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Cost Forecasting of Construction Materials: A review

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Abstract - *Large-scale building projects are increasing day by day and because of that their construction costs become a matter of great concern, especially because of their lengthy construction periods. In particular, recent fluctuations of construction material prices have fueled problems like cost forecasting. This paper reviews the incorporation of artificial neural network for predicting the future cost construction materials. The main benefit of this study is providing construction stakeholders with a very reliable tool for expecting prices of coming projects, especially with the existing Rates of Inflation.*

Key Words: Future cost, construction, materials, artificial networks.

1.INTRODUCTION

Large scale construction projects have recently increased in number of residential, commercial and government facilities worldwide. A lot of high rise buildings are being constructed or planned as urban land marks. The construction costs are dynamic. Prices of different materials, human resources, and other costs varies continuously. This economic uncertainty could have a major impact on the business especially on long term and mega projects. There are many traditional methods for predicting future construction costs in India. A forecasting method based on Artificial neural networks would be a great benefit for contractors, project owners etc.

1.1 5D BIM

For a construction project perspective three phases can be classified such as the pre-construction, the construction and the maintenance and operation phases.5D BIM adds to the third and fourth dimensions with the ability to link costing information to the digital model and the project schedules to allow for better cost management. BEXEL Manager is software that integrates the most important 3D/4D/5D uses of BIM technology changing the perspective of integrated project management and allowing you to optimize your digital workflows and take advantage of advanced open BIM technologies.

1.2 Possibility of Artificial Intelligence

In India traditional methods are followed to forecast the prices of construction materials. But in foreign countries several methods incorporating Artificial Intelligence are widely used to forecast the construction material prices. By incorporating artificial intelligence much more accuracy can be achieved and the values will have more accuracy compared to the ordinary methods of forecasting. Prediction using Artificial intelligence is a faster method and it has world wide recognition. If such methods are used in India, greater accuracy can be achieved and it will be very helpful for the contractors, project owners etc. in evaluating ,pricing and bidding construction projects.

2. COST FORECASTING METHODS

Different approaches have been analyzed to determine the best fitting model for forecasting construction costs. These several methods are analyzed here. They are mainly Vector error-correction model, Time series models like Automated time series cost forecasting system, Interrupted time series forecasting model,5D BIM and Artificial Neural Network approach. They are discussed below.

2.1 Vector Error -Correction model

Forecasting the short and long-term movement of construction material prices can be advantageous to various project stakeholders. By improving accuracy of their cost forecasts, contractors can avoid bidding or profit losses. In 2015 Shanhandashti and Ashuri used VEC models for forecasting construction material prices. Commonly used univariate and multivariate time series models, such as Box Jenkis and VAR models can be used to produce short-term material price forecasts. Cointegration, an econometric property of the time series variables,is generally used to characterize the long term relationships between non-stationary variables. In cases where two or more time series are cointegrated, VEC models can be used to develop short and long term forecasts. VEC model development includes different steps. First one is to identify candidate explanatory variables and collect corresponding data. Time series

analysis includes there are transit subset and testing subset. First step is followed by the check for stationarity. The augmented Dicky fuller test can be used to test the stationarity. The three main versions of augmented Dicky fuller test use the following models. They are mainly Woolridge model 2009,Gujarati 1995 and Dickey fuller 1979.

This step is followed by a casualty test. Cointegration test is used to examine the existence of a long term relationship between explained and explanatory variables. Diagnostic tests are conducted to check for the existence of serial correlation and constant variances among residuals, which implies a lack of heteroscedasticity, and determine the goodness of models. Using the testing subset the prediction accuracy of the constructed VEC models can be evaluated. In this step, the values predicted by the model are compared against the actual values. After the predictability evaluation process has completed, the candidate VEC model that passes the diagnostics and has the better prediction performance among the candidate models is chosen to dynamically forecast the future levels of the explained variable using the explanatory variables. But there are several drawbacks for this model. The VEC models are incapable of predicting future shocks caused by extreme events and disruptive changes in technology, different practices, regulations, market dynamics, inflation, exchange rates etc.

Forecasting Nord Pool day-ahead prices with an autoregressive model was carried out by Tarjei Kristiansen in 2012.Auto regressive model predicts the future behavior based on past behavior.

