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Factors Affecting the Accuracy of Construction Project Cost Estimation in Egypt

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ABSTRACT

An accurate cost estimate is very important for the success of any construction project. This study aims to identify and rank the factors affecting the accuracy of cost estimation in construction projects in Egypt. From the literature review, seventy factors were identified. A questionnaire survey was carried out among 106 contractors and consultants. Relative importance index, Kendall's coefficient and coefficient of variation were used to analyze data. The results revealed that the most significant factors affecting cost estimates are clear and detailed drawings, specifications and project documentation, experience and skill level of cost estimator, completeness of cost information (accuracy, quality and details), materials (prices, availability, quality and imports) and experience on similar projects.

KEYWORDS: Construction cost estimation, Estimation accuracy, Construction industry, Egypt.

INTRODUCTION

Construction industry is regarded as the corner-stone of any economy globally, as it requires a fairly high percentage of the national labor force and contributes to gross domestic product (GDP). In addition, it plays a strategic role in developed as well as in developing countries. This sector is considered one of the largest in the world because of its responsibility for developing the infrastructure for towns, cities and nations. However, it becomes more complex due to the great uncertainties involved during a project's lifetime, as a result of the complexity of the construction process itself, the large number of stakeholders involved in the construction process and its sensitivity to outside changes (Mahamid, 2015).

Improving the functions of construction project management can bring about an improvement in construction industry. One of the most significant functions of construction management is the cost estimation process (Abdal-Hadi, 2010). A project's success or failure depends on cost estimation accuracy. Accurate cost estimation enhances contracting (Ahuja, Dozzi & Abou Rizk, 1994). Enshassi et al. (2013) stated that the success of a construction project is affected by a number of factors, such as project complexity, contractual obligations and effective communications between stakeholders. In addition, the success of a project is measured by time, cost and quality elements. They also stated that cost estimates assess whether the company is prepared to bid on construction tenders and win the tenders. Also, cost estimation plays a significant role in marketing companies. However, the final project costs, in many cases, are higher than the initial estimates due to different factors.

Shash and Ibrahim (2005) identified that the big challenge for construction firms is to surpass the project budget. Cost estimates may be greatly enhanced if the scope of the project, community interest and macro-economy are accurately reflected. Hatamleh et al. (2018) stated that exact cost estimate and practical evaluation of factors that can increase the cost of a project should be performed for projects to be delivered according to a specific budget.

Construction cost estimates may be affected by

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many factors, such as material prices, the accuracy of BOQ, construction method/ techniques/technology and quality of assumptions used in preparing the estimate, among many other factors. From previous studies, it has been found that the success of a project depends not only on cost, time and quality, but also on other factors. However, in this research, we focus on the cost factor only, because it has a huge impact on the success of the project.

Based on previous studies, cost estimation is very important for the success of any project. Therefore, identifying the factors affecting the accuracy of the cost estimate is very important to improve the estimation accuracy. This paper aims to identify the most significant factors affecting cost estimation accuracy, give an accurate construction cost estimate and enable contractors to make more accurate cost estimates for construction projects in Egypt.

Research Objectives

1. Assessing the factors affecting the accuracy of cost estimation in construction projects in Egypt.
2. Ranking and evaluating these factors.
3. Identifying the top ten factors affecting the accuracy of cost estimation in construction projects in Egypt.

LITERATURE REVIEW

Many studies were performed to evaluate and rank the factors affecting construction cost estimates. Azman (2012) studied the accuracy of preliminary cost estimates in the public work department (PWD) in Malaysia. The results of studying 83 projects according to three estimating targets revealed that a project's size, number of bidders, location and type are the most important factors that affect the accuracy of cost estimates. Alghonamy (2015) identified the most important factors that cause cost overrun from the contractors' perspective in Saudi Arabia. Forty-three questionnaire surveys were analyzed, which concluded 34 causes of cost overrun. The study showed that the most important factors are bid award for the lowest price, frequent design changes, payment delay, improper planning and long period between design and implementation.

Enshassi et al. (2013) assessed and ranked the most important factors affecting the accuracy of pre-tender cost estimation in the Gaza strip according to the perspectives of clients and consultants. A questionnaire survey was designed to conclude a total of 64 factors. The results showed that the most essential five factors affecting the accuracy of cost estimation are materials (prices, availability, quality and supply), closure and blockage of borders, project team's experience in the construction type, experience and skill level of consultants and clear and detailed drawings and specifications. Ji et al. (2014) studied the factors that may affect the final contract price in New Zealand. Multi-attribute method was used to analyze 150 responses from professional members of the New Zealand Institute of Quantity Surveyors. The results showed that there are 37 factors affecting the final contract price. Three of the most important factors are poor tender documentation, complexity of design construction and incompleteness of project information.

