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PREDICTION OF THE RELATIONSHIP BETWEEN THE BIST 100 INDEX AND ADVANCED STOCK MARKET INDICES USING ARTIFICIAL NEURAL NETWORK: (2011-2015)

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Abstract – Prediction techniques and models are significant for people and organizations who wish to make prediction at the stage of investment and decision-making. For investors who want to achieve high earnings from investments, the stock market indexes are extremely important. Price movements in the stock such as political and social ones are affected by many factors. In the studies conducted on İstanbul Stock Exchange Index (BIST-100), the estimation generally of foreign exchange rates, interest rates, gold prices, GNP (Gross Nation Product), CPI (Consumer Price Index) and the relationship with macroeconomic variables such as the rate regard to traditional statistical prediction models were used. In this study, international advanced BIST100 Index of the estimation with Artificial Neural Network (ANN) method will be used as input instead of traditional macroeconomic variables (independent variables) and also stock market index data sets will be used. From January 2011 to December 2015 period, daily closing price of some international advanced stock market indices and BIST 100 Index data were used as data set. Data analysis were carried out through Multilayer Neural Network (MLNN) method, which is an ANN model widely used in MATLAB and the successful rate was %96,92.

Keywords – *Investment, BIST-100, International stock market indices, Artificial neural networks, Prediction.*

1. Introduction

In line with the globalization agenda evolving since the beginning of the 21st century, there have been significant developments in the financial markets in parallel with the stock markets, which can be considered barometers of the economy. A need has been arisen to

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analyze stock markets with not only the domestic factors but also with the stock market indices and factors of the countries that they have an interaction with. Forecasting is to generate ideas and scenarios about the future based on existing or historical data. In other words, forecasting can be defined as any attempt made with the aim of predicting the future. Forecasting techniques and models are important for individuals and organizations who wish to make predictions during the decision making and investment phase. Predicting the stock market index is very important for investors who want to achieve higher earnings from their investments.

The index is an indicator for measuring the proportional change, which consists of variation of one or more variables. Indices are instruments that can provide approximate information about events by reducing complex events to a single digit [1]. The prediction of the BIST 100 index, which is the prediction of stock returns, is an important issue in the field of finance [2]. The value of stocks traded on the securities market is influenced by internal and external factors. Internal factors are the company's estimated earnings and changes in the financial structure of the company. And, the external factors can be caused by factors outside the firm. These macroeconomic factors are variables such as exchange rates, interest rates, gold prices, GDP and CPI rate. The prediction of the BIST100 index has attracted much interest, and pretty much study has been conducted in this regard. However, in most of these studies, only the relationship between the BIST100 index and several macroeconomic variables has been analyzed, and statistical estimation techniques and time series models have been used [3,4].

Artificial neural networks has become widespread only recently, in studies regarding the prediction of the BIST100 index [5 - 11]. In this study, instead of traditional macroeconomic variables, the dataset on the international advanced stock market indices was used as the input (independent variables) in order to predict the BIST 100 index with the ANN method. In addition, as a limitation of the study, it should be noted that unpredictable factors such as political uncertainty, "insider trading" in Turkey, natural disasters and wars directly affect the index, making the prediction difficult.

The paper is organized as follows: section 2 describes advanced stock market indices and the structure of prediction method, section 3 presents some applications on real datasets to verify the effectiveness of the proposed method, and finally, section 4 gives the conclusions.

2. Material and Method

2.1 International Stock Market Indices

Economists can make assessments about the course of economy by analyzing the trends in index. For this reason, first the changes in the indices of advanced stock markets in the United States and Europe are evaluated, and then the indices of developing countries are analyzed when performing stock assessments. In this study, the BIST 100 index and some of the advanced international stock market daily closing data of indices from January 2011 to December 2015 period were used as the data set. These datasets were obtained from website [12]. The international stock market indices used were NASDAQ 100 (USA), NIKKEI 225 (Japan), FTSE (UK), DAX (Germany), CAC 40 (France), DJ 30 (USA) and S&P 500 (USA), and are given in Table 1.

