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Cost Estimation Process for Construction Residential Projects by Using Multifactor Linear Regression Technique

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Abstract: ***Cost estimation in early stage plays an important role in the achievement of any construction project. Cost estimating is an assessment of the expected cost of any construction project. The accuracy of such estimate has a serious effect on the expected profit of the construction contractor. Hence, a certain contingency percentage should be added to the base estimate to improve the level of confidence. The process of cost estimating is materially affected by many factors. This paper aims to build a mathematical model for predicting the cost estimation for the residential construction projects. Multifactor linear regression technique is developed and used for predication of the cost of residential projects in Iraq. Ten effectiveness factors are used for cost estimation forecasting by (MLR) model, they include, experience of estimator, market status economic instability, accuracy of bidding documents, site condition and total area of residential building, the height of residential building, project location, type of residential building, estimating method. It was found that Multifactor linear regression has the flexibility to foretell the cost with a excellent degree of accuracy 91.76%, mean absolute percentage error 8.240% and coefficient of correlation (R) was 95.74%.***

Keywords: Cost estimation, early estimate, accuracy of cost estimation, MLR Model, SPSS.

1. Introduction

Cost estimation is an essential part of construction residential projects, where cost is considered as one of the main criteria in decision making at the early stages the reliability of cost estimation has a significant effect on the success of construction residential projects [1].

For example, it may have a serious effect on contractor capability to compete successfully with other contractors. It also possess an important effect on contractor's profit. Therefore, this research is an attempt to build and evaluate an analytical model which may be used to estimate the total cost of residential projects, by using Multifactor Linear Regression Technique (MLRT)[2].

2. Objective

The objective of this research to build and evaluate an analytical model which may be used to estimate the total cost of residential projects, by using Multifactor Linear Regression Technique (MLRT), through the following procedures:

1) Determination of Multifactor Linear Regression model variables, these variables having a high effect on the cost of residential projects in Iraq
2) Construct a comprehensive tool for residential projects cost estimation by using the Multifactor Linear Regression as the most efficient tool in predictions
3) Built an equation to find the cost estimation of construction residential projects.

3. Construction Cost Estimation

The cost estimation is a basic process for each project, it can be defined as the process of calculating the quantities of materials, labor, and equipment expected to be used to complete the work of the construction project within specific specifications, calculating the cost of the project shall be according to that [3].

3.1 The Goal of Estimation

The estimation is the expectations of the cost of implementing the work, where it is difficult to predict certain things such as worker productivity and working conditions. As many parties estimate the construction costs for different purposes. The predictability depends heavily on data from previous experience taking into account the differences between the new situation and past rates for realistic and real estimation [4].

4. Research Methodology

The research methodology followed up in carrying out the field investigation includes:

1) Literature survey
2) Preliminary interviews (Open questionnaire).
3) Building a questionnaire form.
4) Research sample
5) Distribution a questionnaire form
6) Displaying and discussing the results and drawing the final conclusions and recommendations.

Personal interviews were conducted by the researcher with the senior level of engineers working in the construction residential projects. The structured interview questionnaire started with ten questions. The questions which were divided into two parts, the first part includes general background information about the research sample, while the second part includes information about the cost estimation methods and factors affecting the process of cost estimate[4]. The interviews were conducted with a number of experts with great experience in the field of construction projects. Those experts involve engineers in Roads and Bridges Directorate, National Center for Engineering Consultancy, Engineering

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Construction Office, Al-Faw General Engineering Company, Al-Mansour Contracting Company, professors in colleges of engineering in Iraq and engineers in private sector. All of them have more than twenty years working experience in the construction sector in Iraq. Moreover, the expert interviews were helpful in building the baseline questions that focusing on construction projects cost estimation.

Total number of (100) forms were distributed. Only (85) forms were completely returned.

The questionnaire forms were distributed to a number of the Iraqi state institutions as follows:

1) The Ministry of Housing and Construction (National Center for Engineering Consultations, Roads and Bridges Directorate, Engineering Construction Office, and Al-Faw Company).
2) The Ministry of Planning
3) The engineering department in Baghdad governorate.
4) A number of academic professors in Engineering colleges (Baghdad University, AlNahrin University, AlMasour University College, and Al-Esraa University College).
5) A number of experts working in private sector companies (Almajd construction contracting company,Adnan almusawy construction contracting company, Aldibaj construction contracting company, and Alhadbaa construction contracting company).

5. Result Analysis

Keeping in mind the end goal to have the capacity to pick the correct technique for examination, the estimation level must be clear. For each kind of estimation, there are suitable methods that can be utilized. In the following research, ordinal scales were utilized. Ordinal scale as appeared underneath in Table (1) is a positioning framework that regularly utilizes numbers in climbing or diving request. The numbers allocated to the essential (10, 30, 50, 70,90) don't demonstrate that the interim between scales are equivalent, nor do they show supreme amounts [5-8].