Bari et al. (2012) identified the factors affecting the construction cost for industrialized building system (IBS) projects in Malaysia. The relative importance index (RII) was used to evaluate and rank these factors. The total factors are categorized into seven main groups, including characteristics of general contracts, methods of procurements, attributes of contractors, design parameters and external market factors. The results showed that the characteristics of project contractors' attributes and market factors were more important than other factor groups. Elfahham (2019) predicted a construction cost index (CCI) for concrete structure focus on material costs only. Three approaches were used to predict this index; namely, neural networks, linear regression and autoregressive time series. The three approaches were analyzed to evaluate performance and find out which approach would give the highest accuracy. The results showed that the autoregressive time series approach is the most accurate approach.

Elhag et al. (2005) identified and evaluated factors that affect cost estimates in the UK. A questionnaire survey was conducted, including sixty-seven factors. These factors were categorized into six categories. The results showed that there is a strong agreement between responses in ranking cost factors. Pujitha and Venkatessh (2020) developed a unit cost estimation approach to predict a project's final cost. To test this method, a case study was selected based on the collected periodic data. The results showed that this method helped the

construction team minimize unit cost. Also, it was considered as an assessment tool of work standards by comparing project unit production cost values.

Aibinu and Pasco (2008) studied the accuracy of pretended cost estimation in Australia. The study was undertaken on 56 projects. A questionnaire survey was conducted, including eight factors. The results revealed that the accuracy of estimates was affected by project size. Memon et al. (2014) identified the factors affecting construction cost performance. A total of 15 factors were identified from the literature and interviews. A questionnaire survey was carried out to collect data. The results showed that fluctuation in the prices of materials, cash flow, financial difficulties faced by contractors and shortage of site workers are the most significant factors. Musarat et al. (2020) studied the role of inflation rate and its impact on construction industry and economics. The study noted that the inflation rate was neglected in budgeting construction projects. Therefore, this caused cost overruns for the project as labor wages, machinery hire rates and prices of materials. A framework was developed to clarify the strong relationship between construction industry and inflation rate. This framework is useful to overcome cost overrun which occurs because of the inflation rate.

Alumbugu et al. (2014) studied the factors affecting the accuracy of cost estimates in Kaduna state, Nigeria. The study was carried out through a questionnaire survey. The importance index and correlation analysis were used to analyze the collected data. The results revealed that there is a significant agreement between clients, consultant and contractors regarding the most important factors influencing the accuracy of cost estimates. These factors are experience and skill level of consultant, project team experience on the construction type and clear and detailed drawings and specifications. Enshassi et al. (2010) identified the factors affecting cost overrun in construction projects in the Gaza strip. Forty-two factors were identified from the literature review. A questionnaire survey was undertaken to collect data from contractors. Importance index was used to rank and evaluate these factors. The results revealed that the most significant factors that cause cost overrun are increase in material prices due to continuous border closures, delay in construction, supply of raw materials, equipment of constructors and fluctuation in the cost of building materials.

Sayed et al. (2020) studied the factors affecting cost estimates to improve cost estimation in a construction project. From the literature review, twenty-nine factors were collected, then reduced to nine factors by the Pareto technique. The nine factors were used to develop an arithmetical model. This model was tested on fourteen completed projects. The cost variances calculated by the model were 0.5 % and 0.8% for each case. Bakr (2019) identified the most significant factors affecting the accuracy of cost estimates at the tendering phase in Jordan. From the literature review, 59 factors were collected. A questionnaire survey was designed and distributed to 450 experts in construction. The RII was used to rank these factors. The results revealed that level of experience of the estimation team, client's financial capabilities and the experience of the project team are the most important factors.

Kasem and Alhaffar (2011) studied the situation of cost management in building projects in Syria. This study was conducted by a questionnaire survey to collect data. This questionnaire was distributed among a number of workers in the construction sector. The results showed that cost management methodology was not applied in Syrian building projects. Hammad et al. (2008) developed statistical regression models and sample tests depending on real data of 140 projects. These models were developed based on historical data for similar projects. The results showed that the models are effective in predicting project cost and duration. Enshassi et al. (2007) identified and ranked the most significant factors affecting cost estimation in the Gaza strip from the contractors' perspective. A questionnaire survey was used to rank 51 factors. The results revealed that the most important factors are: location of the project, segmentation of the Gaza strip and limitation of movement between areas, political situation and closure of the Gaza strip.

Akinradewo et al. (2020) studied the factors affecting the accuracy of road cost estimates in Ghana. This research showed that improper project planning, insufficient preliminary site investigation, use of shortcuts, use of outdated market prices and incorrect equipment productivity are the most important factors. Akinradewo et al. (2020) stated that, to improve the road project's estimate in Ghana, estimators should give more attention to factors, such as clear definition of project scope, availability of sufficient design in format, formal

feedback between design and estimating teams and proper design documentation and information management.

