Journal of Civil Engineering and Environmental Technology
p-ISSN: 2349-8404; e-ISSN: 2349-879X; Volume 5, Issue 5; April-June, 2018, pp. 300-304

http://www.krishisanskriti.org/Publication.html

Prediction of Cost Overrun in Construction Projects

Malur Shivashankar Reddy Vivek[1], Nandini B[2] and Haranandana B P[3]

[1,2,3]R V College of Engineering Affiliated to VTU, Belagavi
E-mail: [1]msvivek.360@gmail.com, [2]nandini.nv5@gmail.com, [3]haranandana@gmail.com

Abstract—*The construction industry is one of the major contributors to the GDP in most of the countries. Cost overrun is one of the major impediments to the construction industry. This paper aims to identify the various factors affecting the cost overrun and predict the cost overrun before the commencement of the construction phase. The factors affecting the cost overrun are identified based on a questionnaire survey and they are ranked according to their relative importance index (RII). The analyzed data is then used to develop prediction models by three methods which are Fuzzy Logic, Multiple Linear Regression and Monte-Carlo Simulation. Monte-Carlo Simulation and Multiple Linear Regression models are developed using MS Excel and Fuzzy Logic model is developed using MatLab software. These models are calibrated for accuracy by using data from various case studies and are compared for accuracy. The model which gives the least amount of variation from the actual overrun cost is considered for prediction of the overrun.*

1. INTRODUCTION

Construction industry is the second largest industry in India in terms of its contribution to the GDP of the nation. This industry is growing by leaps and bounds. In order to continue this trend, it is necessary to make construction process more economical. The major drawback in this industry is the cost overrun. This puts the project at risk and also causes delay in the project completion. Therefore, this research can be used to predict the cost overrun before the start of the project and thus make necessary arrangements to accommodate them. Many authors have presented models to predict the cost overruns in construction projects. But, very few have compared these models for accuracy and processing time speed. In this paper, the most accurate model is suggested out of the three methods – Fuzzy Logic, Multiple Linear Regression and Monte-Carlo Simulation.

2. LITERATURE REVIEW

S Shanmugapriya et. al. [1] and Senouci et. al. [8] have tried to identify and analyze factors which are responsible for delay and cost overruns in construction projects, so that better execution of the upcoming projects could be planned. The responses obtained from their questionnaire survey were converted to statistical data and the factors were ranked based on the relative importance calculated. In addition to this, the reliability of the data obtained was found out using Cronbach alpha.

In her thesis paper, Karla Grace Knight [2] divulge us upon application of fuzzy logic for prediction of cost overruns in commercial buildings. The author states that fuzzy logic is one of the best modeling techniques to be used when data available is less decisive and large projects are considered. Her model could be used only in case of projects costing from $100,000 to $500,000. The model relates the project characteristics with the risks involved to predict both the cost overrun and underrun. The model was calibrated using Visual Basic 6.0 to attain greater prediction accuracy.

Similar to Mohamed et. al. [3] using simulation method to develop a model for predicting time contingency of a project, the same could be applied for cost overruns. The paper indicates the use of sensitivity analysis to identify the most pivotal factors affecting time overruns. Alike this, sensitivity analysis can be done on factors affecting cost overruns to understand their impact on cost overruns.

Shreenath A et. al. [4] presents a statistical approach for construction cost overrun prediction. The paper aims at development of a fuzzy model to predict cost overruns in construction projects. The data is gathered from questionnaire survey and were then ranked as per their relative importance index (RII). The model was developed using the MATLAB software.

Shanmugam M et. al. [5] develops a Monte Carlo simulation model using Excel and Visual Basic to analyze the behavior of cost overruns in construction projects. The model provides a probability of incurring cost overrun in the projects as a whole rather than for individual projects.

A regression approach was adopted by B O Ganiyu et.al. [7] for developing cost overrun prediction model. Through random sampling and surveys, data was collected for model development. The model was able analyze the effect of the causal factors on cost overruns.