Hemanta Doloi tried to unfold the industry wide perception of cost performance being heavily relient on the contractors performance alone. Doloi's findings are expected to conclude a significant knowledge gap by shifting the priorities in cost estimation and management across all industry sectors.

2.2 Time -Series Models

The ATMF system is composed of four modules. They are mainly time series data input, parameter estimation , GOF calculation, Diagnostic checking. In time series data input first we require a material unit price database. Material unit price data are assigned based on each type and price .When a user selects a material price name, from the corresponding material price database, raw-time series data are automatically extracted and automatically entered into the system. Then comes the important step that is parameter estimation. This parameter estimation module estimates parameters of all tentative ARIMA models and then tests the significance of the parameters. The GOF calculating module determines the suitability of all tentative models by using five GOF criteria which includes : root mean square error (RMSE), mean absolute error, Akaike's information criteria, normalized Bayesian information criterion , and R-squared values. This step is followed by diagnostic checking.

2.2.1 Automated Time-Series Cost Forecasting System

This ATMF system is very useful in predicting future trends in construction material costs. Furthermore, this system is very helpful for cost estimation at a detailed level . So this system can thus help decision makers in the construction industry deal with changes in economic conditions and design by estimating cost escalations caused by volatile factors such as inflation.An autoregressive and moving average(ARIMA) modeling method , which is one of the popular univariate and time series modeling methods suggested by Box and Jenkis(1994) with a focus on non seasonality and trends is analyzed.An autoregressive integrated moving average, or ARIMA, is a statistical analysis model that uses time series data to either better understand the data set or to predict future trends.For a detailed and updatable material cost estimating, an automated forecasting system is developed on the basis of both the ARIMA modeling process and a simplified forecasting procedure proposed by Lu and Abou Rizk.The system focuses on usability for construction practitioners, compatibility with existing estimation software, and simplicity in analysis procedures..This automated system focuses on many things like compatibility with the existing estimation software, on the usability for construction practitioners and the simplicity for analysis procedures.This system also involves the following.They are an automated input module using a price database,a parameter estimation module for alternative models using an optimal solution algorithm, a GOF calculation module using a GOF score, and a diagnostic checking module.This automated system focuses on many things like compatibility with the existing estimation software, on the usability for construction practitioners and the simplicity for analysis procedures.

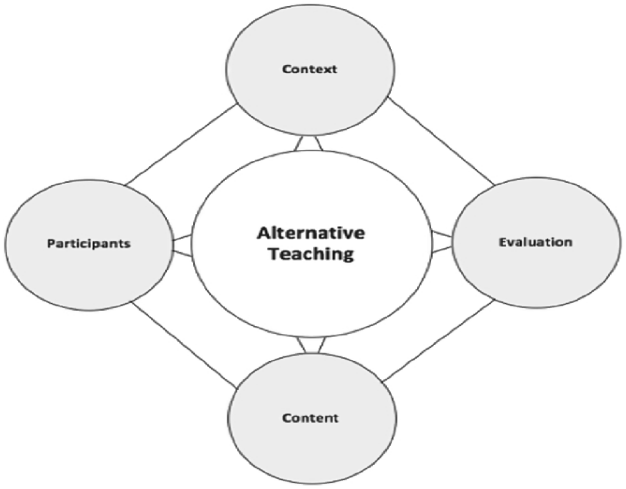


Fig-1: ATMF: A student centered framework for effective implementation of alternative teaching

Rahman and co-authors in 2013 performed a study to find out the significant factors causing cost overrun in the large construction projects. The Relative importance index method is adopted here for the analysis. And from the hierarchichal assessment of factors and it was find out that,the top three most significant factors of cost overrun are variation of prices of material, cashflow and the financial difficulties that may faced by the contractors and because of poor site management and poor supervision. The above mentioned factors belongs to mainly two categories. They are contractor's site management category and contractor's financial management category. Cost overrun is a severe problem faced by large construction industries.

2.2.2 Interrupted Time Series Forecasting Model

Here an interrupted time series forecasting model was developed wherein the economic recession of 2008 was reflected in the forecasting model, which is an outlier identified to have significant impact in the Construction cost index. The forecast result which is obtained using the Interrupted time series forecasting model was better than that of conventional forecasting models. The accurately forecasted Construction cost index using the presented model will help in budget and bid planning as well as assessing the risk of business. Interrupted-time series models provided better predictability than An autoregressive integrated moving average (ARIMA) and Holt-winters exponential smoothing models. An intervention analysis was conducted using the detected outliers to develop an interrupted time-series model wherein the intervention effects are reflected. Through this analysis, an interrupted time-series model was derived.

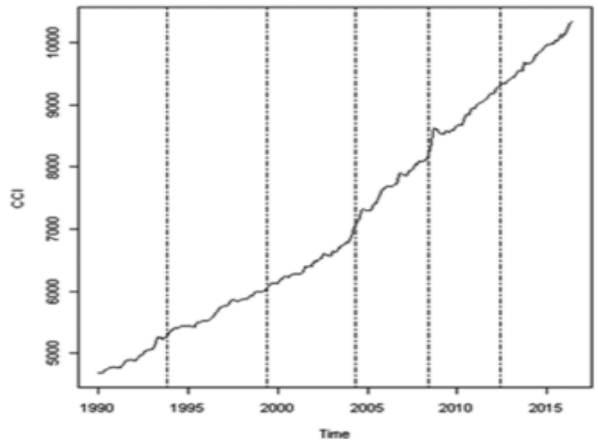


Fig-2: Detection of CCI outliers(using ESD test).

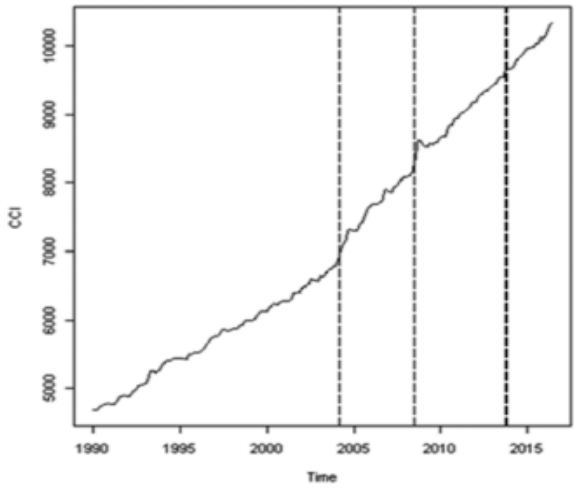
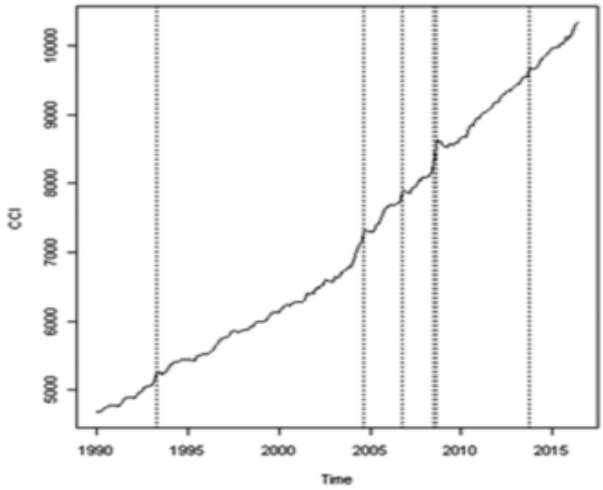


Fig-3: Detection of CCI outliers(using likelihood ratio test).



Fig–4: Detection of CCI(Using break point estimation test)

An intervention analysis was conducted using the outliers which have detected to develop an interrupted time-series model wherein the intervention effects are reflected. From the analysis, an interrupted time-series model was derived by adding the outlier effects to the ARIMA model. It is necessary to determine the intervention timing of the outliers that have actually occurred at the same point in time to validate the significance of the outlier effects in the intervention analysis. Here, the occurence-timing points of the outliers occurring at similar points detected using the different detection methods were defined at the earliest of the occurrence points of the outliers. This was done because latter points could have occurred from the influences of a trend change or a jump in a short period. Hence, when the occurrence point is based on the latter points, the model can be estimated without considering the outlier effects between the earlier and latter points.