With a specific end goal to evaluate information investigation and ascertain the Relative significance (RI), a theoretical Weight Value (WV) was joined to each of the five classes of answers availableThis Weight Value (WV) was compared to the mid-scope of each class on the five class decimal scale as clarify in Table (1)[9-11].

Relative Importance (RI): $RI = \frac{\Sigma(fi*W)}{N}$ Eq.(1)

The percentage is:

Percentage % $= \frac{\text{Number of frequencies}}{\text{total number of the answers}} *100$ Eq.(2)

Eq.(1) and Eq.(2) are used to find the Importance index for every factor that affecting on cost estimation . [6][7] The last phase represents the assessment for the outcomes via contrasting these outcomes inside the proposed intervals [12-14].

Table 1: Weight Value of Descriptive Frequencies

Category	Category Interval	Weight Value (WV)
Not important	0-20	10
Less important	20-40	30
somewhat important	40-60	50
Important	60-80	70
Very important	80-100	90

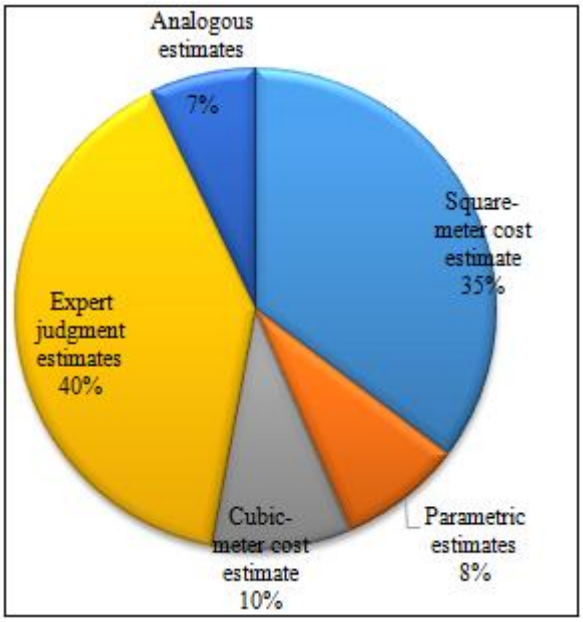

Figure 1: Methods of cost estimation

Illustrates the methods of cost estimation results shown that the highest rate was for Expert judgment by (40%), and by (35%) for Square-meter estimates, and by (8%) for Parametric estimating and by (10%) for Cubic-meter estimates while only (7%) for Analogous estimates.

6. Factors that Affect Accuracy of Construction Cost Estimation

Based on the literature review and the results of interviews (open questionnaire), factors that influences the process of building cost estimation was determined. These factors were used as a base for a questionnaire survey. Such survey identifies the most important factors influencing on the accuracy of the cost estimation. These factors were as the display in Table (2).[2-18]

Table 2: Factors that may affect accuracy of construction residential projects cost estimating

No	Category	Factors affecting in the accuracy of cost estimation	Relative Importance%
1	The Case of Estimation Process	Experience of cost estimator	87.65
2		Estimation method	80.59
3		The time allocated to estimation work	74
4		Updating cost information	65.76
5		Availability of the moderate cost indicators	78
6		Availability of productivity criterion	71.88
7		Procedure used in determining emergency and	44.24

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		profit margin contingency	
1	The Case of Bidding Situation	Accuracy of bidding documents provided by client	85.29
1	The Case of Project Characteristics	Total area of residential building	83.88
2		The height of residential building	83.43
3		Competence and leadership of project manager	75.18
4		Project location	81.76
5		Site condition	84.82
6		Type of residential building	81.29
1	Contractual Side	Quality of company project planning and management	71.41
2		Impact of project schedule "expected to delay"	67.18
3		Availability of labor and equipment required	52.12
4		Owner experience level	62.82
5		Content of the project specifications	78.24
6		Delay Penalty	50
7		Unforeseeable change in work	72.71
1	Executive Side	Number of floors in the building	43.88
2		Number of elevators in the building	40.12
3		Soil type	53.29
4		Building foundation type	42.71
1	Weather Side	Weather Unexpectedly	47.41
2	Social and cultutural side,	Social and cultural impact	38.24

6.1 Most Important Factors

By examining the importance indices of each factor in the table (3), it can be identified the factors that are heavily considered to have a high impact on the accuracy of cost estimate process. These factors, For example, the experience of an estimator, economic instability, accuracy of bidding documents, Site condition, the total area of the residential building. On the other hand, factors such as Social, cultural and ideological impact, the time between project announcement and bid opening average, conditions of weather, the number of elevators in the residential building, have low impact.