Table 1. Indices used in the study

Item Number	Indices	Index of the Stock Exchange
1	BIST 100 Index	İstanbul Stock Exchange - Turkey
2	NASDAQ 100 Index	NASDAQ Stock Exchange - USA
3	DJ30 Index	New York Stock Exchange (NYSE) - USA
4	S&P 500 Index	New York Stock Exchange (NYSE) - USA
5	DAX 30 Index	Frankfurt Stock Exchange - Germany
6	FTSE 100 Index	Londra Stock Exchange - UK
7	NIKKEI 225 Index	Tokyo Stock Exchange - Japan
8	CAC 40 Index	Euronext Paris Stock Exchange - France

The NASDAQ-100 index consists of the top 100 securities, except financial and investment companies, traded on the NASDAQ stock exchange. The NASDAQ stock market, which includes the shares of technology companies such as Facebook, Twitter, Google, Microsoft, IBM, Apple and Cisco, is referred to as the technology stock market of the world. In addition, it is regarded as the world's second largest stock exchange in terms of trading volume and market value. As one of the major stock exchanges of the World, Japan's Nikkei 225 index consists of the 225 largest Japanese companies traded on the Tokyo Stock Exchange. In terms of its calculation, NIKKEI 225 index is a weighted average index. It is one of the most basic of indicators of the Japan's economy. Toshiba, Bridgestone, Kikkoman, Mitsubishi, Tokyo Electric, Kawasaki, and Hitachi are among the companies included in the index. The FTSE 100 (The Financial Times Stock Exchange 100) Index is considered the main index of stock exchange of the UK, and consists of the top 100 companies, in terms of market value, listed on the London Stock Exchange. Approximately 65% of the index consists of domestic companies, whereas 35% is the global companies.

It is among the European stock exchanges with highest returns and trading volume. The DAX 30 index includes companies such as British Airways, British Petroleum, HSBC, Standard Chartered, Tesco Lloyd Banking Group and Unilever. The DAX 30 is an index traded on the Frankfurt Stock Exchange, representing the 30 largest German companies with high liquidity, and is considered as Germany's most important stock market index. It also includes companies such as Adidas, Deutsche Bank, SAP, Siemens as well as number of car manufacturers such as Volkswagen, and BMW. The CAC 40 index is the main index of the Euronext stock exchange in Paris. It consists of the weighted average of the 40 largest French stocks, in terms of market value. It's one of the most important indicators of France's economy. It includes companies such as Renault, Air France, Michelin, Alcatel-Lucent and L'Oreal. DJ 30 (Dow Jones Industrial Average) index is among the most used and important stock indices in the US securities markets. It is traded on the New York Stock Exchange, which is considered the world’s largest stock exchange. This index measures the performances of 30 stocks, which have higher market values, including the leading companies such as IBM, Apple, Microsoft, American Express, Intel, General Electric, Boeing, 3M, and Coca-Cola; and, it's calculated on the basis of weighted average price. And, the S&P 500 index is prepared by US-based international credit rating agency Standard&Poor's (S&P), and includes 500 largest American companies. It covers approximately 75% of the American equity market. Of the shares that make up the index, 93% is traded on the New York Stock Exchange. This index is regarded as one of the most important indicators of the US economy [13]. The time series graphs of stock market indices used in the study are shown in Figure 1.