3. RESEARCH METHODOLOGY

From our literature survey, we found that the best way to gather data was through questionnaire surveys and interviewing the industry experts. So, we devised to develop a questionnaire in which the most probable factors responsible for cost overruns would be rated by the industry experts [6]. They would be rated for their frequency and severity in impacting the project cost overrun. Later, the relative importance of each factor would be calculated. The factors with higher relative importance index will be selected which would serve as inputs for developing the three prediction models.

The models are developed using fuzzy logic, multiple linear regression and Monte Carlo simulation. The predictions of each model are compared with historic data to test for accuracy. The model with the highest accuracy would be used to predict the cost overruns in construction projects.

4. DATA ACQUISITION AND ANALYSIS

The questionnaire constituting of 68 factors grouped into 11 categories were distributed to industry experts. The categories were:

Ineffective project management

Ineffective site management

Scope changes

Consultant's fault

Contractor's fault

Labor crisis

Material and logistics issues

Equipment glitch

Accidents & harsh environmental conditions

Statutory obligations

Others

4.1 Data acquisition

We received a total of 77 responses. The relative importance index of all the factors were calculated and ranked. The 6 factors with higher relative importance index (Table 1) were selected and then incorporated into the models.

Table 1: Factors with higher RII

Factor No.	Factors	Relative Importance Index (RII)
1	Ineffective project planning and scheduling	0.6970
2	Poor financial control	0.6848
3	Poor site management and supervision	0.6667
4	Financial condition of the owner	0.6606
5	Land acquisition	0.6485
6	Change in design according to client's requirement	0.6455

4.2 Fuzzy Logic

This model was developed using the Mamdani type inference engine of the Fuzzy Logic toolbox in MatLab software. To construct the proposed fuzzy assessment model to be used in estimating the cost overrun and time delay, the following steps were followed:

- The factors which were identified previously were the input variables of this prediction model.
- The linguistic variables and fuzzy membership functions were determined.
- The fuzzy rules (if-then rules) were constructed; the relative importance indices of the factors were given as the weights of the fuzzy rules; and the aggregation and defuzzification methods were determined to construct the model to estimate cost overrun.
- The constructed model was calibrated on four construction project data. The model was also validated and tested.

Fig. 1: Rule viewer of Fuzzy Logic model

4.3 Multiple Linear Regression

The model was developed using Microsoft excel, with an add-in of Analysis tool pack. The function of this tool pack is to provide additional data analysis tools, one of it being regression.

Eleven project details were collected and were used to develop and validate the model. The top five factors with higher RII alongwith initial estimate of the project were used as independent variables in this model.

The model generated a linear regression equation:

$$Y = -682.009 + (6969.29*X_1) - (689.297*X_2) + (2247.409*X_3) - (2254.149*X_4) - (5091.577*X_5) + (0.1445*X_6)$$

Where, Y- Cost overrun (INR Cr)

x_1, x_2 …, x_6 – Predictors (the factors responsible for cost overruns)

The relation established between the predictors and the dependent variable has a correlation coefficient of 81.23% (R^2).

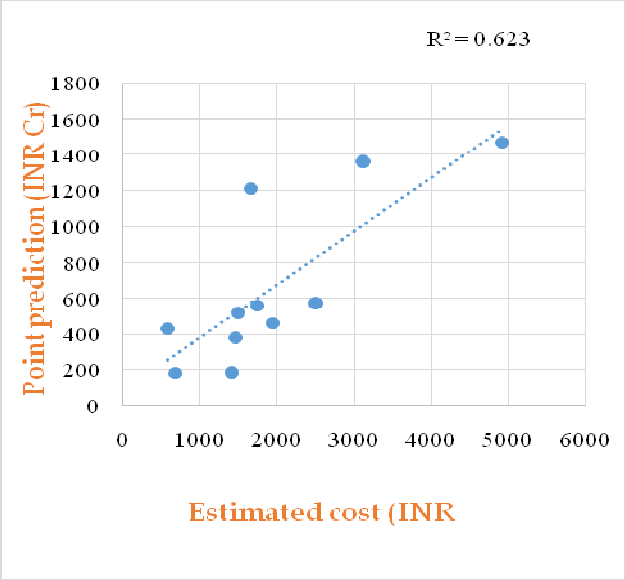

Fig. 2 Point prediction v/s Estimated cost

From the result, a graph of point prediction vs estimated cost was plotted (Fig.2). The correlation efficiency was 56.34%.

