ANALYSIS OF CONSTRUCTION COST PREDICTION STUDIES – GLOBAL PERSPECTIVE

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It is well known that the civil engineering constructions are subjected to cost risk and time overruns. The uncertainties of the cost of construction many times result in disputes among stakeholders. The recent cost fluctuation in sand price in Tamil Nadu is a good example of time and cost overruns. There are too many models developed to predict the cost of construction by using different parameters and tools. The objectives of this research are to analyse the importance of research in this field, the countries focusing on this issue, level of implementation by the practicing engineers, the tools often or successfully used, the difficulties in predicting the cost and the accuracy of prediction and bringing out a useful conclusion to provide the direction for future research. In this research, a sample of 324 research papers out of more than 2000 papers listed in Scopus database between the years 1990 and 2015 were considered and analyzed on five factors. The five factors are 1) authors affiliation – academics, industry or both; 2) country; 3) tools used – ANN, regression, time-series models, etc.; 4) complexity involved or ease of use; 5) accuracy of results. The results show interesting information.

Keywords: construction cost, review, publications, research, Construction Cost Prediction (CCP), Scopus

Introduction

Construction sector risk rating is sensitive among low, medium, sensitive and high-risk scale (Farah Allouche 2017). Construction company gets subdue situation based on unforeseen market circumstances. Notably, small companies are on the lookout for long-term stabilization. Globally, these industries progress slowly through the study of the advanced market (Prediction of future price). A Sense of Prediction is the first step of success in the construction industry (Kim, Kim 2010). Some kind of Prediction Knowledge gives in depth idea in the decision making process of Construction Management. Predictors Demand and trend are not luxuries, but a necessity (Chambers et al., 1971). Contractors use their past experience to achieve the success of upcoming projects. In the name of Construction Cost Prediction (CCP), more numbers of papers are published in well-known academic journals. The review in the journals starts with an outline of Construction Cost Prediction and related publication. Some of the major research areas are identified, such as the availability of tools/techniques (Qualitative techniques, Time Series Analysis and Projection, Causal method) (Hwang 2011), Level of accuracy, level of difficulty, applications, limitations, involvement of experts like academicians, industrial experts, year of publications, county of publications and resources. The reviewed literature helps the researchers and industrial experts to know the importance of Construction Cost Prediction and understand the subject in a very effective manner. Through this critical review, it identifies some black box of predictions and opens a new path to the researchers for further research extensions.

Research methodology

The review methods structured by ElSawy, Hosny and Razek were affiliated to analyze the published papers in the selected areas. Based on their references, CCP topics related journals were selected through SCOPUS indexed journals and the research papers were identified. To the effective understanding of CCP research, a review process was steered to arrange a content analysis of CCP journals from 1990 to 2015.

Search keywords included material prediction, manpower productivity, construction cost prediction, and cost modeling.

Top six journals related to Construction Management were declared by Chau (1997) that were involved in this review. Those journals are, Journal of Construction Engineering and Management (JCEM), Construction Management and Economics (CME), Automation in Construction (AIC), Building Research and Innovation (BRI), Journal of Management in Engineering (JME) and International Journal of Project Management (IJPM). The methodology of the research is highlighted in Fig. 1. The research data for this investigation were viewed by a SCOPUS indexed Journal dated on the 1st week of July 2017. The total count of the research paper is 2025, in other words, it is called a target population. To fetch a sample from a target population, (Hogg, Tannis 2009) the authors used the following statistical formula:

$$\text{Sample size (Ss)} = Z^2 Pp(1 - Pp)/(MOE)^2,$$

$$\text{New sample Size (Ss)} = Ss/\{1 + [(Ss - 1)/N]\},$$

where

Z = confidence level of statistical value i.e., for 99%, 95%, 90%, 80% is 2.575, 1.96, 1.645 and 1.28, respectively,

Pp = Population proportion, if the value is indefinite, (Sincich et al. 2002) prefer a conservative value is 0.5,

MOE = Margin of Error (degree of uncertainty in statistics) 1% to 5% (5% is manageable).

At 5% significance level i.e., 95% confidence level, the sample size of the population:

$$Ss = (1.96)^2\, 0.50 \cdot (1 - 0.50)/(0.05)^2 = 384.16,$$

i.e. approximately 385 nos.

Thus, to get a sufficient quality, at 95% confidence level, 324 papers are required to be reviewed.

As a result, 2025 SCOPUS indexed journal is a target population, i.e., $N = 2025$, the limited by new sample size is derived as below.

The new sample size is obtained by using the formula:

$$\text{New Ss} = Ss/\{1 + [(Ss\text{-}1)/N]\},$$

$$\text{New Ss (limited sample size)} = 385/[1 + (385 - 1)/2025].$$

Approximately = 324 nos of sample.

Accordingly, to confirm the required sample size, 324 nos of samples were randomly chosen from the target population of 2025.

The following things compile the restrictions of this research:
1) Specific publications only considered for collecting data.
2) The duration between 1990 and 2015 only taken into account.

Grouped by players (industrial expert/ academic)

The study of Kothari represents the flow chart for research (Kothari 2004). It indicates 7 stages of the pro-
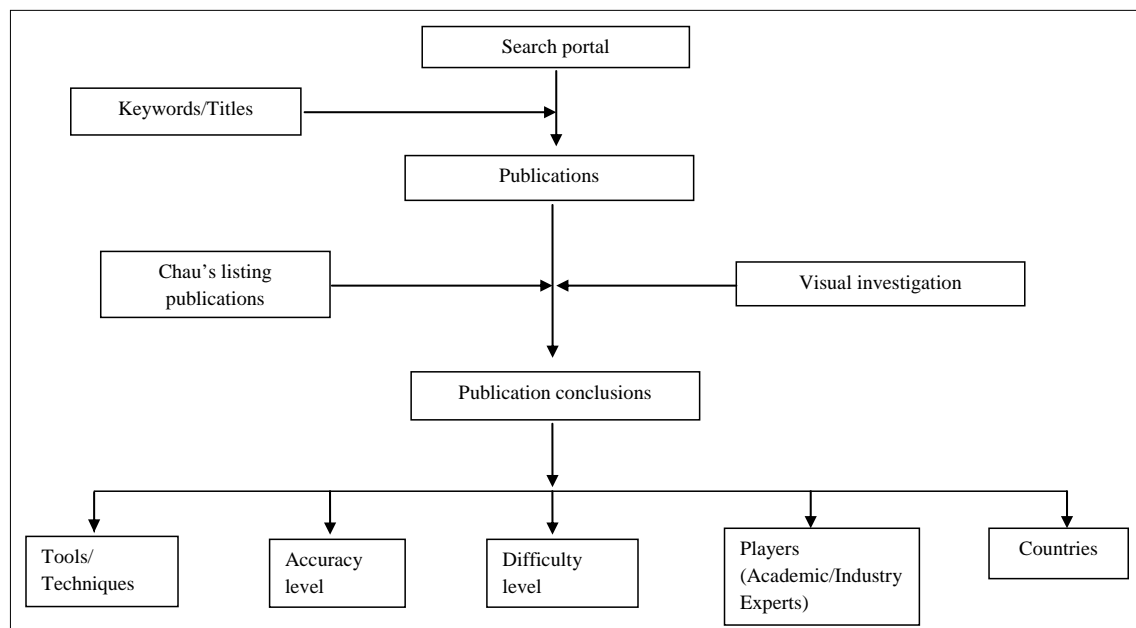

Fig. 1. Methodology of the research

cess in this research. Based on the researcher's research, it may involve various steps in this flow chart. There are no specific sequences. Considerably, it is a benchmark of the research work process.

The number of academic research publications in a country may imply the extent to which industrial innovations and practices in the research areas progress (Hong et al. 2012).

The score of a specific writer in a multi-authored paper can be calculated (Ke et al. 2007)

Mark matrix, if the author is single, the score value will be 1.0. If a co-author is present, first author will get 0.6 and second author will get 0.4. More numbers of authors involved in specific research, the score will be split into 0.47, 0.32, and 0.21 for first, second, and third author, respectively. In this case, authors' weightage are considered based on their position in authorship column.

As per the present research, industrial experts' involvements are considerably less, due to umpteen reasons. Due to practical difficulty in implementation, most of the researches are staked in the pa-

per level. Involving industrial experts in research, it may be considered real time projects. In this case score matrix is to be revised based on their involvement.

In the scheme of Fig. 2, 7 stages of the research process and industrial expert's involvement are notable in Identification of Problem, analyzing earlier research outcome, Accumulate data and Interpret and report.

- Total process score value is 1,
- Total no of process = 7,
- Each process carries equal weight (= 1/7), approximately = 0.143.

A constant minimum score of 0.36 can be allotted to the industrial experts, if they are the third author.

Industry involvement in this research is presented in Table 2.

Prediction tools/techniques

Major construction stages are classified in 3 parts (Martin, Burrows, Pegg 2006). Those are listed below:
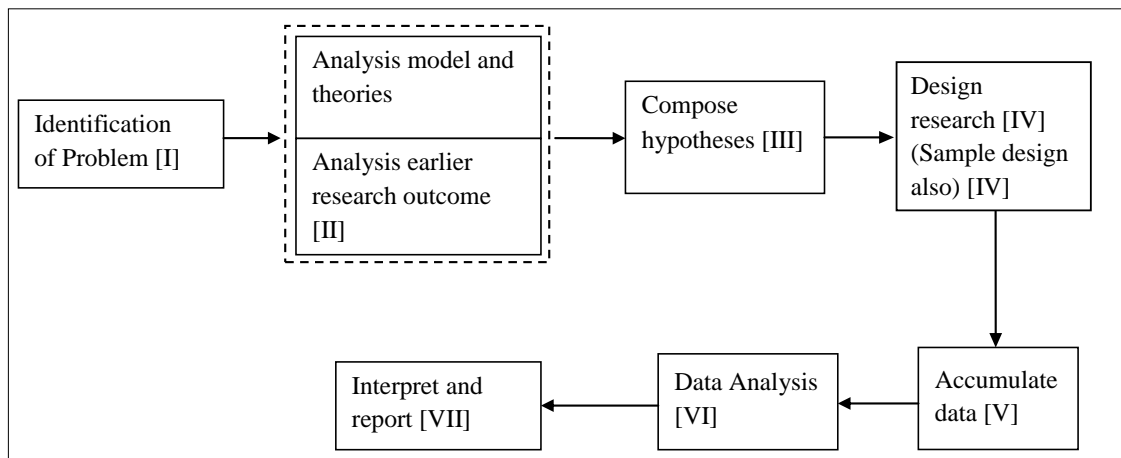

Fig. 2. Stages of the research process

Table 1. Allocation of scores for the selected research processes

Process stage	I	II	III	IV	V	VI	VII	Weightage
Industry expert	0.143	0.072			0.072		0.072	0.36
Academic	–	0.072	0.143	0.143	0.072	0.143	0.072	0.64

Table 2. Comparison of academic and industrial involvement in CCP

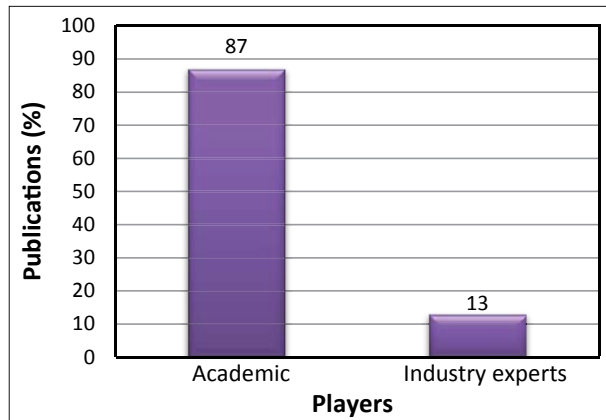|		Weightage	
		Academic (%)	Industry (%)
Academic	70.5	70	0
Industry experts	3	0	3
Combined	26	17	10
Total		87	13

Fig. 3. Comparison of players

– Ready to finance by owner,
– Finalize the contractor to construct,
– Ready to use by end users.

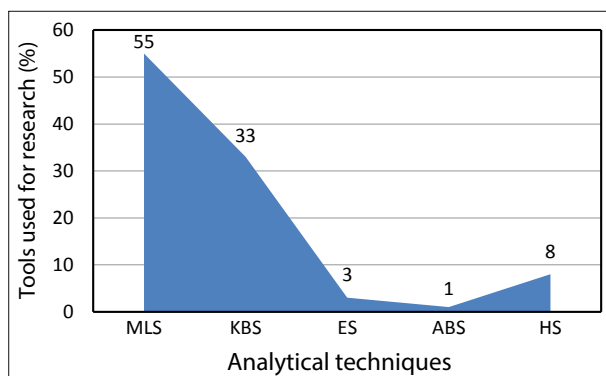Project cost overruns at 20% during the construction period, and 40% of cost overruns at the time of contract award, (Martin, Burrows, Pegg 2006). To avoid cost overrun of the project, it is necessary to apply the forecasting knowledge in the tender period itself. Accurate predictions reasonably need to be made in the tender period for the owner, to commit in future project cost implications (Tysoe 1981, Smith 1995).

In a market, numbers of prediction tools are present to forecast Construction Cost. Forecast model can be chosen by managers and researchers once they formulated their problem using the following techniques such as Qualitative techniques, Casual method and Time series analysis.

When data are panicking, Qualitative techniques can be used, for example, product first in the market. Time series analysis and causal methods can be used to analyze the data.

The time series analysis and causal methods are combined and called as analytical techniques, and split into 5 parts (Elfaki 2014).

Level of accuracy

Improve accuracy needs quantitative techniques.
Accuracy levels are time bound. It gives notable results in short term prediction, acceptable results in medium-term prediction and manageable results in long-term predictions (Chambers, Mullick, Smith 1971).

