Forecasting the Bucharest Stock Exchange BET-C Index based on Artificial Neural Network and Multiple Linear Regressions

RAMONA BIRĂU
Department of Statistics and Economic Informatics
University of Craiova, Faculty of Economics and Business Administration
ROMANIA
birauramona@yahoo.com

MOHAMMAD EHSANIFAR
Department of Industrial Engineering, Science and Research Branch
Islamic Azad University, Arak Branch, Arak
IRAN
Ehsanifar79@gmail.com

HOSEIN MOHAMMADI
Sama technical and vocational training college
Islamic Azad University, Arak Branch, Arak
IRAN
Hosainmohammadi64@yahoo.com

Abstract: This paper aims to highlight a combined approach in forecasting emerging stock market prices based on the case of Bucharest Stock Exchange BET-C index. In recent past, extremely varied techniques have been implemented in order to achieve high performance accuracy of investment strategies. Considering the general worldwide context based on globalization and financial liberalization, international portfolio diversification is perceived as a very attractive opportunity. Compared with financial econometrics classical methodology, Neural networks is considered one of the most suitable techniques of forecasting. The empirical analysis was conducted by using Multi-Layer Feed-forward Neural Networks and multiple regressions over the analyzed time period, namely January 2000 to February 2013.

Key-Words: Neural networks, multiple regressions, Back-Propagation Algorithm, adaptive neuro fuzzy inference systems, BET-C index, models, investment strategies

1 Introduction
Emerging capital market such as Bucharest Stock Exchange is characterized by a quite atypical behavior that is influenced by significant features like: volatility clustering, non-stationarity of price levels, leverage effect, heteroskedastic log returns, deviations from normal distribution, time variation, unpredictability, non-linearity, chaos, fat-tailed distribution. Practically, the previous stylized facts generate an unstable and risky investment climate, but also extremely attractive for international investors. The significant investment potential of emerging capital market is strongly influenced in terms of global financial integration and international spillover effects. The dynamic inter-linkages between developed and emerging capital market based on international transmission patterns became rather highly represented, especially in the context of the global financial crisis that erupted in mid-2007 in U.S.A. Technically, the purpose of this paper is focused on forecasting the Bucharest Stock Exchange BET-C Index based on Artificial Neural Network and Multiple Linear Regressions.

2 Literature review
The empirical analysis is based on certain global factors of influence that were used in developing the models, including the D.J.IA index (U.S.A), Nikkey 225 index (Japan), F.T.S.E 100 index (U.K), WIG 20 (Poland), BUX index (Hungary) and SBI TOP index (Slovenia) over the analyzed time period, January 2000 to February 2013. Considering the accuracy of forecasting Neural networks are considered as more suitable for stock market prediction than any other classical econometric techniques. A basic definition of artificial neural
network suggests that it represent a mathematical model inspired by biological neural networks. An artificial neural network is a representation of the human brain, trying to simulate the representation of the cerebral process of learning. The term “artificial” refers to the fact that neural networks are implemented in computer programs, programs that are able to cope with the large number of calculations required during the learning process.

Fig. 1: The structure of a neuron in the human brain

Fig. 2: The structure of a neuron from an artificial neural network

Artificial neural networks are artificial intelligence technics, used to solve many problems such as linking memories, optimization, prediction, identification and control. Function and structure of artificial neural networks follows human brain and uses parts with simple structures which have intricate communications known as neurons (Strobl et al, 2007). Artificial neural networks are increasingly used for solving practical combinatorial optimization problems. This ability stems from the use of available information in order to come to understand the financial system structure. First step in constructing artificial neural networks is choosing inputs. Another significant step is data preprocessing. Data preprocessing consists of picking effective variants, training patterns, classification of patterns and standardization of them. The purpose of standardization is giving the same value to all elements of a pattern (Hassoun, 1995).