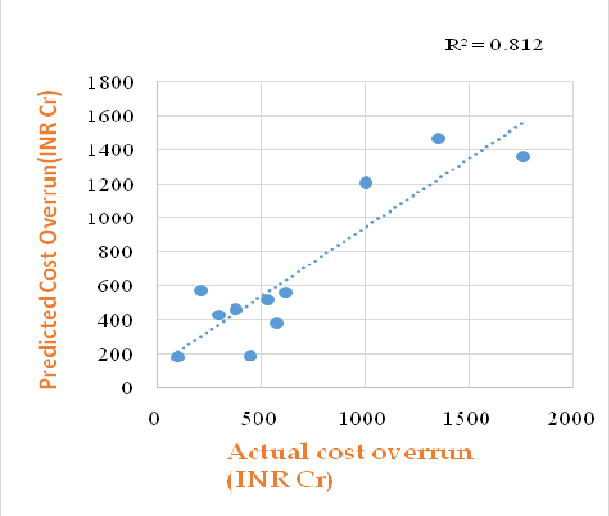

Fig. 3: Predicted cost overrun v/s Actual cost overrun

From the result, a graph of point prediction vs estimated cost was plotted (Fig.3). The prediction could be related to the actual cost overrun with an efficiency of 89.95%.

4.4 Monte Carlo simulation

In the equation obtained from multiple linear regression, the user has to enter the value of each independent variable individually. The data entered might be subject to change as per the circumstances and the prediction might be unreliable. At that moment, we can use Monte Carlo simulation. Its main feature of generating random numbers within the specified range facilitates the solution to the above problem.

We can use the software @RISK 7.5 for Monte Carlo simulation which can be adopted into Microsoft excel. Each independent variable can be assigned a distribution such that software generates a random number within the given range. The output is set using the equation obtained from multiple linear regression. Then the software performs 5000 iterations resulting in a histogram and a simulation model.

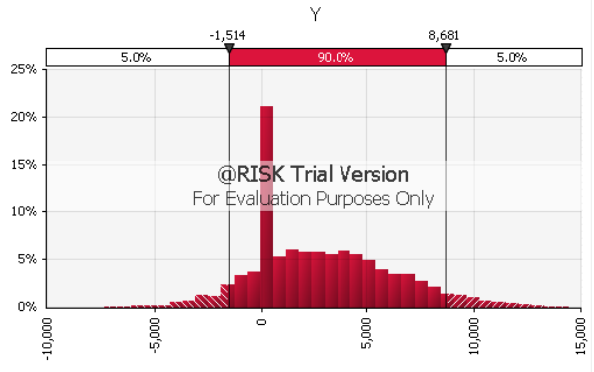

Fig. 4: Histogram of Cost overrun v/s Relative frequency

Fig.4 shows a histogram between cost overrun in INR Cr and the relative frequency in percentage. The histogram can be interpreted as certain amount of cost overrun for certain percentage of the total projects. For example, 5,000 INR Cr is the probable cost overrun for 5% of 5000 projects (each iteration can be considered as an individual project).

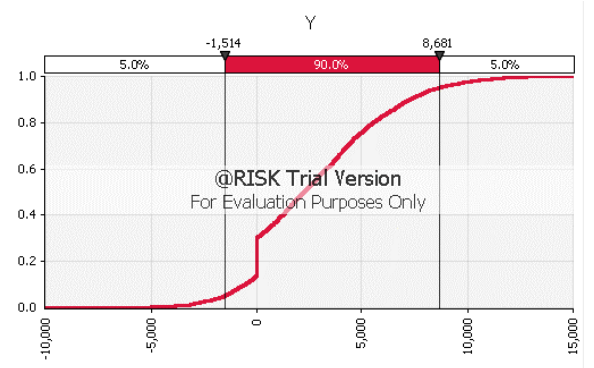

Fig. 5: Cost overrun v/s Cumulative probability – Simulation model

Fig.5 gives a trend line between cost overrun and the cumulative probability. The graph can be interpreted as, say, the probability of the cost overrun of 5,000 INR Cr is 0.78.

