optimize its practical application. The results indicated that the factors affecting profit in construction projects were estimation quality, information of the project in the bidding stage, the ability of the client, condition of the contract and the ability of management, organization commitment, and ability and experience of the contractor [8]. In Kuwait, the most important factors impacting markup size decisions were the owner type and project size [9]. In New Zealand, 37 factors affecting the final price of the contract were clustered. The most important factors were documentation of the tender and construction complexity [10]. In Egypt, the most important factors affecting the cost variance were the instability of the economy, the location of the project, the qualified team, finance, labor, equipment efficiency, detailed estimates, and documents of the bidding. A Neural Network model was created that may be used to estimate the cost variance of any future building project [11].

The most important factors influencing the construction profitability of private companies in Addis Ababa (Ethiopia) were the cash flow, capital structure, and working capital management. The size of the company and inflation rates had a statistically insignificant relationship with construction company profit [12]. In Nigeria, the owner's financial capability, project cash flow, and availability of the needed funds were the most critical variables influencing the bidding decision [13]. A fuzzy fault tree model was developed to help contractors' decisions on bidding [14]. The most important factors influencing the ratio of markup in Egypt were the cash flow of the project and material price inflection. A model proposed for determining the markup ratio for various project situations was developed. The model calculations were based on adding the markup percentages of all components that influence the markup percentage. [15]. The factors affecting the decisions of bidding on construction projects in Saudi Arabia were divided into 4 major categories according to characteristics of the market, owner, labor, project, and contractor. The critical factors were job size and job type [16].

The key factors affecting contractor profitability in construction projects in Nigeria were government policies and economic uncertainty as they constantly put pressure on the cost of materials and labor causing many contractors to barely recover their costs [17]. The most critical factors in improving the cost estimation of Egyptian construction projects were the state of the market and the experience of the estimation team. A mathematical model was developed to make the estimation [18]. The significant factors affecting the cost estimation accuracy of construction projects in Egypt were clear drawings, project documentation, and the experience of the estimation team [19]. The most important factors of increased overhead were inflation, payment delays, and government requirements [20]. The significant factors influencing the markup decisions for infrastructure projects in Sri Lanka were estimated direct cost, the competitiveness of other bids, work type, and duration of the project [21].

The researchers were interested in studying the factors affecting the markup margin and costs and how the decision was taken to enter tenders, but few have been interested in studying the factors affecting the determination of profit for construction projects. There is a boom in construction projects in Egypt and the local market has rapid changes that affect the determination of the project profit. Therefore, there is a high need to develop a model to predict the net profit ratio.

3. RESEARCH METHODOLOGY

This research aims to explore the significant factors affecting the determination of the profit in construction projects and develop a model for determining the profit ratio for construction projects in Egypt.

Compensative literature has been conducted to study the most common factors affecting profit determination. 35 Factors affecting the profit ratio were determined based on the previous literature analysis. These factors were classified into 5 categories: characteristics of the project, contractor, owner, tendering, and external factors .

A questionnaire survey was designed and distributed to investigate the significance of the 35 factors influencing the profit ratio decision in the Egyptian market employing the Likert scale (very high, high, medium, low, very low). These factors were classified into five major categories. The survey categories were characteristics of the project, contractor, owner, bidding, and external factors. Pareto analysis was employed, and the 35 factors influencing the profit ratio were reduced to 12 significant factors. A second questionnaire was designed, and respondents were asked to identify the profit ratio for the various construction projects of the significant factors. The data from 44 real-life construction projects built in Egypt were used for developing the Artificial Neural Network model to determine the profit ratio.

4. SAMPLE SIZE

This study's population included all project managers, construction managers, site engineers, cost estimation engineers, cost controlling engineers, procurements engineers, quantity surveying engineers, and planning engineers, which included all civil engineers in Egypt.

In determining sample size, the alpha level means that the true margin of error may exceed the acceptable margin of error. In Cochran's formula, the alpha level is incorporated into the formula by utilizing the t-value (the t-value for an alpha level of 0.05 is 1.96 for sample sizes above 120) [22]. The sample size was found to be equal to 267 employing alpha level = 0.05, t = 1.96, and the margin of error = 0.05.

5. DATA ANALYSIS

The Relative importance index (RII) was calculated in Table 1to rank the 35 factors affecting the profit using the following Eq. (1) [15].

$$\mathrm{RII} = \frac{5 * \mathrm{N5} + 4 * \mathrm{N4} + 3 * \mathrm{N3} + 2 * \mathrm{N2} + 0 * \mathrm{N1}}{5 * (\mathrm{N5} + \mathrm{N4} + \mathrm{N3} + \mathrm{N2} + \mathrm{N1})} \quad (1)$$

Where RII: Relative Importance index, and N5, N4, N3, N2, N1 are the numbers of the respondents in each group.