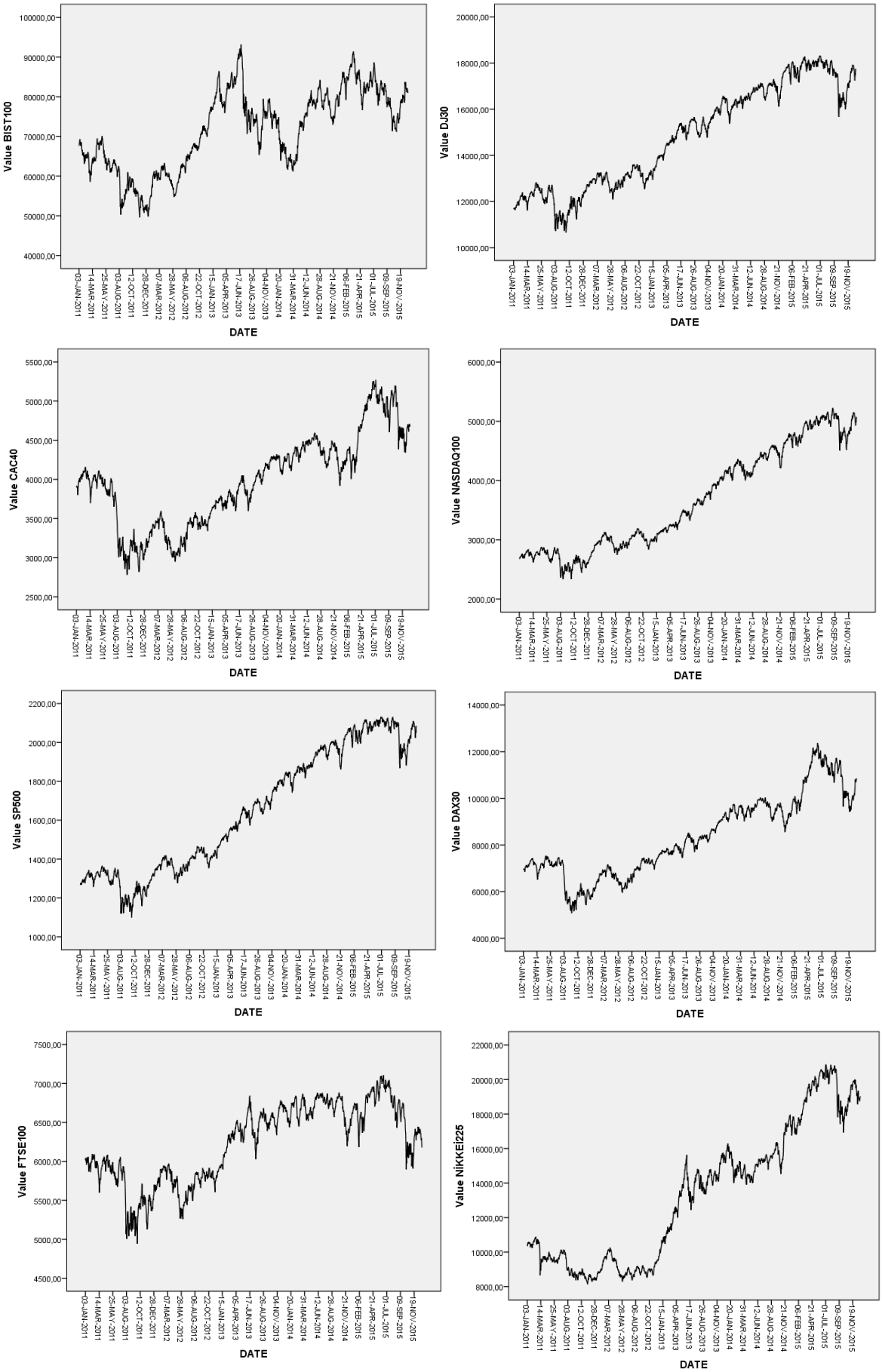

Figure 1. The time-series graphs of stock market indices over the 2011-2015 study period

The behavior of the indices was investigated by examining the time-series graphs in Figure 1. It is demonstrated that time series graphs with the purpose of seeing the price movements shown by data and relationship between indices in the period 2011-2015. It is addressed that BIST 100 indice's volatility is more than the other developed stock exchange indices. As a cause of this, if there is a sovereign, it can be interpreted as being more of capital inflows and outflows because of foreign capital ratio is very high in Borsa Istanbul. One of the interesting point in the graphics is that BİST 100 indice showed a sharp drop unlike other indices in the year 2013. This situation can be considered to be due to political uncertainty in the country, the high regional risks and more hot money flows in this period. Furthermore as determined from correlation matrix, time series graphics also support that S&P 500 and NASDAQ 100 indices act very close together and have quite a high positive correlation.

2.2 Artificial Neural Network (ANN)

The process that allows making comments about newly encountered situations on the basis of available examples with known results is called prediction. In this study, Multilayer Neural Network (MLNN) was used as the method of prediction since it's the most widely used artificial neural network (ANN) model. The overall structure of the neurons in the MLNN is shown in Figure 2.