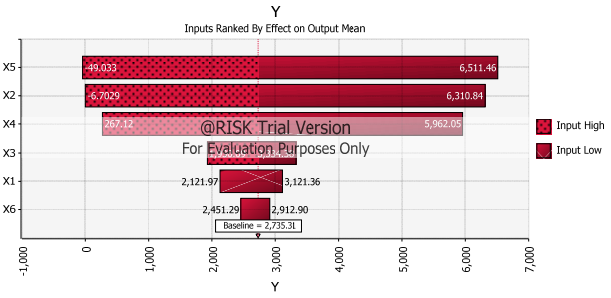

Fig. 6: Ranking of factors according to their sensitivity

Fig. 6 gives the ranking of each factor based on their intensity to impact the cost overrun.

5. RESULT

The results of the models were compared with past construction projects. The fuzzy logic model was able to predict the cost overrun with an average percentage error of 6.64% while the multiple linear regression resulted in an average percentage error of 18.09%. The limitation of Monte Carlo simulation model is that the output cannot be compared with any one particular project. It gives a summarized result as what percentage of the total projects would incur how much cost overrun.

6. CONCLUSION

From the results, it's very clear that Fuzzy logic model is the better model that can be used to predict the cost overruns. By, considering this prediction, we can plan ahead to optimize the project processes, such that the project cost wouldn't cross the estimate. This will also give the client an insight about the contingency reserve they might need in case hardships do arise.

7. ACKNOWLEDGEMENTS

We would like to thank our guide, Dr. V Anantharama, professor at R V College of Engineering, Bengaluru. We would like to thank all our college professors and our friends for their support. We also would like to thank Krishi publications for conducting this conference.

REFERENCES

[1] S. Shanmugapriya, Dr. K. Subramanian, "Investigation of Significant Factors Influencing Time and Cost Overruns in Indian Construction Projects", *IJETAE, ISSN 2250-2459, ISO 9001:2008 Certified Journal*, Vol. 3, Issue 10, October 2013

[2] Karla Grace Knight, "A Fuzzy Logic Mode1 for Predicting Commercial Building Design Cost Overruns", *Master's thesis*, National Library of Canada, 2001

[3] Dalia Mohamed, Florida Srour, Wael Tabra, Tarek Zayed, "A Prediction Model for Construction Project Time Contingency", *ASCE Construction Research Congress*, 2009

[4] Shreenaath.A., Arunmozhi.S., Sivagamasundari.R, "Prediction of Construction Cost Overrun in Tamil Nadu- A Statistical Fuzzy Approach", *International Journal of Engineering and Technical Research (IJETR) ISSN: 2321-0869*, Volume-3, Issue-3, March 2015

[5] Menaha Shanmugam, M.N.Zainudeen, R.D.G.Amaratunga, "Simulation modelling of cost overruns in building projects", *USIR*, University of Salford, Manchester, 2006

[6] Ghulam Abbas Niazi, Noel Painting, "Significant Factors Causing Cost Overruns in the Construction Industry in Afghanistan", *Science Direct Elsevier, 7th International Conference on Engineering, Project and Production Management, Procedia Engineering,182*, pp. 510 – 517, 2017

[7] B.O. Ganiyu, I.K. Zubairu, "Project cost prediction model using principal component regression for public building projects in Nigeria", *Journal of Building Performance ISSN: 2180-2106, Volume 1, Issue 1, 2010*

[8] Ahmed Senouci, Alaa Ismail, Neil Eldin, "Time Delay and Cost Overrun in Qatari Public Construction Projects", *Creative Construction Conference 2016, CCC 2016, 25-28 June 2016, Science Direct, Procedia Engineering 164, 368 – 375, 2016*