3 Methodological approach and main empirical results

Back-Propagation Algorithm

Multi-Layer Feed-forward Neural Networks are used widely in different fields such as classifying patterns, processing images, estimating functions. Back-Propagation Algorithm is one of the most relevant patterns for training Multi-Layer Feed-forward Neural Networks. This algorithm is an approximation of steepest descent (S.D) algorithm and is placed in performance learning field. Back propagation process consists of two major paths: forward path and backward path. A training pattern is given to the forward path and its effects scatter through mid-layers and then final layer so that the real output of MLP is acquired. In this path, network parameters (weight matrices and bias vectors) are assumed to be constant. In backward path, parameters of network are changed and modified. These modifications are based on the principle of learning to correct errors. Error signals emerge in exit layer of network. Error vector is equivalent to the difference between real output and suitable output.

In MLP networks each neuron has a nonlinear stimulation function that is a differential function. The relationship between network parameters and error signals is complex and nonlinear. So, partial differentials are not simply acquired. To get differentials, we use algebra principles [1].

Formulating BP algorithm

The BP algorithm is based on SD approximately algorithm. Adjusting network parameters is done according to error signals which are calculated when every pattern is given to the network.

ANFIS (Adaptive Neuro-Fuzzy Inference System) toolbox provided by MATLAB was used in order to conduct empirical analysis in general terms of computational modeling. Basically, this particular toolbox is based on a given input/output data set by implementing a fuzzy inference system (FIS) whose membership function parameters are adjusted using either a backpropagation algorithm alone or in combination with a least squares type of method. The method enables the fuzzy systems to learn from the data series which is included in analysis. The modeling approach used by ANFIS toolbox incorporates learning techniques that are very effective in financial modeling. Technically, model validation is the process by which the input vectors from input/output data sets on which the FIS was
not trained, are presented to the trained FIS model, to see how well the FIS model predicts the corresponding data set output values (MATLAB Fuzzy Logic Toolbox user guide).

Fig.3: MATLAB ANFIS Editor GUI window

![MATLAB ANFIS Editor GUI window](image)

Fig.4: MATLAB ANFIS model structure a), b)

![MATLAB ANFIS model structure](image)

The steepest descent (S.D) algorithm is described as follows:

\[ W^L_{ji}(K + 1) = W^L_{ji}(K) - \alpha \frac{\delta F}{\delta W^L_{ji}(k)} \]  
(1)

\[ b^L_{j}(K + 1) = b^L_{j}(K) - \alpha \frac{\delta F}{\delta b^L_{j}(k)} \]  
(2)

where \( W^L_{ji} \) and \( b^L_{j} \) are parameters of \( j^{th} \) neuron in \( i^{th} \) layer. \( \alpha \) is learning rate and \( F \) is the average error squares.

\[ \frac{\delta F(k)}{\delta W^L_{ji}(k)} = S^L_{ji}(k)ai^{l-1}(k) \]  
(3)

\[ \frac{\delta F(k)}{\delta b^L_{j}(k)} = S^L_{j}(k) \]  
(4)

\[ S^L_{j}(k) = \frac{\delta F(K)}{\delta b^L_{j}(K)} = \left[ \sum_{t=1}^{2n1} S^L_{ji}(k)W^L_{ji}(k) \right]f^L(N^L_{j}(k)) \]  
(5)

Where \( S^L_{j}(k) \) is network manner sensitivity in \( L^{th} \) layer[2].

First stage:
Entering Data to Anfis Toolbox (adaptive fuzzy inference systems and neural networks) and a set of values for the decision maker, including the Membership function, degree of error, function optimization is used here back propagation algorithm, the simulation epochs, as follows:
First stage : interring data in Anfis
Second stage:
Neural network architecture introduce with consideration of input values, hidden layer, and Model output, as follows:

Fig.5: Neural network architecture

![Neural network architecture](image)
Third stage: 
In this step 1000 epoch point were used and the error tolerance is 0.05 and it is similar to multiple regression model error tolerance, Starting simulation are shown in figure (5):

**Fig.6 : Starting the simulation**

Fourth stage: End of the simulation, and report the final decision, as follows:

**Fig.7: Final decision**

Fifth stage: 
At this particular Stage with considered to maximum and minimum rang of input data, decision maker will be able to predict the position of the Romanian stock market (BET INDEX).