The above-mentioned literature review indicates that different authors have used different techniques to assess factors that influence the accuracy of cost estimates in construction projects. A total of seventy factors affecting construction cost estimation were identified from the literature and were categorized into six main categories. As previously reported, several studies are being performed to analyze the effects of various factors on the performance of cost estimates. However, there is no agreement among researchers on the most significant and influential factors influencing the accuracy of cost estimates. Furthermore, to the best of the researchers' knowledge, no research in this field has been performed in Egypt. As a consequence, this is the key factor that motivated the researchers to perform this analysis.

This paper evaluates and ranks factors affecting cost estimation of construction projects in Egypt. A questionnaire survey is used to collect data from a randomly selected group of contractors and consultants in Egypt. The questionnaire was filled by 82 contractors and consultants and the rate of their responses was 77.36%. In addition, the paper describes the statistical analysis of the survey, which includes severity index and coefficient of variation.

RESEARCH METHODOLOGY

A two-stage research methodology was performed for the research. Firstly, literature surveys and contractor interviews were conducted to identify factors affecting the accuracy of cost estimates of construction projects in Egypt. Seventy factors were identified and grouped into six main factor categories as follows:

- Consultants, design parameters, information and estimators.
- Client characteristics.
- Project characteristics.
- Contract requirements.
- Contractor characteristics.
- External factors.

Secondly, a questionnaire was designed to rank the identified factors according to their importance level. To develop the questionnaire prior to distribution, a pilot study was carried out with ten experts involved in construction projects. Depending on their experience, several expressions were revised and the questionnaire was put in its final form. According to sample size calculation, one hundred and six questionnaire forms were randomly distributed among 84 contractors and 22 consultants. The number of contractors is more than the number of consultants, because the detailed cost estimate is very important for contractors. The response rate to the questionnaire was 82 respondents representing about 77.36%; 66 contractors (80.49%) and 16 consultants (19.51%). A five-point Likert scale was used to evaluate these factors (1 for extremely not important, 2 for moderately not important, 3 for neutral, 4 for moderately important and 5 for extremely important).

Sample Size

The population in this research includes all contracting firms of first and second categories for construction projects. The samples were selected randomly from each level of the two contractor categories. The total number of contracting companies was 576. The formula which is shown below in Eq (1) was used to determine the sample size of an unlimited population (Bartlett et al., 2001).

$$n = \frac{Z^2 \times \mathrm{P} \times (1 - \mathrm{P})}{C^2} \ldots\ldots\ldots\ldots\ldots Eq\ (1)$$

- n= sample size.
- Z = z value for (90% confidence level =1.645).
- P= percentage of picking a choice, expressed as a decimal (0.5 used for sample size needed).
- C = confidence interval (0.1).

$$n = \frac{1.645^2 \times 0.5 \times (1 - 0.5)}{0.1^2} = 67.9 \sim 68$$

Correction for finite population

New

$$n^* = \frac{ss}{1 + \frac{ss - 1}{pop}}$$

Where, pop=576.

$$n^* = \frac{68}{1 + \frac{68 - 1}{576}} = 60.91 \sim 61$$

Data was collected from professionals and experts in construction projects in Egypt, who were mostly participating contractors and consultants. The sample was selected randomly for data collection. A total of 106 questionnaire forms were distributed to professionals and experts in construction projects in Egypt by interviews. A total of 82 questionnaire forms were returned, representing 77.36% of the total. Eighty-two questionnaire forms were returned; 66 from contractors and 16 from consultants. Their classification due to experience is shown in Table 1.

Table 1. Classification of responses

Experience	Project manager		Estimator		Site engineer		Total	
	Freq.	Percent (%)	Freq.	Percent (%)	Freq.	Percent (%)	Freq.	Percent (%)
Less than 5 years	0	0	2	5.50	1	6.25	3	3.66
More than or equal to 5 and less than 10 years	0	0	5	13.9	4	25	9	11
More than or equal to 10 and less than 15 years	8	26.7	7	19.4	8	50	23	28
More than or equal to 15 and less than 20 years	10	33.33	10	27.8	3	18.75	23	28
20 years or more	12	40	12	33.33	0	0	24	29.3
Total	30	100	36	100	16	100	82	100.00

ANALYSIS OF DATA

Relative Importance Index

The relative importance index is determined for each factor to rank these factors according to their importance accurately. RII is determined by Eq (2) (Esnshassi et al., 2013).

$$\text{RII} = \frac{\sum W}{A \times N} \ (0 \leq RII \leq 1) \ldots\ldots\ldots\ldots\ldots\ldots Eq(2)$$

where RII: relative importance index.

(W: weight given to each factor by the respondents ranging from 1 to 5; A: the highest weight (i.e., 5 in this case) and N: the total number of respondents).

