Prediction of Gold Prices Using Artificial Neural Networks

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Abstract

Gold, which has fulfilled the functions that money has in the past years, is now mostly used as a means of saving. Gold has been an investment instrument for Turkish society for many years. In addition, it is perceived as the most reliable means of investment by people in times of crisis and war. It is very important to estimate gold prices for investors who want to earn high profits from their investments. In this study, as input (independent variables), the data set consisting of Brent oil price, USD price, BIST100 index, Central Bank of the Republic of Turkey weekly interest rate, silver and copper prices was applied to the price of gold in ounce by applying Multi-Layer Perceptron Neural Network (MLPNN) is intended to be estimated. As the data set, weekly price and index values were used between January 2010 and December 2016 period. As a result of the study, suggestions were made about the effectiveness of gold on the input variables created by using MLPNN.

Key Words

"Investment, Gold prices, Prediction, Artificial Neural Network"

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1. INTRODUCTION

Investment; depositing money on an income-generating, movable or immovable property (Sjaastad,2008). Saving owners (investors) want to make money with the help of various investment tools. One of these alternatives is precious metals. Among the precious metals, gold comes first.

Gold, which has fulfilled the functions that money has in the past years, has not lost much in its importance, although it is often used as a means of saving money today. Gold has been seen as an investment tool in Turkish society for many years. It is perceived as the most reliable investment tool by people during crisis and war periods.

It is very important to estimate gold prices for investors who want to earn high profits from their investments. Investors' interest in gold is shaped by the influence of various factors. International gold prices; foreign exchange prices, interest rates, stocks, commodity prices and so on are some of these factors. Any change in these factors affects the supply and demand of gold.

Forecasting is to produce scenarios for the future based on existing or past data. Estimation is an important factor in planning ahead and calculating numerical values (Armutlulu,2000). Throughout their lives, people make many guesses without realizing it. Even the simplest situation that requires a decision requires estimation. Decision making is the selection of one or more definitions from among other definitions by evaluating the definitions made in determining the characters of the variables (Bağırkan,1983).

The demand for gold increases in case of a decrease interest in other investment instruments. The idle funds tend to gold in periods when interest in stock exchanges declines and real interest rates provide negative income. In the opposite case, the interest in gold of the investor falls to a very low level (ITO,1983).

There are many studies about the estimation of gold prices using different methods. Some of these are given below.

Atan et al. found that gold prices have a positive interaction with stock returns (Atan et al.,2000). Albeni and Demir found the existence of a positive relationship between the Republican gold and the financial index contrary to expectations (Albeni et al.,2005). Aye et al. developed models for estimating gold prices. They selected nominal interest rate, exchange rate, commodity prices, stock prices as factors affecting gold. The results show that dynamic model selection is the best method. The exchange rate is very high predictive power has been identified (Aye et al.,2005).

Yuksel and Akkoc investigated models for estimating the gold prices with artificial neural networks. The findings show that artificial neural networks can be successfully used in estimating gold prices. When the results of the sensitivity analysis are evaluated, it is found that silver and oil prices are the leading factors affecting gold prices (Yüksel et al.,2016). Aksoy and Topcu analyzed short and long term relationships between gold and stocks, government debt securities, consumer price index and producer price index as an investment tool in their work. Regression analysis results show that there is a negative relationship between the gold and stock returns (Aksoy et al.,2013).

Kocatepe and Yıldız estimated the direction in change of gold prices using artificial neural networks. In the study, the gram price of gold in Turkey is taken as the dependent variable. The independent variables were crude oil price, dollar index, dollar exchange rate, Standard & Poor's 500 index, BIST100 index, Turkish inflation, bond and interest rates, US inflation, bond and interest rates, silver and copper prices. In the study, for estimating the future value of the dependent variable, the one month earlier values of the independent variables were used. The success predicting the direction of change in gram gold price was found to be 75.24% (Kocatepe et al.,2016).

Kristjanpoller et al. analyzed a hybrid model (ANN–GARCH) to predict the gold spot price. The results of the study show that the proposed ANN-GARCH model performs 38% better volatility estimates of gold prices than the GARCH model. This result was found in the 21-day volatility estimates. The same situation was also estimated for 14 and 28 day changes (Kristjanpolleret al.,2016).