Sixth Stage: A comparison of neural network and multiple regression taking 30 samples of real data:
In this stage to test the Anfis model and it’s resoult, 30 sample of data including the DJIA index (U.S.A), Nikkey 225 index (Japan), F.T.S.E 100 index (U.K), WIG 20 (Poland), BUX index (Hungary) and SBI TOP index (Slovenia) ,from January 2000 to February 2013 in the same date, were injected to Anfis model and multiple regression,the results are shown in table(1).

**Table 1 : Forecasting BET-C index**
As a result, we obtain:

\[ MAPD \text{ (Between N.N and Real Data (Romania))} = \sqrt{\frac{\sum |A_i - F_i|}{\sum A_i}} = 297.94 \pm 0.003 \]

\[ MAPD \text{ (Between multiple regression and Real Data (Romania))} = \sqrt{\frac{\sum |A_i - F_i|}{\sum A_i}} = 8998.73 \pm 0.09 \]

equation (6) shows the multiple regression equation.

\[ Y = -1184.469 + 0.213X_1 + 0.025X_2 - 0.499X_3 + 0.130X_4 + 0.958X_5 + 0.430X_6 \]  

The range data can be injected into any arbitrary input and the desired result can be obtained with acceptable precision (the input data should be between min and max for each column):

**Fig. 8: The min and max values for each variable**

<table>
<thead>
<tr>
<th></th>
<th>DJIA (USA)</th>
<th>NIKKEI 225 INDEX (JAPAN)</th>
<th>FTSE100 INDEX (UK)</th>
<th>BUX index (Bulgaria)</th>
<th>SBITOP (Slovenia)</th>
<th>WIG20 (Poland)</th>
<th>BET-C (Romania)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MIN</td>
<td>6577</td>
<td>7054.98</td>
<td>3945.87</td>
<td>8184.58</td>
<td>540.73</td>
<td>1011.84</td>
<td>1125.60</td>
</tr>
<tr>
<td>MAX</td>
<td>14164.33</td>
<td>20833.21</td>
<td>6402.01</td>
<td>28307.40</td>
<td>2674.83</td>
<td>3917.07</td>
<td>7048.34</td>
</tr>
</tbody>
</table>

The daily movement of stock market BET-C index from Jan 2001 to Feb 2013 is shown in following figure:

**Fig. 9 : The graph of the BET-C index**
4 Conclusions
In recent past, particular multi-disciplinary and interdisciplinary research are included increasingly more often in financial approach based on complex methodology able to provide improved accuracy results. Traditional paradigms are rather unsuitable regarding decisions making process based on noisy data requiring intensive computing such as pattern recognition. Consequently, the neural networks field has expanded considerably and has quite relevant practicability in financial modeling. The main purpose of the empirical analysis conducted in this article is the results based on different methodologies. According to the results, Neural networks are much more accurate than multiple regressions. Several global factors that influence the Romanian stock market were used in the model, based on stock market data collected from January 2000 to February 2013. The data from 30 samples were extracted by taking the min and max of each country. Selected data were injected to ANFIS for predict the results. The actual data compared with the results of multiple regression and ANFIS absolute percentage deviations of the model with the smallest deviation was chosen as the model predictions were identified and introduced. The special point of this model (ANFIS) is the ability to online forecasting. At the moment of time according to influencing factors like D.J.IA index (U.S.A), Nikkey 225 index (Japan), F.T.S.E 100 index (U.K), WIG 20 (Poland), BUX index (Hungary) and SBI TOP index (Slovenia) the model can predict with relatively high accuracy the Bucharest Stock Exchange BET-C Index. Despite the inherent limitations, the results achieved by ANFIS provide superior accuracy compared to conventional methods of financial modelling.

References: