Developing a forecasting model for the prediction of inflation rates for use in life cycle cost analysis

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ABSTRACT: Life cycle cost (LCC) is a technique that satisfies the requirements of owners for adequate analysis of total costs. Inflation rate may be considered as one of the main parameters that may have an effect on a LCC analysis of a project. Therefore it is necessary during the life cycle cost analysis to carry out a detailed analysis and predict inflation rates for the future.This paper outlines the development of an artificial neural network model for forecasting the inflation rates for the project period. The artificial neural network back propagation algorithm is implemented by using Mat lab Package. The model trained by 25 inflation index values and tested with 25 inflation index values, by comparing the two sets, the error rates was found as 0.022. LCC spreadsheet was developed in Microsoft Excel, taking into consideration all costs that may be incurred during the project life and predicted inflation rate.

1 INTRODUCTION

Life-cycle cost analysis is an economic method of evaluating a project by, taking into consideration the costs of owning, operating and eventually disposing of the project (Fuller & Petersen, 1996).

Another fundamental concept of life cycle cost analysis is inflation (Kirk & Dell'Isola. 1995). Inflation reduces the purchasing power of the currency over time. In life cycle cost analysis a common practice is to estimate the future costs in constant dollars and to use an assumed inflation rate to transform these estimates to actual values. (Celik & Ibisevic, 2009)

That is why for countries such as Turkey, where the inflation rate historically has been high and fluctuating it is important to predict the future inflation rates as accurately as possible.

The primary objective of this research is the development of an accurate life cycle cost analysis by incorporating the effect of inflation during the estimation process. This paper proposes a forecasting model to predict the inflation indexes for adjusting the effect of inflation during the estimation process.

2 ARTIFICIAL NEURAL NETWORKS

The research focuses on development of a framework Life Cycle Cost analysis. To achieve this objective, the inflation for the last 28 years were added to the developed model and the inflation for the project period were predicted by using Artificial Neural Network (ANNs) as a forecasting method. ANNs has been widely applied to various areas. ANN is developed in three layers; an input layer, middle or hidden layer(s), and an output layer. Each layer consists of several neurons, which are interconnected by sets of correlation weights. The input layer's neurons receive their activation from the environment, while the activation levels of neurons in the hidden and output layers are computed as a function of the activation levels of the neurons feeding into them. The information which is received as inputs will be transferred to the hidden layer, and produce an output with the transfer function. Additionally, the learning processing (or training) is formed by adjusting the weight of interconnectivity neurons. (Al-Tabtabi, 1998)

3 BACK PROPAGATION ALGORITHM IN MAT LAB

Different available Neural Network Models were investigated to find a suitable one meeting the expectations. There are many software packages which implement the back propagation algorithm, however many of these software packages are huge; they need to be compiled and sometimes difficult to understand. The Mat lab package is chosen for implementing the back propagation algorithm because of its ease of use and rather rapid generation of the necessary output. Another advantage of using Mat lab is that it allows the user to monitor what is going on inside a specific network by using the graphical capabilities offered by the package. Mat lab is commercial software developed by Math Works Inc. It is an interactive software packages for scientific and engineering numeric computation (Pro-Matlab For Sun Workstations, 1990).

The Back Propagation Network (BPN) model is used in writing the algorithm in Matlab. Among different models, BPN is the most popular and has the highest success rate. A BPN learns by example. You give the algorithm examples of what you want the network to do and it changes the network's weights so that, when training is finished, it will give you the required output for a particular input. A BPN model is composed of several layers of neurons. Each layer contains a predetermined number of neurons. Every neuron in a layer connects to all neurons in the adjacent layers. The network is first initialized by setting up all its weights to be small random numbers. Next, the input pattern is applied and the output is calculated. The calculations give an output which is completely different to the target since all the weights are random. Then the error of each neuron is calculated. The error is then used mathematically to change the weights in such a way that error will get smaller. "This part is called the reverse pass". This process is repeated again and again until the error is minimal.(Nazari, Ersoy,1992 & Rumelhart, Hinton, and Williams, 1986)

3.1 *Training the Back Propagation Network (BPN)*

The process of training a BPN includes the following steps;

(1) Set the connection weights of a BPN model randomly

(2) Select a training case from the training set and applies the inputs to the networks

(3) Work out the outputs

(4) Calculate the errors of output neurons using the following formula

$$Error_B = Output_B\,(1- Output_B)\,(Target_B - Output_B)$$

"Where B is the neurons in layer output"

(5) Change output layer weights, Let W^{+}_{AB} be the new (trained) weight and W_{AB} be the initial weight

$$W^{+}_{AB} = W_{AB} + (Error_B \times Output_A)$$

"Where A is the neurons in hidden layer"

(6) Calculate "Back-Propagate" hidden layers errors. This is done by taking the errors from the output neurons and running them back through the weights to get the hidden layer errors. For example if neuron A is connected to B and C then the errors from B and C are taken to generate an error for A.

$$Erro_A=Output_A(1-OutputA)(Error_B W_{AB}+Error_C W_{AC})$$

(7) Having obtained the Error for the hidden layer neurons now proceed as in stage 5 to change the hidden layer weights. By repeating this method, the network of any number of layers can be trained.

4 4. PREDICTION OF BUILDING CONSTRUCTION COST INDICES (BCCI)

The developed artificial neural network model is used to predict inflation rates for the project period starting from the last published data. The data available of the past inflation rates were obtained from the State Institute of Statistics –Turkey- and divided into two sets, the training set and test set, one to be used for the training and the other for the network validation. Mat lab package, was used for writing the code of the algorithm for the training of all the neural networks. The Back Propagation Model is used in developing the networks, so a three layer back propagation neural networks was created for training. A three input neurons layer, five neurons hidden layer, and one output neuron layer. The training data set was continuously looped through the network and after every predefined number of iterations; the test set data was passed through the evolved network to generate an output. Then the error of each neuron was calculated. The training is stopped once the error fall is less than the target error which is 0.022. The total error is evaluated by adding up all the errors for each individual neuron and then for each pattern in turn to give a total error as shown in figure 1.

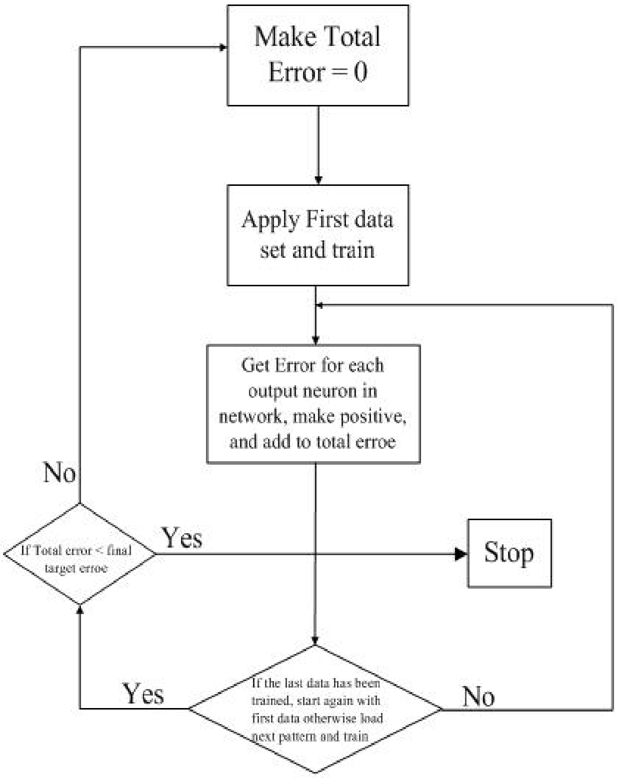

Figure 1: Error Calculation in BPN Algorithm

The network keeps training until the total errors falls to some pre-determined low target value and then it stops. Once the network has been fully trained, the test set is used to check the validation networks. The data used in the training is used in the test set, and the obtained results are shown in tables 1 & 2. The obtained Mean Square Error (MSE) is shown in figure 2, as it can be observed the error rate converges to a relatively small Mean Square Error (MSE), MSE Training = 0.022 and MSE Test = 0.019, which is acceptable. After the validation of the network is checked, it is used to generate the predictive cost indices. The last three published inflation rates data are used as inputs to generate the output for the next year. The new generated inflation rate and the last two published inflation rates will be the new inputs. This method continuously looped till the generation of the inflation rates for the project period. The obtained results for the years 2005 till 2008 are as shown in table 2; the developed model can be used for forecasting the inflation rates for the whole project period. (Baalousha & Mohamed, 2007)

Table 1: Data Used in Training Test

Code & Material		**Total**	
	Year	**AVG**	**Inflation**
5 General Total	**2000**	13126.5	56.50%
	2001	20543.25	35.88%
	2002	27913.75	21.28%
	2003	33855	14.60%
	2004	38797.25	

Table 2: Obtained Results in the test set

Code & Material		**Total**	
	Year	**AVG**	**Inflation**
5 General Total	**2005**	44003.325	11.21%
	2006	48937.625	8.31%
	2007	53002.125	7.47%
	2008	56961.38	

5 LIFE CYCLE COSTING

The life cycle costing analysis was prepared for a dormitory project that is to house students. The project is suppose to last for 25 years, however the years analyzed in this paper are the first six years of the project. The analysis was performed in MS Excel. Initially an inflation index table was constructed using the obtained results, and this index table was used to adjust the costs for inflation. The costs that were considered in the preparation of the life cycle costing analysis were:

- Construction Cost: Includes the cost to construct the project. It is made up of the substructure cost, superstructure costs and finishing and furnishing costs.
- Energy Costs: Includes the cost of electricity and gas for heating and the water spent.
- Operation and Maintenance cost: The operation and maintenance costs includes the cost of the salaries that will be paid to the employed and the maintenance cost include annual maintenance and major maintenance. Major maintenance is maintenance that will take place at some specific time of the period and annual maintenance is the annual recurring cost of maintenance.