By evaluating the importance indices of each factor in Table 1, the most important factors for net profit ratio determination were economic stability, cash flow, degree of difficulty, size of contract, and type of contract with relative importance indices of 90.79%, 89.44%, 88.01%, 86.89%, and 86.37%. The least important factors for net profit ratio determination were delay penalties, safety rules, and experience of the client with relative importance indices of 2.85%, 2.10%, and 1.80%.

Table 1. The ranking factors and relative importance index

ID	Category	Factors	RII	Rank	[13]	[15]	[16]	[18]	[19]
1.1	Project characteristics	Size of contract	86.89%	4	●	●	●		●
1.2		Contract duration	73.33%	11	●	●	●		●
1.3		Cash flow	89.44%	2	●	●	●		
1.4		Project location	19.48%	16	●	●	●		●
1.5		Degree of difficulty	88.01%	3	●	●	●		●
1.6		Safety rules	2.10%	34	●	●			
1.7		Type of project	57.00%	12	●		●		●
1.8		Site condition	4.87%	32	●			●	●
1.9		Equipment required availability	9.74%	24	●		●	●	●
1.1		Material availability	11.31%	21	●				●
1.11		Delay penalties	2.85%	33					
1.12		Advanced payment	6.44%	31					●
2.1	Contractor characteristics	Cost estimation Accuracy	84.12%	6			●		●
2.2		Need of work	7.34%	29	●	●	●		
2.3		Previous profit in similar projects	22.55%	15		●	●		

ID	Category	Factors	RII	Rank	[13]	[15]	[16]	[18]	[19]
2.4		Current workload	24.87%	14		●	●		●
2.5		Experience in similar old projects	80.22%	8	●	●			●
2.6		Technical staff availability	32.43%	13		●		●	●
2.7		labor (cost, availability)	9.66%	25	●		●	●	●
2.8		Contractor classification	10.86%	22					●
2.9		Productivity of labor	8.61%	28		●		●	
2.1		Expected waste quantity	6.52%	30					●
3.1	Owner characteristics	Type of client	79.40%	9	●	●			●
3.2		Experience of client	1.80%	35					●
3.3		Delay in payments by the owner	17.75%	17					●
3.4		Expected Changes	78.95%	10					
3.5		Experience of consultant	9.21%	27					●
4.1	Tendering situation	Tender selection method	9.59%	26			●		●
4.2		Availability of other projects	83.30%	7		●			●
4.3		Level of competition	9.89%	23	●	●	●	●	●
4.4		Type of contract	86.37%	5	●			●	●
4.5		Accuracy of bidding documents	12.73%	19	●	●			●
5.1	External factors	Economic stability	90.79%	1					●
5.2		Currency exchange fluctuation	11.69%	20				●	
5.3		Changing government laws	16.63%	18					●