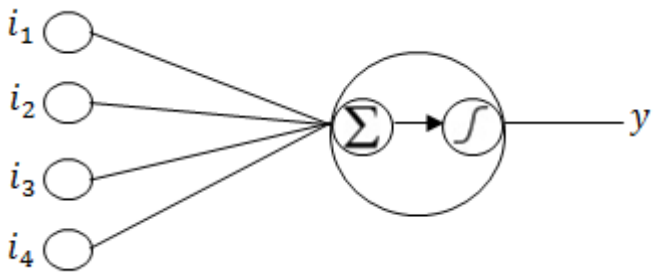

Figure 2. The neuron structures used in MLNN networks

The neuron in the MLNN model shown in Figure 2 has four inputs and one output. Each input (i_1, i_2, i_3, i_4) of the data is multiplied by the separate weight values (w_1, w_2, w_3, w_4) in the neuron, and the generated y value is provided at the output. The neuron has two processing units where linear and nonlinear operations are carried out. In the linear unit, each input is multiplied by the weight value, summed, and the result is sent to the second unit. The operation in the linear unit, which is the n value is shown in Equation 1 [14].

$$n = \sum_k i_k w_k \tag{1}$$

In the second unit, where nonlinear operations are carried out, the resulting total value passes through activation function, and the value obtained is sent to the output of the neuron. The y value at the neuron output is calculated as given in Equation 2.

$$y_{out} = f(n) \tag{2}$$

where, f in Equation 2 is the selected activation function. The commonly used activation functions are sigmoid, hyperbolic tangent, and step functions. In general, variants of back propagation algorithm are used in MLNN as the training algorithm. The weights of connections between neurons are adjusted with the help of training algorithm in order to optimize the output of the network.

The accuracy of the value obtained as a result of MLNN is based on the Mean Squared Error (MSE), and hence minimizing the Root Mean Squared Error (RMSE).

$$\mathrm{MSE} = \frac{1}{\mathrm{N}}\sum_{\mathrm{i}=1}^{\mathrm{N}}(\mathrm{d_i} - \bar{\mathrm{d}}_\mathrm{i})^2 \tag{3}$$

$$\mathrm{RMSE} = \sqrt{\mathrm{MSE}} \tag{4}$$

The $\mathrm{d_i} - \bar{\mathrm{d}}_\mathrm{i}$ expression in the Equation 3 gives the error (distance) between each target variable and calculated linear equation. And, the RMSE expressed in the Equation 4 is used to determine the error rate between the predictions and the measured values. RMSE closer to zero indicates and increasing prediction capability of the system [15].

In the study, MLNN model was used to predict the BIST 100 index by providing international advanced stock market indices as the input datasets. This model is shown in Figure 3.

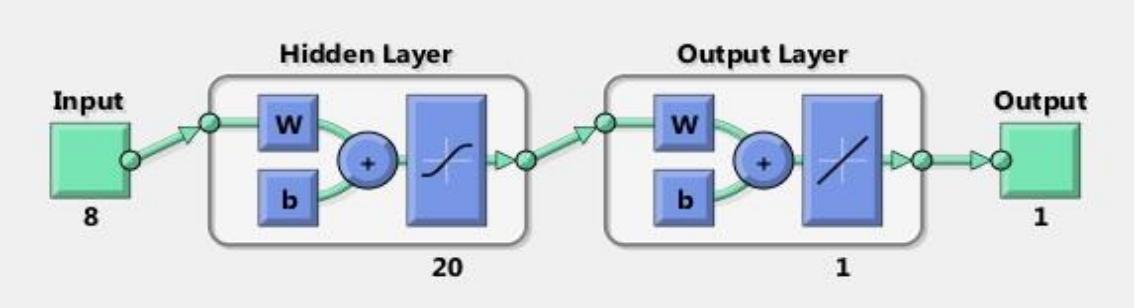

Figure 3. The ANN model used

As seen in Figure 3, there are 20 neurons in the hidden layer in this model, and the sigmoid function was used for activation in neurons as well as the Levenberg-Marquardt back-propagation algorithm, used for training. The study was carried out in Matlab 2014.