Measuring Respondents' Level of Agreement

The coefficient of variation (COV) represents the standard deviation as a percentage of the mean. It is used to determine the relative variation of different responses (El Hag et al., 2005). The formula is determined as Eq (3) as follows:

$$COV = \frac{S}{\bar{x}} * 100 \ldots\ldots\ldots\ldots\ldots\ldots Eq\ (3)$$

where COV is the coefficient of variation, S is the standard deviation and $\bar{x}$ is the weighted mean of the sample. The statistical results represent that the variation of responses for factors affecting cost estimates of construction projects is relatively low, indicating that there is a high agreement among responses. The COV for all factors was found to be between 16% and 40%.

Kendall's Concordance Test

The measure of the relationship between cost factor rankings for each category explains the agreement or similarity of each category of factors among respondents in their judgments.

Kendall's concordance coefficient (W) gives a measure of agreement among respondents and concordance between cost-factor rankings. It ranges from "0" to "1" whereas "0" indicates no agreement and "1" indicates perfect agreement. It is outlined by Eq (4) given as follows (Mann, 2005 and Groebner et al., 2008):

$$W = \frac{12 \times S}{K^2 \times n \times (n^2 - 1)} \ldots\ldots\ldots\ldots\ldots\ldots Eq\ (4)$$

where S is the sum of squares of deviations of

factors, k is the number of respondents and n is the number of factors in each category. Kendall's concordance test is conducted to identify the (contractors' and consultants') responses on the six different groups of the construction cost factors. Then, the SPSS software is used to rank them.

The results of this test revealed that Kendall's coefficient values range between 0.014 and 0.168, which are more than 0 for the six categories. These results indicated that there is an agreement among the respondents in ranking the factors affecting the accuracy of construction cost estimation. The significance level is less than 0.002 for all categories, except for the category of contract requirements, which showed a 0.339 level of significance. These results indicate that the null hypothesis (there is no agreement among the respondents in ranking the factors) is rejected ($p < 0.05$), except for the category of contract requirements. The hypothesis stating that there is a significant agreement among respondents in ranking the factors is accepted ($p<0.05$), except for the category of contract requirements.

Validity of the Questionnaire

To ensure the validity of the questionnaire, two statistical tests were applied. The first was a criterion-related validity test (Spearman test) and the correlation coefficient and *p*-value were calculated for each of the six factor groups. The results revealed that the *p*-values are less than 0.05; so, the correlation coefficients of the field are statistically significant at $\alpha = 0.05$ ($0.01 < p$-value < 0.05). Thus, it can be concluded that the factors of all groups are consistent and valid to measure what they are intended to measure.

The second test was a structure validity test (Spearman) to test the validity of the questionnaire structure by testing the validity of each group and the validity of the whole questionnaire. The test results showed that the p-value for each group is less than 0.05; so, the correlation coefficients of all the groups are significant at $\alpha = 0.05$ ($0.01 <$ p-value < 0.05).

Reliability of the Questionnaire

The questionnaire's reliability is measured by the use of the Coefficient Alpha from Chronbach. Chronbach's Coefficient Alpha (George and Mallery P, 2003) is designed as an internal consistency measure, i.e., do all devices measure the same things? Typically, the value of Alpha varies from 0 to 1. The closer the value of alpha to1, the greater the internal consistency of assumed items in the instrument. Cronbach's Alpha can be written as a function of the number of test items and the inter-correlation between the items on average. The formula shows the standardized Cronbach's Alpha in Eq (5) as follows:

$$\alpha = \frac{Kr}{1+(K-1)r} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots Eq\ (5)$$

where K is the number of items and r is the average inter-item covariance among items. The normal range of Cronbach's alpha value is between 0.0 and 1.0, where a higher value reflects a higher degree of internal consistency. The value of Cronbach's alpha of the questionnaire is 0.930, which indicates excellent reliability of the questionnaire.

RESULTS AND DISCUSSION

Ranking Factors of Consultants, Design Parameters, Information and Estimators

Table (2) categorizes the ranking of factors in the category of consultants, design parameters, information and estimators according to contractors' and consultants' points of view. This category contains fifteen factors. "Clear and detailed drawings, specifications and project documentation" was ranked first by both contractors and consultants with an RII of 0.898 and ranked first in the overall ranking. Contractors ranked this factor first with an RII of 0.915 and consultants ranked it third with an RII of 0.825. This factor is considered a very important factor affecting cost estimate accuracy. This result is similar to the results found by (Alumbugu et al., 2014) and (Hatamleh et al., 2018). The factor of "Number of estimating staff" was ranked at the end by both contractors and consultants for this group with an RII of 0.595 and ranked 69th in the overall ranking. Also, contractors and consultants ranked this factor at the end in this category with an RII of 0.612 and 0.525, respectively. This category contains four factors out of the top ten factors.