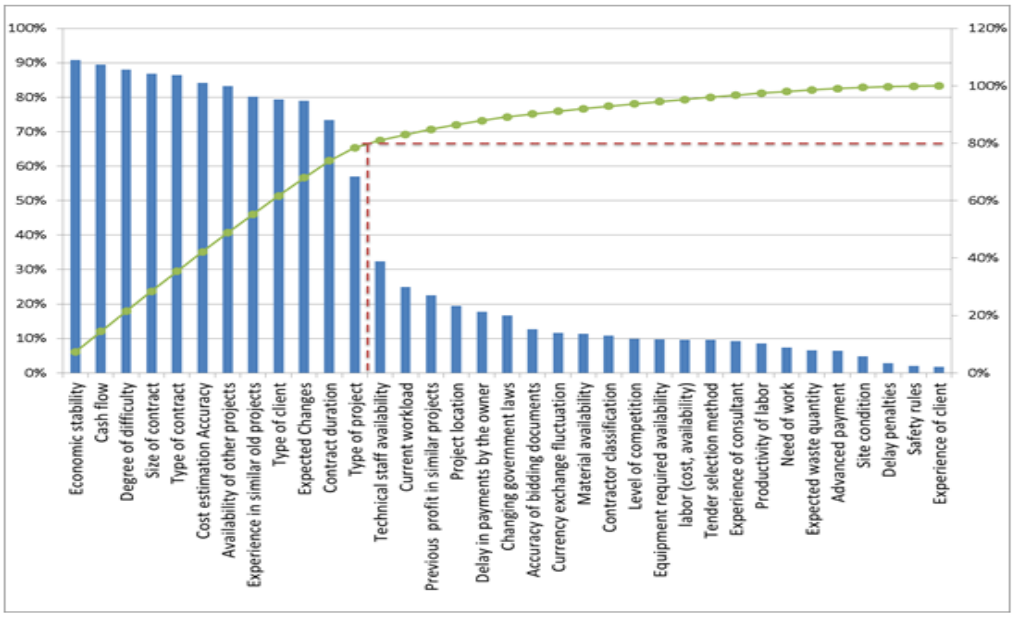

Fig 1. Pareto Analysis Chart

The most important factor influencing the ratio of markup (including profit) in Egypt was the cash flow [15]. In this survey, the cash flow was ranked as the 2nd most significant factor. Cash is the main engine of the project's success. Maintaining the cash flow is critical for keeping the project moving, and profitable.

Economic stability was determined as the 2nd significant factor affecting the markup (including profit) [15]. In this survey, economic stability was ranked as the 1st most significant factor. Economic instability strongly affects the loss of profit .

Previous experience of the contractors was determined as the 2nd significant factor affecting the markup (including profit) [15]. In this survey, the previous experience was ranked as the 27th most significant factor. Previous experience of the contractors helps in predicting the main problems of the project.

Cost accuracy was the most important factor influencing the profit ratio in Korea, but it was the 6th in Egypt. Bidding documentation was the 2nd important factor influencing the profit ratio in Korea, but it was the 19th in Egypt. The cash flow was the 3rd important factor influencing the ratio of profit in Korea, but it was the 2nd in Egypt. The type of the contract was the 4th important factor influencing the profit ratio in Korea, but it was the 5th in Egypt. Project site condition was the 5th important factor influencing the ratio of profit in Korea, but it was the 32nd in Egypt. Previous experience of the contractor condition was the 6th important factor influencing the ratio of profit in Korea, but it was the 8th in Egypt [8].

6. PARETO ANALYSIS

The Pareto principle (the 80/20 rule) states that for many outcomes, roughly 80% of consequences come from 20% of causes (the "vital few"). As a result of this percentage, the first twelve significant factors were selected, as shown in Figure 1.

7. MODEL DEVELOPMENT

Many critical construction decisions need the use of neural network models, which have been designed to help decision-makers. It was proposed the use of neural networks in the development of optimal markup estimation [23]. The genius of neural networks lies in their ability to build nonlinear models of variable interactions [24]. In Singapore, modeling of contractor's markup estimation was used by the neural network [6]. The researchers also developed an automated program, MATLAB, to reduce the uncertainty of activity costs to predict the best-fit probability distribution of cash flows, overdrafts, and profit [25]. Some of those models were created to estimate costs, make decisions, forecast the percentage of markup, and so on. The main goal of this research is to create an artificial neural network (ANN) model to predict the profit ratio for construction projects in Egypt using the most important factors that influence the profit ratio as input variables using the SPSS software version (27).

ANNs have many significant benefits:

1. ANN can learn and model nonlinear and complicated interactions, where many relationships between inputs and outputs in real life are nonlinear and complex.
2. After learning from the raw inputs and their associations, ANNs can generalize and forecast the unseen data.
3. Unlike many other prediction approaches, ANN places no constraints on input variables (such as how they are distributed).

7.1. Data Gathering and Artificial Neural Network Model Design

Forty-four projects were collected from the 2nd questionnaire for training and testing the proposed ANN-based model. The types of projects are commercial, residential, institutional, educational, and other construction projects accounting for 13%, 34%, 13%, 13%, and 27% of the surveyed projects, respectively, as shown in Figure 2.

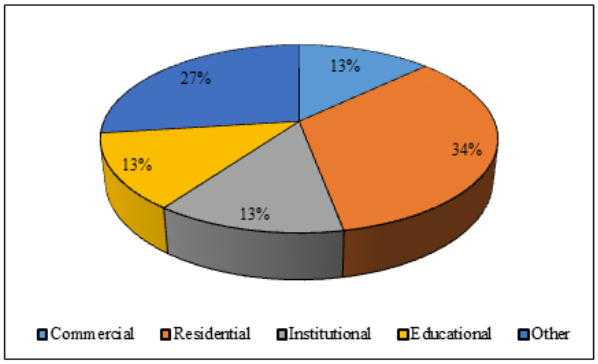

Fig 2. Studied 44 Construction Projects in Egypt

To determine if the amount of data obtained is sufficient to train the network and address the problem at hand, there is a potential method to start getting the proper number of neurons by using Eq. (2) [7].:

$$\text{The number of hidden neurons} = \frac{\text{Input} + \text{Output}}{2} = \frac{12+1}{2} = 7 \text{ neurons.} \quad (2)$$

The minimum number of projects required for the ANN to be adequately trained, tested, and validated by the model was calculated by using Eq. (3) [7].

$$\text{The minimum number of projects} = 2 * (\text{Input} + \text{Hidden} + \text{Output})$$
$$= 2 * (12+7+1) = 40 \text{ projects} \quad (3)$$

7.2. Data Encoding Methodology

Table (2) shows the method used to encode the input fields to accurately simulate the system. When combined with the previously mentioned strategies, these encoding techniques enable the building of a robust Neural Network, given predictive information exists in the data.

Table 2. Data field encoding scheme

ID	Factors	Subcategory (Values)	Coding
1	Economic stability	Stable	1
		Medium- stable	2
		Un stable	3
2	Cash flow	Front Loaded	1
		Normally distributed	2
		Back loaded	3
3	Degree of difficulty	Low	1
		Medium	2
		High	3
4	Size of contract	<100 M	1
		100 -200 M	2
		200- 500 M	3
		>500 M	4
		Fixed Price economic price adjustment	1
		The fixed price	2
5	Type of contract	Fixed price with economic price adjustment	1
		Fixed price	2
6	Cost estimation Accuracy	Quick estimation	1
		Detailed	2
7	Availability of other projects	Not available	1
		Available	2
8	Experience in similar old projects	Not available	1
		Available	2
9	Type of client	Public Client	1
		Private Client	2
10	Expected Changes	Low	1
		High	2
11	Contract duration	< 12 Months	1
		12 - 24 Months	2
		> 24 Months	3
12	Type of project	Residential buildings	1
		Educational buildings	2
		Entertainment projects	3
		Commercial buildings	4
		Institutional buildings	5
		Industrial buildings	6
		Water and irrigation projects	7

7.3. Model Training

Training the ANN model is a procedure that modifies the network's weight strength using one of many learning approaches. The ANN model is fed with a training data set as inputs, and the outputs are calculated.

The difference between the predicted profit ratio and the actual profit ratio is analyzed. The ANN model weights are continually modified as the training progresses until the inaccuracy in the estimated outputs converges to an acceptable level. It creates the input-to-output mapping by minimizing absolute difference by using Eq. (4) and the root mean square error (RMS) by using Eq. (5) [7]:

$$\text{Absolute difference} = \frac{\sum_{I=1}^{X}|P-A|}{N} \quad (4)$$

$$\text{RMS} = \frac{\sqrt{\sum_{I=1}^{X}(P-A)^2}}{N} \quad (5)$$

Where:

- **X** is the number of samples to be assessed during the training phase,
- **P** is the predicted profit ratio from the ANN model for sample I (i=1 ...x),
- **A** is the real profit ratio.

When the root mean square error (RMS) remains constant, the training procedure should be terminated. The training file contains 86.3% of the information gathered (i.e., 38 projects). These details are utilized to train and self-test the ANN model.

The resulting number for each of them quantifies the prediction error; a value close to 0.0 indicates that the model is intact, whereas a value close to 1.0 indicates that the model is broken [26].

7.4. Model Testing

Testing and training of the model were done using the neural network. It is critical to assess the ANN model performance following training. If the findings are satisfactory, the network will be operational. If not, this indicates that more or better data is required, or that the network should be redesigned.

13.6% of the information gathered (i.e., 6 projects) is then used to assess the ANN model's ability to anticipate a new output. This data is utilized to assess the ANN model's capacity to forecast a new output, where the absolute difference is generated automatically by the program for each project outcome.

7.5. SPSS Data File Creation

The database that fed into the Excel file had 38 construction projects in Egypt and six other projects for final best model testing. 28 projects (73.7%) were required for the program for training correctly, and 10 projects (26.3%) were used for validation (SPSS self-testing).

7.6. Choosing the Best Model

The neural network automatically configures the model training, and tests the variables that must be specified by the program during the design steps:

1. The number of hidden layers (up to two);
2. The number of hidden nodes in each layer; and
3. The kind of transfer function (tangent or sigmoid).