3. Results and Discussion

In the experiments carried out using the datasets and techniques described in the previous section, a dataset of international advanced stock market indices (NASDAQ-100, NICKEI-225, FTSE 100, DAX 30, CAC 40, DJ-30, S&P 500) were used to predict the BIST 100 Index.

The normality tests of the daily closing data of the index over the 2011-2015 study period were performed with the help of the SPSS 22.0 software, and the results shown in Table 2 were obtained.

Table 2. Normality test results of the stock market indices

	Kolmogorov-Smirnova			Shapiro-Wilk		
	Statistic	Df	Sig.	Statistic	df	Sig.
BIST100	,078	1229	,000	,969	1229	,000
DJ30	,135	1229	,000	,923	1229	,000
FTSE100	,106	1229	,000	,951	1229	,000
NİKKEİ225	,155	1229	,000	,904	1229	,000
DAX30	,100	1229	,000	,966	1229	,000
CAC40	,051	1229	,000	,979	1229	,000
SP500	,140	1229	,000	,908	1229	,000
NASDAQ100	,152	1229	,000	,905	1229	,000

The normal distribution of the data was tested with Kolmogorov-Smirnov test if the number of data is 29 and above, and Shapiro-Wilk test was used if it's lesser than 29 [12]. According to Kolmogorov-Smirnov test, all the daily closing data of the indices had non-normal distribution since the significance values were below 0.05 for all indices ($p<0.05$). And, the results obtained using SPSS 22.0 statistical package program according to Spearman correlation used in data that have non-parametric distribution are shown in the correlation matrix given in Table 3, which presents the relationship between stock exchange indices datasets.

Table 3. Correlation Matrix

	BIST100	**NASDAQ100**	**S&P500**	**DJ30**	**FTSE100**	**NIKKEI225**	**DAX30**	**CAC40**
BIST100	*1,000*	*0,764*	*0,792*	*0,784*	*0,750*	*0,770*	*0,780*	*0,657*
NASDAQ100	*0,764*	1,000	0,992	0,984	0,839	0,931	0,946	0,860
S&P500	*0,792*	0,992	1,000	0,995	0,862	0,932	0,947	0,861
DJ30	*0,784*	0,984	0,995	1,000	0,865	0,917	0,931	0,835
FTSE100	*0,750*	0,839	0,862	0,865	1,000	0,854	0,878	0,832
NIKKEI225	*0,780*	0,931	0,932	0,917	0,854	1,000	0,946	0,916
DAX30	*0,770*	0,946	0,947	0,931	0,878	0,946	1,000	0,947
CAC40	*0,657*	0,860	0,861	0,835	0,832	0,916	0,947	1,000

Based on the correlation matrix given in Table 3, the S&P 500 index of the United States has the strongest relationship with BIST100 index. This is followed by DJ 30 index of the United States, and Germany's DAX 30 index. The fact that the US and Germany are the top two countries that make investments in Turkey, and both countries are the top two countries that have the largest foreign trade volume with Turkey in the America and Europe regions, can be the reason behind the strong correlation between these two countries and the BIST 100 index.

In this study, the random selection cross-validity method was applied to test the MLNN model without any bias in the dataset prepared for the prediction of the BIST 100 index. In this method, the available data is randomly distributed into training, validation and test groups. In the study, the distribution of the data was 50% training, 15% validity, and 35% test respectively. In order to normalize the results, the dataset is rearranged with the same distribution ratios, and was subjected to 10 different training phases. The training, validity, test and mean prediction accuracy of the first of these experiments are shown in Figure 4.