Table 2. Ranking and RII of factors of consultants, design parameters, information and estimators

Main factors	Contractors		Consultants		Both contractors and consultants		Overall rank
	RII	Rank	RII	Rank	RII	Rank	
Clear and detailed drawings, specifications and project documentation	0.915	1	0.825	3	0.898	1	1
Suitable estimating method	0.782	6	0.825	4	0.790	7	19
Completeness of cost information, quality, cost data and details	0.858	3	0.813	5	0.849	3	3
Impact of team integration and alignment	0.748	9	0.813	6	0.761	7	29
Experience and skill level of estimator	0.870	2	0.888	1	0.873	2	2
Buildability of design	0.676	14	0.663	13	0.673	14	65
Frequency and value of construction variation and additional works	0.773	7	0.700	10	0.759	8	30
Level of involvement by the project manager	0.709	11	0.688	12	0.705	12	56
Procedure for updating cost information	0.812	5	0.738	9	0.798	5	17
Relationship with (client, contractors, other design team consultants) (previous/present)	0.700	12	0.763	7	0.712	10	51
Use of checklists to ensure completeness and technical basis	0.691	13	0.625	14	0.678	13	63
Designer experience level	0.758	8	0.750	8	0.756	9	33
Quality of assumptions used in preparing the estimate	0.815	4	0.863	2	0.824	4	9
Number of estimating staff	0.612	15	0.525	15	0.595	15	69
Estimator work load during estimation	0.718	10	0.688	11	0.712	11	52

Ranking Factors of Client Characteristics

Table 3 identifies the ranking of factors in the category of client characteristics according to the responses of contractors and consultants. This category contains five factors. “Client’s requirements and expectations on quality” ranked first by both contractors and consultants as the most important factor affecting the accuracy of the expected cost estimate for this group with an RII of 0.780 and ranked 24th in the overall ranking. Also, the responding contractors and consultants ranked this factor first with an RII of 0.767 and 0.838, respectively. This result is similar to the result found by (Ji et al., 2014). "Client experience and expertise" was ranked at the end by both contractors and consultants for this group with an RII of 0.661 and ranked 67th in the overall ranking. Also, the contractors and consultants ranked this factor in the last position in this category with an RII of 0.667 and 0.638, respectively.

Table 3. Ranking and RII of factors of client characteristics

Main factors	Contractors		Consultants		Both contractors and consultants		Overall rank
	RII	rank	RII	rank	RII	rank	
Client's financial status and budget	0.764	2	0.763	3	0.763	2	28
Type of client	0.742	3	0.775	2	0.749	3	36
Client's requirements and expectations on quality	0.767	1	0.838	1	0.780	1	24
Client's experience and expertise	0.667	5	0.638	5	0.661	5	67
Experience of procuring construction	0.724	4	0.650	4	0.710	4	51

Ranking Factors of Project Characteristics

Table 4 identifies the ranking of factors in the category of project characteristics according to contractors and consultants. This category contains 16 factors, among which" accuracy of BOQ" was ranked first by both contractors and consultants as a very important factor affecting the accuracy of the expected cost estimate for this group with an RII of 0.844 and ranked 6th in the overall ranking. Also, the responding contractors ranked this factor first with an RII of 0.845, but the consultants ranked this factor 4th with an RII of 0.838. This result is similar to the result found by (Enshassi et al., 2005). "General project arrangement including layout" was ranked last by both contractors and consultants for this group with an RII of 0.654 and ranked 68th in the overall ranking. Also, contractors and consultants ranked this factor in the last position in this category with an RII of 0.661 and 0.625, respectively.

Table 4. Ranking and RII of factors of project characteristics

Main factors	Contractors		Consultants		Both contractors and consultants		Overall rank
	RII	rank	RII	rank	RII	rank	
Location of the project	0.742	9	0.738	11	0.741	9	41
Project size/ gross floor area	0.779	6	0.800	8	0.783	7	23
Project complexity of design and construction	0.815	2	0.850	2	0.822	2	10
Construction method/ techniques /technology	0.806	3	0.813	7	0.807	4	15
Project duration	0.797	4	0.925	1	0.822	3	11
Site constraints/site access	0.761	8	0.800	9	0.768	8	25
Type of project	0.709	11	0.788	12	0.724	11	47
Type of structure (steel, concrete, brick, timber, masonry)	0.673	15	0.700	14	0.678	15	64
Site conditions and topography	0.685	14	0.838	5	0.715	12	48
Number of project team members	0.691	12	0.638	15	0.680	14	62
Site requirements	0.688	13	0.738	13	0.698	13	58
Level of uncertainty in soil condition	0.715	10	0.800	10	0.732	10	44
General project arrangement including layout	0.661	16	0.625	16	0.654	16	68
Accuracy of BOQ	0.845	1	0.838	4	0.844	1	6
Overlap of phases or concurrency	0.782	5	0.825	6	0.790	5	20
Quality of construction required	0.776	7	0.850	3	0.790	6	21

Ranking Factors of Contract Characteristics

Table 5 identifies the ranking of factors in the category of contract characteristics according to the points of view of contractors and consultants. This category contains 11 factors. "Type of contract" was ranked first by both contractors and consultants and considered the most important factor affecting the accuracy of the expected cost estimate for this group with an RII of 0.766 and ranked 26th in the overall ranking. Also, the responding contractors ranked this factor 5th with an RII of 0.745, but consultants ranked this factor 1ST with an RII of 0.850. This factor was ranked 26th out of 70. However, the research conducted by Elhag et al. (2005) ranked this factor 45th out of 67, while Chan (2012) ranked it 21st out of 27.

Table 5. Ranking and RII of factors related to contract characteristics

Main factors	Contractors		Consultants		Both contractors and consultants		Overall rank
	RII	Rank	RII	rank	RII	Rank	
Procurement routes and contractual arrangement	0.688	11	0.725	6	0.695	11	60
Type of contract	0.745	5	0.850	1	0.766	1	26
Tender selection method (open, selected, negotiation, … etc.)	0.721	9	0.763	2	0.729	7	45
Tender period	0.727	8	0.663	10	0.715	9	49
Amount of specialist work	0.745	6	0.775	2	0.751	3	34
Risk share between construction parties	0.770	1	0.675	9	0.751	4	35
Advance payments	0.761	3	0.688	8	0.746	5	38
Liquidated damage amount	0.770	2	0.713	7	0.759	2	31
Contract requirements	0.736	7	0.775	3	0.744	6	39
Bid bond and maintenance period	0.700	10	0.763	5	0.712	10	53
Amount of percentage of retention from the contractor's payment	0.748	4	0.638	11	0.727	8	46

Ranking Factors of Contractor Characteristics

Table 6 presents the ranking of factors in the category of contractor characteristics according to the opinions of contractors and consultants. This category contains 11 factors. It contains 3 factors out of the top ten factors. This can be considered as an indication that such a category plays a critical role in cost estimate accuracy. "Experience on similar projects" was ranked first by both contractors and consultants with an RII of 0.846 and ranked 6th in the overall ranking. The responding contractors ranked this factor in the first position with an RII of 0.839. Also, consultants ranked it in the first position with an RII of 0.846." Record of payments to subcontractors" was ranked last by both contractors and consultants with an RII of 0.685 and ranked 61st in the overall ranking. Also, the responding contractors and consultants ranked this factor 11th with an RII of 0.700 and 0.688, respectively.

Table 6. Ranking and RII of factors of contractor characteristics

Main factors	Contractors		Consultants		Both contractors and consultants		Overall rank
	RII	Rank	RII	rank	RII	Rank	
Construction team's ability to control the project	0.824	3	0.775	5	0.815	4	13
Experience on similar projects	0.839	1	0.875	1	0.846	1	5
Financial capability	0.821	4	0.850	2	0.827	3	8
Current work load	0.736	8	0.775	6	0.744	7	40

Management team (suitability, experience, performance)	0.833	2	0.850	3	0.837	2	7
Level of communications within the contractor organization	0.761	6	0.700	7	0.749	6	37
Planning capability and level of resource deployment/ utilization	0.788	5	0.800	4	0.790	5	22
Number of subcontractors	0.706	9	0.663	10	0.698	10	59
Record of payments to subcontractors	0.700	11	0.625	11	0.685	11	61
Mark up policies and % (general and project-wise) (special or normal)	0.745	7	0.688	9	0.734	8	43
% of main contractor direct work and % of subcontracted work	0.706	10	0.700	8	0.705	9	57

Ranking of External Factors

Table 7 presents the ranking of factors in the category of external factors according to the opinions of contractors and consultants. This category contains 12 factors. It contains 3 factors out of the top ten factors. This indicates that this category plays a very important role in cost estimate accuracy. "Materials (prices, availability, quality, imports)" was ranked first by both contractors and consultants as a critical factor affecting the accuracy of the expected cost estimate for this group with an RII of 0.849 and ranked 4th in the overall ranking. The responding contractors ranked this factor 1st with an RII of 0.830. Also, the consultants ranked it 1st with an RII of 0.925. However, the factor "weather conditions" was ranked in the last position by both contractors and consultants for this group with an RII of 0.588 and ranked 70th in the overall ranking. Contractors and consultants considered it the least important factor.