The program developed in this research was created by making the following changes, and the model structure with the lowest RMS value was then chosen.

- Sigmoid Transfer Function with one Hidden Layer, 14 trials.
- Tangent Transfer Function with one Hidden Layer, 14 trials.
- Sigmoid Transfer Function with two Hidden Layers, 14 trials.
- Tangent Transfer Function with two Hidden Layers, 14 trials.

The best ANN Model was produced through the trial-and-error method. This model is being tested with the following design parameters:

- Inputs neurons (nodes): 12
- Output neurons (node): 1
- Hidden layer: two
- No. of Hidden Nodes 1st hidden layer: 4
- No. of Hidden Nodes 2nd hidden layer: 1
- The transfer function is a Tangent transfer function for both hidden layers.
- RMS (Root Mean Square Error) = 0.10968509
- The absolute mean difference = 0.44670233

7.7. Model Validation

Six projects, as mentioned previously, were introduced to the final designed model without the percentage of their profit ratio. The predicted percentages were compared to the real project percentages, and the differences between them were calculated using the absolute difference using Eq. (6). The actual and predicted percentages for the six projects are shown in Figure 3. These six Egyptian construction projects were 1) social housing for members of the Egyptian Judges Club, 2) New Helwan University, 3) residential villa in Fifth Settlement (Beit Al-Watan Housing), 4) a commercial center and administrative complex in the International City of Horses, 5) a residential project (Decent Life Initiative), and 6) Manfalut General Hospital project.

$$\text{Absolute difference} = \frac{\text{Predicted} - \text{Actual}}{\text{Actual}} \quad (6)\ [7]$$

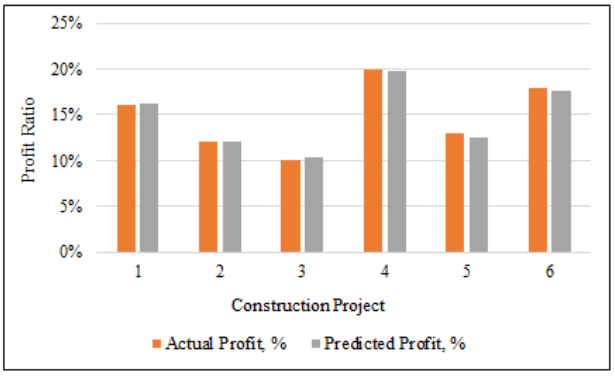

Fig 3. The Actual and Predicted Profit Ratios

The absolute differences ranged between -0.0315% and 0.043%, which are considered satisfactory to demonstrate that the suggested model can predict the profit ratio

8. CONCLUSIONS

The purpose of this paper is to study the main factors influencing the profit ratio in the Egyptian construction industry. This study investigated 35 factors that influenced the profit ratio. A questionnaire was designed, and 267 responses were analyzed to determine the importance of each factor using the Relative Importance Index (RII). The most important factors for profit determination were economic stability, cash flow, degree of difficulty, size of the contract, and type of contract. The least important factors for profit determination were delay penalties, safety rules, and the experience of the client. Pareto analysis was employed, which achieved reducing the 35 factors influencing the profit to only 12 significant factors.

A second questionnaire was designed, and responses were studied to identify the profit ratio for the various construction projects of significant factors. An Artificial Neural Network (ANN) model was proposed using the 12 significant factors and the data from 38 construction projects in Egypt. The model was validated by other 6 construction projects in Egypt

using the absolute difference between the actual and the predicted profit ratios from the developed model. The absolute differences ranged between -0.0315% and 0.043%, which are considered satisfactory to demonstrate that the suggested model can predict the profit ratio. This model will help the top management to predict the optimum profit ratio.

REFERENCES

[1] Ahmad, I. and Minkarah, I. (1988). "Questionnaire survey on bidding in construction". Journal of Management in Engineering, 4(3), 229-243.

[2] Akintoye, A. and Skitmore, M. (1991). "Profitability of UK construction contractors". Construction Management and Economics, 9(4), 311-325.

[3] Shash, A. A. and Abdul-Hadi, N. H. (1992). "Factors affecting a contractor's mark-up size decision in Saudi Arabia". Construction Management and Economics, 10(5), 415-429.

[4] Fayek, A., Young, D. M., and Duffield, C. F. (1998). "A survey of tendering practices in the Australian construction industry". Engineering Management Journal, 10(4), 29-34.

[5] Dulaimi, M. F. and Shan, H. G. (2002). "The factors influencing bid markup decisions of large-and medium-sized contractors in Singapore". Construction Management & Economics, 20(7), 601-610.