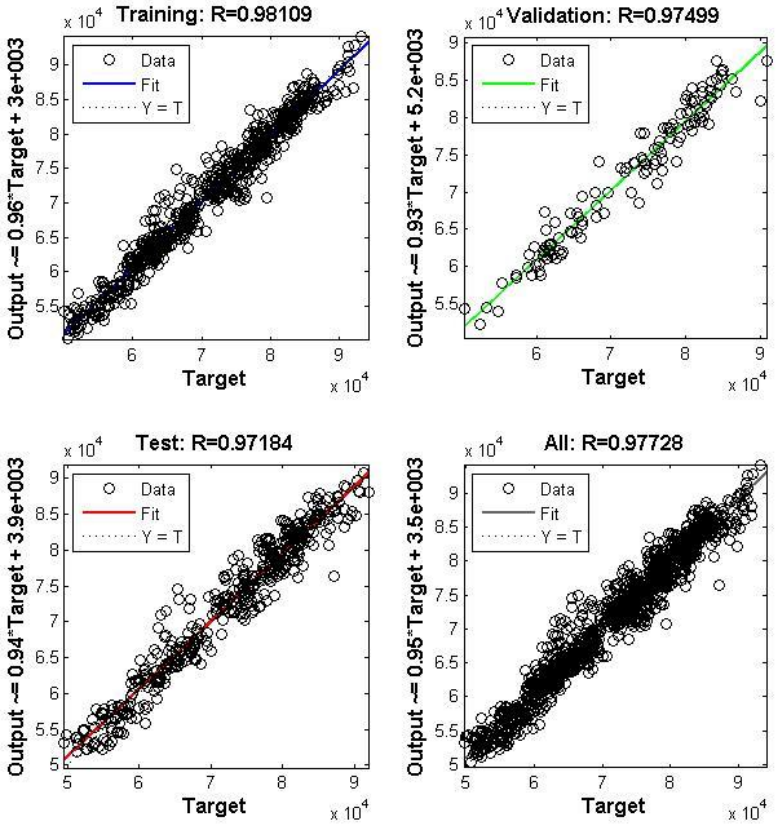

Figure 4. The success graph of MLNN training of the Experiment-1

In addition, prediction accuracy for each experiment as well as the MSE values are shown in Figure 5.

Results

	Samples	MSE	R
Training:	676	3801134.58826e-0	9.81094e-1
Validation:	123	4556329.37347e-0	9.74988e-1
Testing:	430	5750575.53445e-0	9.71835e-1

Figure 5. The MSE values and success rates of MLNN training of the Experiment-1

As provided in Figure 5, the prediction accuracy values of each experiment and RMSE values are presented in Table 4. The minimization of RMSE value ensures minimization of the error. The average of these values gives the success rate of our model.

Table 4. The prediction accuracy and RMSE values obtained after MLNN application on the model

Experiment Number	The rate of prediction accuracy (%)	Root mean square error (RMSE)
1	97,18	2398,04
2	97,26	2332,02
3	96,78	2576,12
4	97,28	2295,82
5	97,15	2409,12
6	96,14	2692,95
7	96,66	2551,81
8	97,31	2287,74
9	96,44	2615,64
10	96,91	2527,84
Mean	**96,92**	**2480,72**

As shown in Table 4, the model to be applied for the prediction of the BIST 100 index has a 96.92% prediction accuracy and 2480.72 RMSE.

4. Conclusion

Forecasting techniques and models are important for individuals and organizations who wish to make predictions during the decision making and investment phase. Predicting the stock market index is very important for investors who want to achieve higher earnings from their investments. Price movements in the stock market are affected by many factors such as political, and social effects. In studies on the prediction of the BIST 100 index, generally its relationship with traditional macroeconomic variables such as exchange rates, interest rates, gold prices, GDP and CPI rate was investigated, and statistical prediction models were utilized. In this study, the dataset on the international advanced stock market index was used as the input (independent variables), instead of traditional macroeconomic variables. These index values are the variables that may affect the value of the BIST 100 index, as an alternative investment instrument for international investors and arbitragers. The MLNN method, which is the most widely used ANN model, was used to predict the value of the BIST100 index.

Nowadays, artificial neural networks can be applied to many financial problems such as macroeconomic forecasts, the assessment of bank loans and insurance policies, predictions of bonds, stocks and exchange rates, and risk analysis. ANN is used in the financial sector as well as in many areas, thanks to its ease of design, quick adaptation to the problems, and ability to provide successful results, despite the limited data.

As a result of the study, it was observed that there is a strong relationship between the BIST 100 index and indices of advanced countries. The BIST 100 index was predicted with a high success rate of 96.92% thanks to the artificial neural networks model. An optimal

forecasting model can be tested in future studies by incorporating indices of developing countries along with domestic macroeconomic factors as well as the indices of developed countries.

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