Table 7. Ranking and RII of external factors

Main Factors	Contractors		Consultants		Both contractors and consultants		Overall rank
	RII	Rank	RII	Rank	RII	Rank	
Number of competitors in the market	0.700	10	0.763	7	0.712	10	54
Labor (cost, availability, performance, productivity)	0.803	4	0.763	8	0.795	5	18
Equipment (cost, availability, performance, supply condition)	0.797	5	0.825	3	0.800	4	16
Interest rate and inflation rate	0.745	7	0.875	2	0.766	6	27
Impact of government regulation requirements	0.718	8	0.813	5	0.737	8	42
Materials (prices, availability, quality, imports)	0.830	1	0.925	1	0.849	1	4
Weather conditions	0.597	12	0.575	12	0.588	12	70
Economic situation	0.806	3	0.825	4	0.810	3	14
Bidding climate comprising of competitiveness and classification of competitors	0.718	9	0.700	10	0.715	9	50
Lead times for delivery of materials	0.758	6	0.763	9	0.759	7	32
Availability of other projects for tendering	0.664	11	0.700	11	0.671	11	66
Percentage of loss in construction materials	0.818	2	0.813	6	0.817	2	12

Ranking and COV for All Factors

Table 8 indicates that there are fifteen factors that have RII values above 80%. COV ranges between 16% and 40%, which means that there is a strong agreement between respondents in ranking factors affecting the accuracy of cost estimates in construction projects.

Table 8. RII and COV for all factors

Main factors	COV	Overall	
		RII	Rank
Consultants, design parameters, information and estimators			
Clear and detailed drawings, specifications and project documentation	17%	89.8	1
Suitable estimating method	21%	79	19
Completeness of cost information, quality, accuracy, cost data and details	20%	84.9	3
Impact of team integration and alignment	23%	761	29
Experience and skill level of consultant/estimator	16%	87.3	2
Buildability of design	33%	67.3	65
Frequency and value of construction variation and additional works	26%	75.9	30
Level of involvement by the project manager	30%	70.5	56
Procedure for updating cost information	26%	798.	17
Relationship with (client, contractors, other design team consultants) (previous /present)	29%	71.2	51
Use of checklists to ensure completeness and technical basis	29%	67.8	63
Designer experience level	27%	75.6	33
Quality of assumptions used in preparing the estimate	20%	82.4	9
Number of estimating staff	38%	59.5	69
Estimator's work load during estimation	30%	71.2	52
Client characteristics			
Client's financial status and budget	32%	76.3	28
Type of client	32%	74.9	36
Client requirements and expectations on quality	26%	78	24
Client experience and expertise	36%	66.1	67
Experience in procuring construction	30%	71	55
Project characteristics			
Location of the project	33%	74.1	41
Project size / gross floor area	28%	78.3	23
Project complexity of design and construction	19%	82.2	10
Construction method/ techniques /technology	20%	80.7	15
Project duration	24%	82.2	11
Site constraints / site access	28%	76.8	25
Type of project	30%	72.4	47
Type of structure (steel, concrete, brick, timber, masonry)	33%	67.8	64
Site conditions and topography	29%	71.5	48
Number of project team members	31%	68	62
Site requirements	30%	69.8	58
Level of uncertainty in soil condition	32%	73.2	44
General project arrangement including layout	29%	65.4	68
Accuracy of BOQ	23%	84.4	6
Overlap of phases or concurrency	23%	79	20
Quality of construction required	25%	79	21

Contract characteristics			
Procurement routes and contractual arrangement	26%	69.5	60
Type of contract	27%	76.6	26
Tender selection method (open, selected, negotiation, … etc.)	32%	72.9	45
Tender period	30%	71.5	49
Amount of specialist work	26%	75.1	34
Risk share between construction parties	26%	75.1	35
Advance payments	32%	74.6	38
Liquidated damage amount	30%	75.9	31
Contract requirements	26%	74.4	39
Bid bond and maintenance period	31%	71.2	53
Amount of percentage of retention from the contractor's payment	36%	72.7	46
Contractor characteristics			
Construction team's ability to control the project	22%	81.5	13
Experience on similar projects	19%	84.6	5
Financial capability	22%	82.7	8
Current work load	27%	74.4	40
Management team (suitability, experience, performance)	18%	83.7	7
Level of communications within the contractor organization	25%	74.9	37
Planning capability and level of resource deployment/ utilization	22%	79	22
Number of subcontractor**s**	31%	69.8	59
Record of payments to subcontractor**s**	31%	68.5	61
Mark up policies and % (general and project-wise) (special or normal)	33%	73.4	43
% of main contractor direct work and % of subcontracted work	32%	70.5	57
External factors			
Number of competitors in the market	27%	71.2	54
Labor (cost, availability, performance, productivity)	26%	79.3	18
Equipment (cost, availability, performance, supply condition)	23%	80.	16
Interest rate and inflation rate	30%	76.6	27
Impact of government regulation requirements	32%	73.7	42
Materials (prices, availability, quality, imports)	23%	84.9	4
Weather conditions	40%	58.8	70
Economic situation	25%	81.	14
Bidding climate comprising of competitiveness and classification of competitors	29%	71.5	50
Lead times for delivery of materials	29%	75.9	32
Availability of other projects for tendering	33%	67.1	66
Percentage of loss in construction materials	26%	81.7	12

Ranking Main Categories and Kendall's Coefficient

Table 9 illustrates that the category of "contractor characteristics" is ranked first with an RII of 0.766. COV varies between 19% and 33%, which indicates a good agreement between respondents. Kendall's coefficient for this category is 0.098 with a significance level of 0.00, which represents a good agreement between the respondents. However, the category of "client characteristics" is the least significant category with an RII of 0.733. The coefficient of variation ranges between 26% and 36%. Kendall's coefficient is 0.05 with a significance level of 0.002. These results indicate that there is a strong agreement between respondents in ranking factors affecting the accuracy of cost estimates.