Abd Wahab and Nursu, is predict monthly price of gold. The monthly sample data of gold price (in RM per ounce) were taken from January 2004 to November 2015. The model performance was evaluated in term of error magnitude (EM) and directional change error (DCE). The result of the study had suggested that the ANN model with LMBP algorithm had perform the best model compared to ARIMA model and another ANN model using RBP and SCGBP algorithm (Wahab,2016).

The aim of this study is to estimate the gold prices by using artificial neural networks method with some macroeconomic variables which are thought to affect gold prices.

2. MATERIAL AND METHOD

2.1. Material

In the study, the dollar rate for the January 2010 - December 2016 period, the weekly interest rates for CBRT and the weekly closing values for commodity prices were used as the data set. These data sets were obtained from http://investing.com/. The input variables used are given in Table 1.

Table 1: Input variables used in the study

Sıra No	Input variables
1	Brent Petrol Fiyatı
2	ABD Dolar Kuru
3	BIST100 Endeksi
4	TCMB Haftalık Faiz Oranı
5	Gümüş fiyatı
6	Bakır fiyatı

Referring to previous years, exchange rates (USD) gained value in real terms from time to time and thus has created a positive return investment opportunity. From this point of view, it is thought that it can be effective on gold value as an alternative investment tool.

Interest is the rent income that is obtained as a result of the capital being rented at a specified rate and for a certain period of time (Rüzgar,2001). It is the biggest rival bank depositor to invest in capital markets in developing countries. Theoretically, the increase in interest rates increases the cost of borrowing. In terms of investors, when interest rates rise, investments will channel to that side. Therefore, the change in interest rates will affect the prices of other investment instruments.

It is included in the gold and petroleum commodity category in finance literature. Both are important factors shaping the global economy. The most important reason for the correlation between gold and oil prices is the effect of crude oil prices on inflation. Increase in oil prices increases gasoline prices, gasoline prices also affect inflation. Here, the causality effect leads to an increase in precious metals as inflation increases (Hürriyet,2017).

Securities exchanges are markets where long-term investment instruments such as stocks and bonds are bought and sold (Karan,2004). Stocks are described as the barometer of the economy. If the economy worsens, investors exit the stock market and turn towards different investment instruments.

In the markets, silver is demanded in serious transaction volumes as an alternative to gold. The intense demand for gold causes prices to rise. When the gold price reaches the psychological upper limit for investors, demand will decrease and prices will go downhill. Therefore, investors are making silver and copper transactions which are alternative assets instead of gold trading. In this case, demand for silver and copper is increasing (forexaltinpiyasasi,2017).

Time series graphs of macroeconomic input variables used in the study are given in Figure 1.
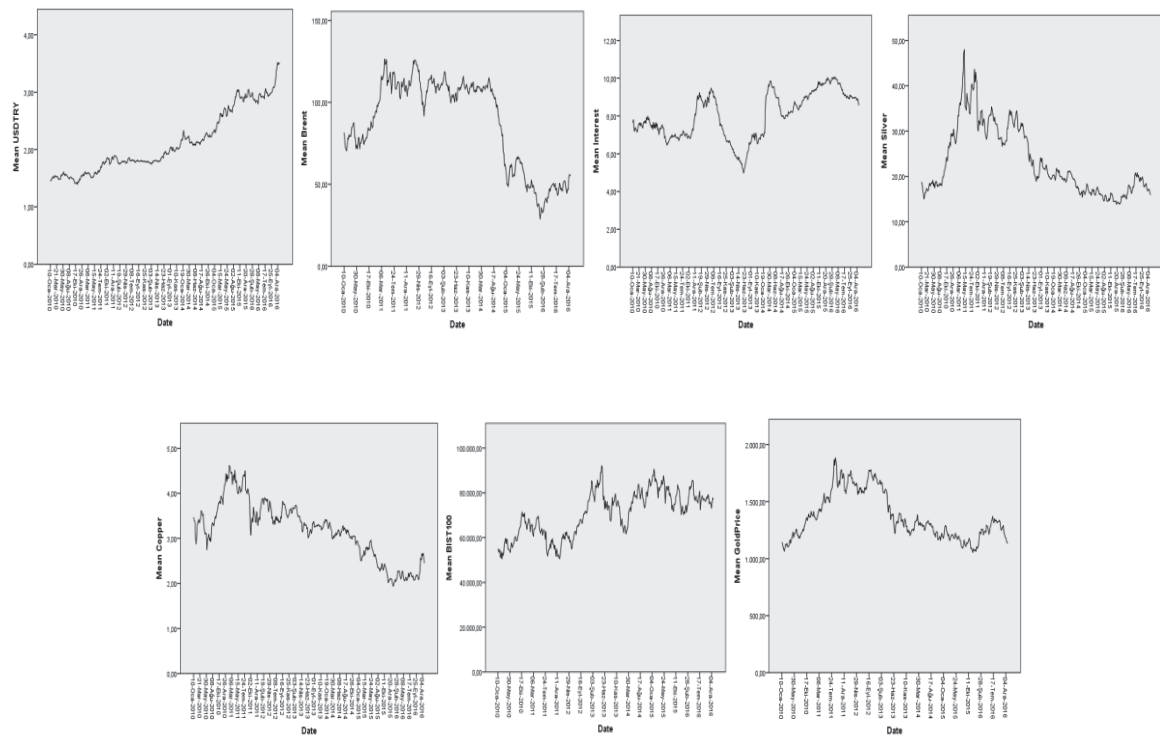
Figure 1: Time series charts for input variables