Level of difficulty

Difficulty level describes based on the restrictions of prediction tools, data collection, availability of tools, system support, learn to operate, read output and prepare report.

Fig. 4. Analytical techniques

Table 3. Analytical techniques

Analytical techniques	Machine learning system	Knowledge-based system (KBS)	Evolutionary system (ES)	Agent-based system (ABS)	Hybrid system
Examples	Artificial neural network (ANN), Support vector machine (SVM)	Expert system, CBR, AHP, Time series analysis, Regression analysis	Genetic Algorithm, Decision support system (DSS)	Multi-agent system (MAS)	1. ANN + SVM, 2. CBR + Data analysis + statistical analysis, 3. ANN + GA, 4. Fuzzy + ANN
Usage of tools in publications	55%	33%	3%	1%	8%

Table 4.

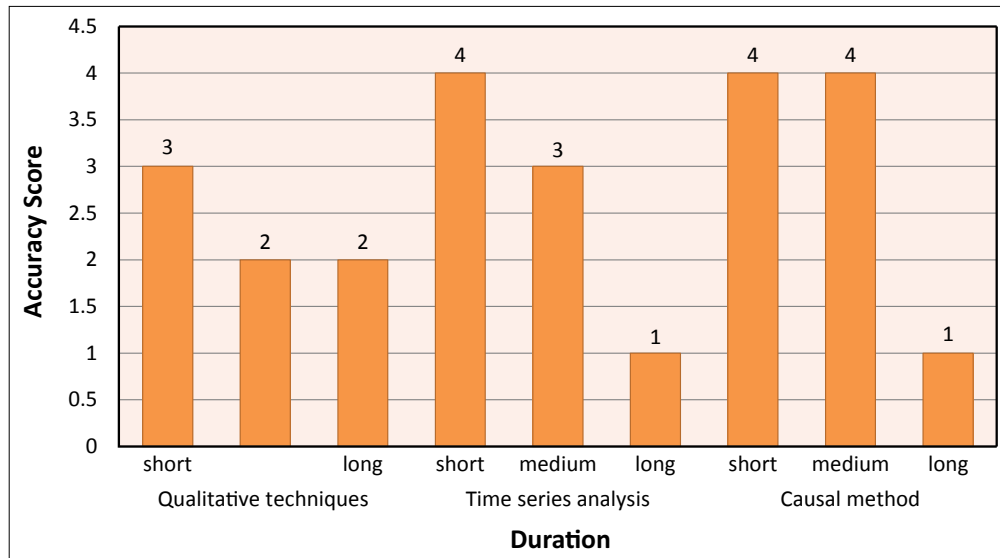| Duration	Qualitative techniques	Time series analysis	Causal method
Short term (0–3 months)	good	very good	very good
Medium (3 months to 2 years)	fair	good	very good
Long term (>2 years)	fair	poor	poor

Fig. 5. Duration of techniques and methods

Machine learning systems (ML), Knowledge-based system (KBS), Hybrid system (HS) have a low difficulty level as compared to Evolutionary system (ES) and Agent-based system (ABS):

– ML has the capability to deal with vagueness; the capability to work with insufficient data to judge new problems is based on the earlier experiences from correlative issues.
– KBS is simple method, and capable to judge any output.
– HS is capable to solve any type of problem.

Table 5.

Country	Publications (%)
USA	26
China	12
UK	8
Australia	5
Canada	5
Germany	4.3
South Korea	4
Japan	3
Taiwan	3
Iran	2.3
France	2
Italy	2
India	1.5
Spain	1.5
Total	79.6

– ES and ABS are quite difficult to extracting results.

Countries

As per Euler Homes, the economic research report in a global sector in construction 2017, three players are vital in the global construction market. In this report, USA is in Low-risk area because USA academic and industry experts are doing more research on this topic. Accurate Construction Cost Prediction is reducing the construction risk. There is more number of countries involved in publications of research articles in this topic worldwide, some government sectors are also sponsoring to do this kind of research work. Due to this action markable count of research works are published on this platform. This can be understood from Table 5.

Conclusions

Construction Cost Prediction has more attention. The progression of the research in this area has been growing fast in developing countries for the past four decades. This critical review has presented the importance of Construction Cost Prediction in the field of academic and industry, also it gives wide platform to the researchers. Documentation of this review reports provides detailed knowledge to the industry persons to manage their projects in a positive way. Innumerable prediction tools are available in the market, among these, best tools are listed based on accuracy and difficulty. This research has executed in limited construction industry only. In this direction, more research can be done in other industries also.

Fig. 6.

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