Table 3 summarizes all the costs incurred during the analyzed period of the project. (Celik et al., 2009)

Once the costs were adjusted with the inflation for the respective years using the Present Value formula available in MS Excel and a discount rate of 25% all the cash flows were discounted to year zero and the present value was obtained. The obtained present value was 30,788,756.79YTL.

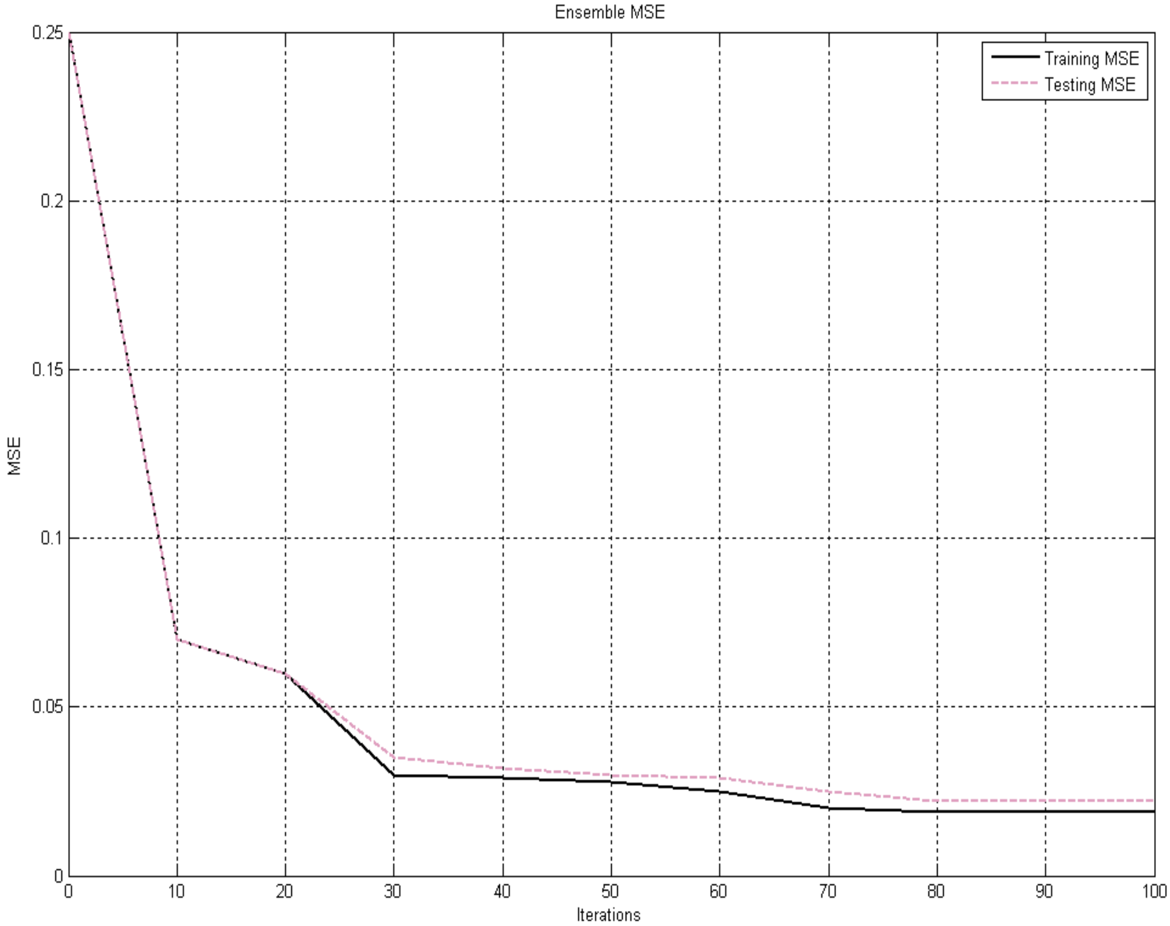

Figure 2: MSE Error

Table 3: Cost & Present Worth

		Years						
	Present Worth	0	1	2	3	4	5	6
Constrcution Cost	10,068,772.10	1,672,764	10,495,010					
Operation Cost	3,916,170.51			294,901	543,071	1,170,980	2,872,519	7,738,040
Energy Costs	14,475,447.84			1,012,100	1,967,307	4,359,054	10,741,397	28,668,337
Maintenance Cost	2,328,366.34			66,640	287,165	710,236	1,909,594	4,661,711
Total	30,788,756.79							

6 CONCLUSION

Construction price indices are primarily used for analysis of price movements and price formation in the construction industry, for price escalation clauses in construction contracts, and for deflation of components of the national accounts. The indices presented in this research are specifically designed for civil works constructions, and are specific for each of the major civil works features. Only indices for construction costs have been developed. The indices are used to escalate or inflate various project cost features to current or future price levels. Predicting the Construction Cost index is often resulting in large errors. To improve the accuracy of the Cost Index forecasts, the implementation of the Back Propagation Network in Matlab is chosen because it results in more accuracy results. The results of ANN were compared with the data published by the state of institute of statistics. The results of verification show that the neural network methodology could be successfully applied in prediction of costs for a life cycle analysis.

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