2.2. Artificial Neural Network (ANN)

Estimation is a process that produces a relationship using examples that have definite consequences and allows you to comment on the new situation through this derivation. As a prediction method, Multi-Layer Neural Network (MLNN), which is an artificial neural network model, was used in this study. In Figure 2, a sample MLNN is given.
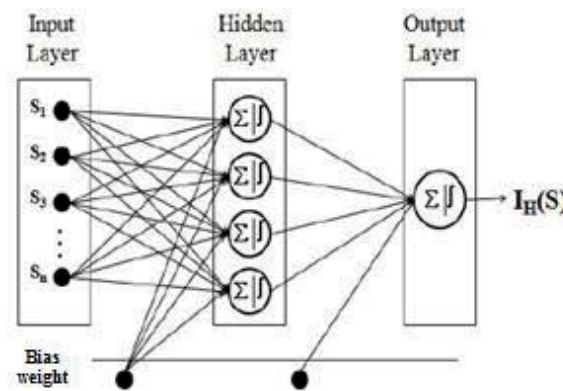

Figure 2: A sample MLNN

As shown in Figure 2, the output value (y) produced after each input ($s_1, s_2, ..., s_6$) is processed in the neuron by multiplying it by a separate weight value ($w_1, w_2, ..., w_6$). There are two processing units within the neuron that perform linear and non-linear processing. In the linear unit, each input is multiplied by the weight value and the result is sent to the second unit (Bellanger,2000).

The value obtained after passing through the selected activation function of the total value obtained in the second unit in which non-linear transactions are made is given to the output of the neuron. The y value at the exit of the neuron is calculated as given in Equation 1.

$$I_H(s) = f(n) \tag{1}$$

The expression *f* in Equation 1 shows the selected activation function. Commonly used activation functions are sigmoid, hyperbolic tangent and step functions. Generally, back propagation algorithm derivatives are used as training algorithm in the MLNN. With the aid of the training algorithm, the network output is optimized by adjusting the weights of the connections between the neurons.

The correctness of the value obtained at the MLNN output is based on the finding of the smallest value of the Mean Squared Error (MSE), and hence of the Root Mean Squared Error (RMSE), as expressed in Equation 2.

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

$$RMSE = \sqrt{MSE} \tag{3}$$

$(d_i - \bar{d_i})$ in Equation 2 indicates the distance (error) between each target variable and the correct equation to be calculated. Root Mean Square Error (RMSE) in Equation-3 is used to determine the error rate between the measured values and the estimates. The approach of the RMSE value to zero means that the estimation capability of the system is increased (Chenard et al.,2008).

In the study, the MLNN model was used to estimate the gold prices. As input to the model, data sets consisting of macroeconomic input variables (dollar rate, TCMB weekly interest rates and weekly closing values of commodity prices) were used. In this model, 10 neurons in hidden layer, sigmoid function for activation in neurons and Levenberg-Marquardt back propagation algorithm for training were used. Experiments were performed in Matlab 2016 platform.