Table 9. RII and ranking of the main categories, Kendall's coefficient and COV

Main factors	RII	Rank	COV	Df	Chi- square	Kendall's coefficient	Sig.
Contractor characteristics	0.766	1	19% - 33%	10	80..377	0.098	0.000
Consultants, design parameters, information and estimators	0.759	2	16% - 33%	14	192.672	0..168	0.000
External factors	0.751	3	23% - 40%	11	121.795	0.135	0.000
Project characteristics	0.753	4	19% - 33%	15	124.97	0.102	0.000
Contract requirements	0.736	5	26% - 36%	10	11.24	0.014	0.339
Client characteristics	0.733	6	26% - 36%	4	16.54	0.05	0.002

Top Ten Factors and Their Related Categories

Table 10 shows the top ten factors affecting the accuracy of cost estimates in construction projects in Egypt with their corresponding categories. The results represent that four factors out of ten are related to the category of consultants, design parameters, information and estimators. Moreover, three factors out of ten are related to the contractor characteristics category. In addition, two factors out of ten are related to the project characteristics category. Finally, only one factor out of ten is related to the external factors category.

Table 10. Top ten factors and their related categories

Category	Factors	RII	Rank
Consultants, design parameters, information and estimators	Clear and detailed drawings, specifications and project documentation	0.898	1
	Experience and skill level of the estimator	0.873	2
	Completeness of cost information, accuracy, quality, cost data and details	0.849	3
External factors	Materials (prices, availability, quality, imports)	0.849	4
Contractor characteristics	Experience on similar projects	0.846	5
Project characteristics	Accuracy of BOQ	0.844	6
Contractor characteristics	Management team (suitability, experience, performance)	0.837	7
Contractor characteristics	Financial capability	0.827	8
Consultants, design parameters, information and estimators	Quality of assumptions used in preparing the estimate	0.824	9
Project characteristics	Project complexity of design and construction	0.822	10

Table 10 presents the ten most important factors affecting the cost estimation accuracy of construction projects in Egypt. By comparing these findings and the results of the study conducted by Elhaj et al. (2005) in the UK, we found that there is strong agreement between both studies, although there are minor differences in ranking the factors. "Clear and detailed drawings, specifications and project documentation" was ranked

first in this study and was ranked 7th in the study of Elhaj et al. "Completeness of cost information, accuracy, quality, cost data and details" was ranked 3rd in this study, whereas it was ranked 4th by Elhaj et al. However, the factor "financial capability" ranked 8th in this study, while it was ranked 34th out of 67 factors by Elhaj et al.

Implications and Limitations

This research is a preliminary analysis to gather data that will be used to assess the effect of these factors on cost estimate accuracy. Furthermore, it explores the effect of cost estimate accuracy on project success. Moreover, these results could be used to develop a model by the AHP technique.

Only seventy factors were considered in this study; so, there might be other factors that were not considered in this study. The number of respondents to the questionnaire was 82. The accuracy of the study could be improved by increasing the number of respondents in collecting data.

CONCLUSION

This study was performed to assess the factors affecting the accuracy of cost estimation in construction projects in Egypt. A total of seventy factors were gathered from the literature review. These factors were clustered into six main groups; consultants, design parameters, information and estimators; client characteristics; project characteristics; contract requirements; contractor characteristics; external factors.

A questionnaire survey was used to collect data. A total of eighty-two questionnaire forms were returned out of one hundred and six questionnaire forms. The results showed a strong agreement between respondents in ranking the factors. This is proven by the low coefficient of variation for each factor and by Kendall's coefficient concordance test. The relative importance index is used to rank these factors. The results also showed that RII of factors ranged between 59% and 90%. This reflects that these factors have a significant impact on the accuracy of cost estimates in Egyptian construction projects. RII for the main categories ranged between 73% and 76%. These results indicate that there are no significant differences in ranking these categories.

The top ten factors affecting the accuracy of construction project cost estimation are:

- Clear and detailed drawings, specifications and project documentation.
- Experience and skill level of estimators.
- Completeness of cost information, accuracy, quality and details.
- Materials (prices, availability, quality, imports).
- Experience on similar project.
- Accuracy of BOQ.
- Management team (suitability, experience, performance).
- Financial capability.
- Quality of assumptions used in preparing the estimate.
- Project complexity of design and construction.

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