[6] Ling, F. Y. Y. and Liu, M. (2005). "Factors considered by successful and profitable contractors in mark-up size decisions in Singapore". Building and Environment, 40(11), 1557-1565.

[7] El-Sawy, I., Abdel Razek, M. E. and Mohammed, H. H. (2010). "Assessment of Overhead Cost for Building Construction Projects". M. Sc. Thesis presented to the College of Engineering and Technology, AASTMT, Cairo branch, Egypt). Engineering and Management, 138(3), 376-389.

[8] Han, S. H., Kim, D. Y., and Kim, H. (2007). "Predicting profit performance for selecting candidate international construction projects". Journal of Construction Engineering and Management, 133(6), 425-436.

[9] Jarkas, A. M. (2013). Primary factors influencing bid markup size decisions of general contractors in Kuwait. Journal of Financial Management of Property and Construction, 18(1), 53-75.

[10] Ji, C., Mbachu, J. and Domingo, N. (2014). "Factors influencing the accuracy of pre-contract stage estimation of the final contract price in New Zealand". International Journal of Construction Supply Chain Management, 4(2), 51-64.

[11] Asal, E. (2014). "Factors affecting building construction projects' cost estimating". Master's Thesis in Construction Engineering and Management, Arab Academy for Science, Technology and Maritime Transport (AASTMT)).

[12] Kidanu, t. (2016). "Factors affecting profitability in the case of Ethiopian selected private construction companies". (Doctoral dissertation, St. Mary's University).

[13] Oyeyipo, O., Odusami, K. T., Ojelabi, R. A., and Afolabi, A. O. (2016). "Factors affecting contractors' bidding decisions for construction projects in Nigeria". Journal of Construction in Developing Countries, 21(2), 21-35.

[14] Marzouk, M., & Mohamed, E. (2018). Modeling bid/no bid decisions using fuzzy fault tree. Construction innovation, 18(1), 90-108.

[15] Mohamed, S. M., Khalil, A. H., and Badawy, M. (2017). "Factors Influencing the Markup Ratio in the Construction Industry". International Journal of Innovative Research in Science, 6(12), 22889-22901.

[16] Alsaedi, M., Assaf, S., Hassanain, M. A., and Abdallah, A. (2019). "Factors affecting contractors' bidding decisions for construction projects in Saudi Arabia". Buildings, 9(2), 33.

[17] ALAGBOSO, O. J. (2019). "Assessment of Factors Affecting Contractor" s Profit in Construction Projects in South-East Nigeria". Iconic Research and Engineering (IRE) Journals | Volume 3 Issue 4 | ISSN: 2456-8880

[18] Sayed, M., Abdel-Hamid, M., & El-Dash, K. (2023). Improving cost estimation in construction projects. International Journal of Construction Management, 23(1), 135-143.

[19] Ibrahim, A. H. and Elshwadfy, L. M. (2021). "Factors Affecting the Accuracy of Construction Project Cost Estimation in Egypt". Jordan Journal of Civil Engineering, 15(3).

[20] Aziz, F. and Willis, C. (2021). "An Investigation of Construction Company Overhead Costs in Guyana". Int J Account Res, 9, 216.

[21] Perera, B. A. K. S., Wijewickrama, M. K. C. S., Ranaweera, W. R. S. C., and Gamage, I. S. W. (2021). "Significant factors influencing the bid mark-up decision of infrastructure projects in Sri Lanka". International Journal of Construction Management, 21(8), 769-783.

[22] Barlett J., Kotrlik J., and Higgins C. (2001). "Organizational research: determining appropriate sample size in survey research". J Inf Technol Learn Perform.19(1):43–50.

[23] Moselhi, O., Hegazy, T., and Fazio, P. (1991) "Neural Networks as Tools in Construction". Journal of Construction Engineering & Management, ASCE, 117(4), 606–625.

[24] Andrew, S. (1999)."Neural Connection 2.1" University of Texas at Arlington. http://www.und.edu/instruct/aquinn/neural_connection.pdf.last accessed on 1/3/2014

[25] Lee, D. E., Lim, T. K., & Arditi, D. (2012). Stochastic project financing analysis system for construction. Journal of Construction Engineering and Management, 138(3), 376-389.

[26] Hasan, S. and Elwakil, E. (2020). "National bridge inventory data-based stochastic modeling for deck condition rating of prestressed concrete bridges". Practice Periodical on Structural Design and Construction, 25(3), 04020022.