3. DISCUSSION

In the experiments conducted using the dataset and techniques described in the previous section, it was tried to estimate the ounce value of gold prices by using the US dollar rate, BIST100 index, CBT weekly interest rate and commodity (copper and silver) prices. The correlation results obtained using the SPSS 22.0 statistical package program to analyze the relationships between input variables are shown in Table 2.

Table 2: Correlation matrix between input variables

	Gold	BIST100	USDTR	Brent	Silver	Copper	Interest
Gold	1	0,687	0,783	0,690	0,892	0,515	0,653
BIST100	0,687	1	0,770	0,676	0,742	0,699	0,846
USDTR	0,783	0,770	1	0,757	0,726	0,864	0,677
Brent	0,690	0,676	0,757	1	0,736	0,839	0,608
Silver	0,892	0,742	0,726	0,736	1	0,803	0,669
Copper	0,515	0,699	0,864	0,839	0,803	1	0,649
Interest	0,653	0,846	0,677	0,608	0,669	0,649	1

According to the correlation matrix given in Table 2, the strongest correlation with gold prices is the silver price index. This situation reveals the importance of silver, which is a direct alternative investment in gold investment. Copper is one of the most comparable commodities of gold and there is usually a positive relationship between gold and copper. However, after the 2008 crisis, there has been a decline in this correlation. Gold prices have risen rapidly after the crisis, but have fallen considerably in copper prices. The divergence between the two commodities has become increasingly apparent since the second quarter of 2010. For this reason, there is no strong correlation between gold and copper prices, as seen in the table.

In the study, a cross-validation method was applied to the data set prepared for the estimation of gold prices. In this method, the given data is randomly distributed to 3 clusters as training, validity and test. In the study, the distribution of data was 40% education, 20% validity and 40% test data. In order to make the results more objective, the data set has been relocated within the same distribution ratios and subjected to 10 different education stages. The accuracy of the training, validity, test and mean estimation of the first of these experiments is given in Fig 3.
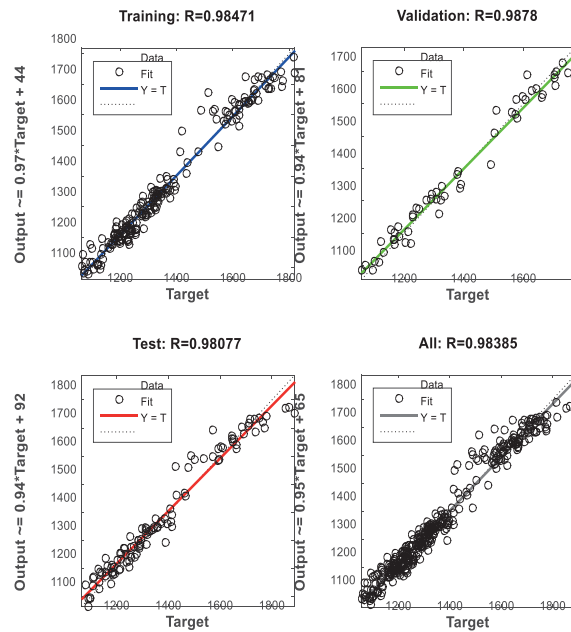
Figure 3: Success graph of ANN training (Exp. No:5)

The estimated accuracy values obtained from each experiment as given in Fig. 3 are given in Table 3. The average of these values gives the success rate of the model we have created.

Table 3: Predictive accuracy values of the MLNN experiments

Experiment	Accuracy (%)
1	98,60
2	97,73
3	98,51
4	97,56
5	98,39
6	97,95
7	99,13
8	97,87
9	97,90
10	98,01
Mean	**98,17**

The estimation accuracy of the model considered for the estimation of gold prices was 98.17% as seen in Table 3.

4. RESULTS

Estimation techniques and models are important for those who want to make estimates during decision making and investment stage. In the study, gold prices, which are important for investor decision makers, were estimated using artificial neural networks. ANN is used in the financial sector as well as in many areas because of their ease of design, rapid adaptation to probing and successful results in spite of a small number of donations. For estimating the future value of the dependent variable, the weekly values of the independent variables between 2010 and 2016 were used.

As a result of the study, it is seen that there is a strong correlation between the gold prices and the input variables used in the study. Using the artificial neural network model, gold prices were estimated with a high success rate of 98.17%. In future studies, it is considered to use the stock market indices of the developed countries. In addition to the ANN model, other data mining methods can also be applied.

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