6.2 Pareto Analysis Technique (PAT)

Assumes that 20% of factors can have the most important effect. Therefore, this percentage will lead us to the selection of the first ten factors as shown in table (3).[13]

Table 3: Factors that may affect accuracy of construction residential projects cost estimating by using Pareto Analysis Technique (PAT)

No	Factors affecting in the accuracy of cost estimation	RII
1	experience of estimator	87.65
2	Market status	86.94
3	Economic instability	86.47
4	Accuracy of bidding documents	85.29
5	Site condition	84.82
6	Total area of residential building	83.88
7	The height of residential building	83.41
8	Project location	81.76
9	Type of residential building	81.29
10	Estimating method	80.59

Where: RII which mean relative important index

These variables are represented fell into two classifications, subjective and objective variables. All variable can be analyzed so as to find the optimum approach to illustration for the variable within the modeling process.

Objective variables content three variables and can be measured using the unit of measurements such as the first variable experience of the estimator (x1) measured in a number of estimator years and the sixth variable total area of residential building (x6) measured in a square meter. While the seventh variable Height of residential building (x7) measured in the meter.

Subjective variables content seven variables and may be measured relying on coding system, as an example, the second variable Market status(x2) can be classified to stable and medium stable and unstable and assigns them the value 1,2 and 3, respectively. Also, the third variable Economic instability(x3) can be classified to stable and unstable. It assigns them the values of 1,2 and 3 respectively. Latterly, the ten variable Estimating method (x3) defines a method that used in Iraqi residential construction projects to cost estimation in early stage with five types Parametric estimate, Square-meter cost estimate, Estimates by the expert consultation, Cubic-meter cost estimate, Cost estimates for each user, It assigns them the values of 1,2,3,4,and 5 respectively. The forth variable the Accuracy of bidding documents can be classified to accurate, medium accurate and not. accurate. It assigns them the values of 1, 2 and 3 respectively. The fifth variable the Site condition can be classified to good condition, medium condition and poor condition, it assigns them the value 1,2 and 3 respectively. the ninth variable Type of residential building can be classified to house and flat, It assigns them the values of 1, 2 respectively. The eighth variable The project location can be classified to suitable and not suitable, It assigns them the values of 1, 2 respectively.

7. Development of Multiple Linear Regression (MLR) Model

A lot of many subscriptions and books and thesis explained the (MLRT). In this paper, multifactor linear regression technique can use the optimum forecasting model and an extremely powerful statistical tool that permits the researchers to find relationship between dependent variables (actual cost) and independent variables (objective and subjective variables) (e.g. estimating method, experience of estimator etc.) It can tentatively formulate:

$$Y = A0 + A_1 x_1 + A2 x_2 + \ldots\ldots + C\text{Eq (1)}$$

Where:

1) $x_{i1}$and x_{i2} are the values of the input variables for the *i*the experimental run
2) *Yi* is the corresponding response

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3) *C is the blunder segments that are thought to be free typical factors with mean zero and fluctuation σ2*
4) A_0, A_1, the regression parameters.[13]

The developers of the Statistical Package for the Social Sciences let all work to do the product easy to utilize. Additionally, the it has been trusted in this research that SPSS is one of the prescient investigation program, can be anticipated with unquestionably what will occur next and can be settled on more quick witted choices. In this study, it was utilized SPSS to headway of the MLR display and the aftereffects of the measurable investigation are appeared in Table (4), Table (5), and Table (6)

Table 4: Shows the summary of statistical analysis.

Variables	N	Range	Std. Deviation
X1	20	11	4.98287
X2	20	1	1.08094
X3	20	1	.50262
X4	20	1	1.29371
X5	20	1	.48936
X6	20	5.08	.05280
X7	20	9	1.97084
X8	20	1	.51299
X9	20	1	.51042
X10	20	1	.51299

Table 5: Results of the correlation

Model	Model Fit statistics		
Actual cost model 1	R	R-squared	Adjusted R-squared
	98.0	96.1	91.7

Where: The quantity (R), called the linear correlation coefficient, which is used to measure the power of the connection linking two factors or more. And the coefficient of determination (R2) which is used to know the explanatory power of the model estimated (The estimated equation).And Adjusted R-squared which is used to interpret the explanatory power of the multiple linear regression models It is derived from (R2).