[9] Abhimanyu S. Rathi, Pravin V.Khandve, "Study of Factors Influencing Cost Overruns: An Overview", *International Journal of Science and Research (IJSR) ISSN (Online): 2319-7064*, Volume 5 Issue 3, pp-334-336, March 2016

[10] Savita Sharma, Pradeep K. Goyal, "Cost Overrun Assessment Model in Fuzzy Environment", *American Journal of Engineering Research (AJER) e-ISSN: 2320-0847 p-ISSN: 2320-0936* Volume-03, Issue-07, pp-44-53, 2014

[11] Arazi Idrus, Muhd Fadhil Nuruddin, M. Arif Rohman, "Development of project cost contingency estimation model using risk analysis and fuzzy expert system", *Expert Systems with Applications 38, Elsevier*, pp-1501–1508, 2011

[12] Hamed Samarghandi, Seyed Mohammad Moosavi Tabatabaei, Pouria Taabayan, Ahmad Mir Hashemi and Keith Willoughby, "Studying the Reasons for Delay and Cost Overrun in Construction Projects: The Case of Iran", *Journal of Construction in Developing Countries*, 21(1), pp. 51–84, 2016

[13] Jui-Sheng Chou, I-Tung Yang, Wai Kiong Chong, "Probabilistic simulation for developing likelihood distribution of engineering project cost", *Science Direct Elsevier, Automation in Construction*, 18, pp. 570–577, 2009

[10] Sphurti S. Arage Nagaraj V. Dharwadkar, "Cost Estimation of Civil Construction Projects using Machine Learning Paradigm", *International conference on I-SMAC (IoT in Social, Mobile, Analytics and Cloud)*, ©IEEE, 2017

[11] A. Khan, M. A. Choudhary, S. Khushnood, S. A. Masood, "Development of Econometric Models for Cost & Time Over-runs: An Empirical Study of Major Road Construction Projects in Pakistan", *Technical Journal*, University of Engineering and Technology (UET) Taxila, Pakistan, Vol. 20, No. IV, 2015

[12] S M Renuka, S Kamal, C Umarani, "A model to estimate the time overrun risk in construction projects", *Theoretical and Empirical Researches in Urban Management*, Volume 12, Issue 2, May 2017

[13] Hyojoo Son, Changmin Kim, Changwan Kim, "Hybrid principal component analysis and support vector machine model for predicting the cost performance of commercial building projects using pre-project planning variables", *Science Direct Elsevier-Automation in Construction*, 27 , pp-60–66, 2012

[14] Guozhu Dong, Vahid Taslimitehrani, "Pattern-Aided Regression Modeling and Prediction Model Analysis", *IEEE Transactions on Knowledge and Data Engineering*, Vol. 27, No. 9, September 2015

[15] Swapnil P Wanjari, Gaurav Dobariya, "Identifying factors causing cost overrun of the construction projects in India", *Indian Academy of Sciences, Sadhana*,Vol. 41, No. 6, pp. 679–693, June 2016

[16] T.Subramani , P S Sruthi, M.Kavitha, "Causes of Cost Overrun In Construction", *IOSR Journal of Engineering (IOSRJEN), ISSN (e): 2250-3021, ISSN (p): 2278-8719, Vol. 04*, Issue 06, pp-01-07, June. 2014

[17] Ghulam Abbas Niazi, Noel Painting, "Significant Factors Causing Cost Overruns in the Construction Industry in Afghanistan", *Science Direct Elsevier, 7th International Conference on Engineering, Project and Production Management, Procedia Engineering,182*, pp. 510 – 517, 2017

[18] Chantal C. Cantarelli, Bent Flybjerg, Eric J. E. Molin and Bert van Wee, "Cost overruns in large-scale Transportation Infrastructure projects: Explanations and their theoretical embeddedness", *European Journal of Transport and Infrastructure research*, 10(1):5-18, 2010