2.3 BIM 5D

Building Information Modeling is a process supported by several tools, technologies and contracts involving the generation and management of digital representations of physical and functional characteristics of places. Building information models (BIMs) are computer files which can be extracted, exchanged or networked to support decision-making regarding a built asset. Government agencies, Individuals, business. Organizations use BIM software in their planning, designing and construction stage, operate and maintain buildings and diverse physical infrastructures, such as water, refuse, electricity, gas, communication utilities, roads, railways, bridges etc. From a construction project perspective three phases can be classified such as; the pre-construction, the construction, and the maintenance and operation phases. The pre-construction stage includes the concept, definition and design stages. Planning, designing, site preparation, foundation plinth construction, column, beam and slab construction, plastering, and finishing work are the different stages in construction. Finally in the maintenance and operation phase there are build and commission stages and hand over stage.5D BIM adds to the third and fourth dimensions with the ability to link costing information to the digital model and the project's schedule to allow for the better cost management.

The cost estimating features of most 5D BIM tools allow the creation of cost estimates that represent with more precision the actual cost of a project and overall cost reduction. There are five steps. Mainly the step one includes the following. they are: clarify scope, search for information, develop a framework and validate the frame work. The second step also was divided into three levels. They are mainly; the identification of available BIM 5D solutions, evaluation of solution's functionalities, and finally the synthesis of solution's functionalities The framework includes three levels. They are pre-construction, construction and post construction. The top three solutions have been identified for each 5D BIM level. For the first level, top three solutions are CostX, Vico office,iTWO. And for the second level top three solutions are mainly in the order Vico office, iTWO,CostX.In BIM 5D solutions there are mainly BIM readable solutions and BIM non-readable solutions. BIM readable solutions denote the tools that can both import data from and export data to the main 5D BIM software used on a project .BIM non - readable solutions have only the ability to import data from the main 5D software used without the ability to export data.

2.4 Artificial Neural Network Approach

Artificial neural network approach is a machine learning method. This method can be effectively used for cost estimation. In this method first thing is to identify the input variables. The various input variables identified are; scale of work, project phases, project duration, scope of work, type of work, level of experience on client side, the scope definition, size project team,multi disciplinary, type of client, main market type, attitude towards design changes etc. In order to determine the cost influencing factor that are used in the estimation process interviews are done with 13 employees. After the database has been developed methodology was applied to build and train the cost estimating model. In this approach there are different phases. In first phase, best training function is defined. The correlation coefficient and mean absolute percentage error(MAPE) were used for assessment of model performance. After identifying the best model, next training algorithm was selected until all the training algorithms were tested.

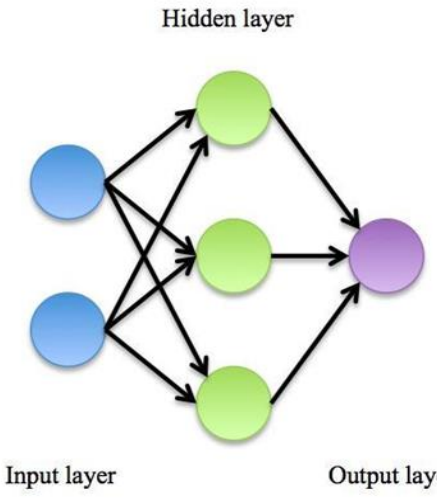


Fig-5: Structure of deep neural network.

Phase two defines the feature selection. Here the irrelevant input variables are eliminated. Connection Weights Algorithm was used to determine the relative importance of variables. Variables with lowest relative importance are eliminated from the best model identified in the earlier phase. These variables are used to train the variables. There are Connection Weights Algorithm(CWA) and Multiple Linear Regression (MLR) method. In phase three, there is determining the model scope/range. Since the accuracy of the model depends on the size of the input data, three different scenarios were identified.

Here the possibility of developing an accurate ML-based cost estimation method for tendering of engineering services has been done using neural network model to estimate the preliminary cost of engineering services. This research applied a systematic methodology that provides a guideline for developing and optimizing an Artificial Neural Network for cost estimation. It is found to efficient in improving the performance of the model. ANN can be used t0 obtain a fairly accurate cost estimate, even with minimum data that is available during the tendering phase.

3.CONCLUSION

Here different methods were analyzed to determine the best fitting model. Time series models like Automated Time Series Cost Forecasting systems, Interrupted time series forecasting model, Vector error correction model,5D BIM and Artificial Neural Network model were used for determine the best method for cost forecasting. And it is identified that the Artificial Neural Network approach is much more capable for predicting the accurate results. Forecasting using ANN is a more realistic approach than others.

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