Table 6: Regression Coefficients Values

Model	Unstandardized Coefficients	
	B	Std. Error
(Constant)	1.299	1.385
X1	0.321	0.003
X2	-0.321	0.014
X3	0.155	0.027
X4	-0.015	0.008
X5	0.117	0.022
X6	0.876	0.248
X7	-0.047	0.006
X8	0.213	0.047
X9	-0.265	0.075
X10	-0.316	0.062

Relapse examination produces a condition to portray the measurable connection between at least one indicator factors and the reaction variable. SPSS programming marks the institutionalized relapse coefficients as "Beta", whereas the unstandardized coefficients are named "B". It has been trusted a relapse forms as a capable device that could be utilized to anticipate the charge of the private venture from multi-factors, and it permitting to expectation the cost of undertakings in future relying upon the data about past or introduce ventures. Estimations of unstandardized coefficients in a table (5.5) could be utilized to manufacture the multifactor direct relapse, as demonstrated the accompanying condition:

Total estimation cost = 1.299+0.321X1 – 0.321X2+0.155x3-0.015X4+0.117X5+0.876X6-0.047X7+0.213X8-0.265X9-0.316X10 Eq(4)

8. Validity of the Multiple Linear Replace (MLR)

The objective behind this the validation can be to realize a measurable dependable form. Through the current research, Ten novel papers for construction residential ventures. These types of papers hadn't been integrated into form that was made, other than applied for validation and confirmation of the following form. The real charge of these ventures besides the forecasted charge as shown in the table (7).

Table 7: The Actual and the Predicted Cost

Project No.	*Actual Cost (A)*	*Estimate Cost (E)*	*MPE*
P1	22500	28173	0.2521
P2	60800	57501	0.0543
P3	52800	54535	0.0329
P4	40980	42080	0.0268
P5	49870	43982	0.1181
P6	37000	39373	0.0641
P7	54900	58538	0.0663
P8	43815	39217	0.1049
P9	64800	66889	0.0322
P10	58600	62828	0.0722
MPA= $\left\lvert\frac{\sum\frac{A-E}{A}}{n}\right\rvert$ *100 = (0.824/10) * 100 =8.24			0.824

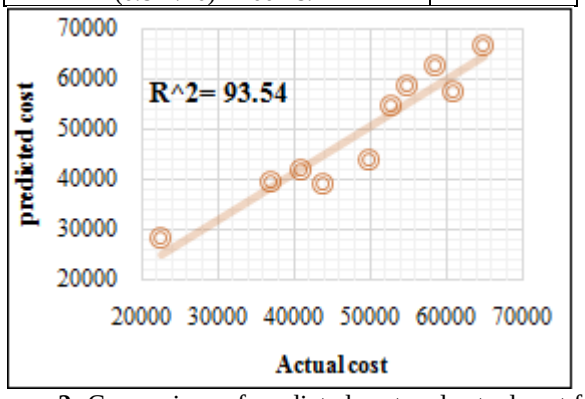

Figure 2: Comparison of predicted cost and actual cost for validation mode

Table 8: Statistical Measures Results for Regression model

Description	Statistical parameters
MPE	0.824
MAPE	8.240
AA%	91.76
R	95.74
R^2	93.54

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9. Conclusions

Some conclusions resulted from achieving this research can be summarized:

1) Questionnaire is considered one of the adopted approaches in the scientific research field to better diagnose the project problems and to know the opinion of the senior management level, consultants..etc,
2) Cost estimation traditional methods are experiencing the ill effects of the real impediments of the absence of exactness, however, a (MLR) presents a few points of interest over conventional courses for the forecast of the construction residential ventures charge estimation.
3) The conclusions from this study are:
   - Multifactor linear replace possesses the capability to evaluate the charge of building residential ventures, one an ideal determining form made as a complete apparatus for parametric cost estimation with a high level of precision 91.76%.
   - Coefficient of defining utilized to explain the linear connection amid project estimation charge and project real charge is 93.54%
   - The improved form is interesting for scholars and partners since it gives simple essay device (instrument)to forecast the charge of residential ventures.
   - The improved form of making the traditional statistics is equivalent to 20 previous residential projects as historical data and finding the connection amid output and input factors.
4) Ten impacting factors are used for prediction the total cost of residential projects, by using Multifactor Linear Regression Technique (MLRT), these factors are, the experience of the estimator, Market Status, Economic instability Accuracy of bidding documents, Site condition, Total area of the residential building, The Height of residential building, Project Location, Type of residential building and Estimating method.

10. Recommendations

The researchers introducing proposals for future studies as follows:

1) Conducting similar research through employing another neural system techniques and doing comparison and evaluation among the findings to explain which technique is additional satisfactory to be utilized with the sector of management.
2) Improving many Multifactor Linear Regression models to demonstrate the methods in that many kinds of construction management difficulties ensure the winning improvement and application of this knowledge to projects problems.
3) All construction parties are encouraged to be more aware of cost estimation development and pay more attention for using a new developed technique in the estimation process.

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