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AN APPLICATION ABOUT DETERMINING EXCHANGE INVESTMENT STRATEGY USING GREY SYSTEM THEORY AND GAME THEORY[1]

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ABSTRACT

The most important factor in exchange investments is the forecast that the value of the invested exchange will change. For this reason, the investor wants to have an idea beforehand about whether the price of foreign exchange which he wants to invest before investing will increase in the future. The purpose of this study is to establish a successful exchange rate investment strategy by using the grey forecast method and the game theory method together. So as to achieve this, the exchange rate was estimated by grey system theory using weekly closing data of eight exchange rates from January 2010 to March 2016 and investment decision was made by game theory. At the end of the study, as the number of data used in methods was reduced, it was observed that more successful results were obtained.

Keywords: Exchange Forecast, Game Theory, Grey System Theory.

Jel Codes: C53, F31.

GRİ SİSTEM TEORİSİ VE OYUN TEORİSİ İLE DÖVİZ YATIRIM STRATEJİSİ BELİRLEMEYE YÖNELİK BİR UYGULAMA

ÖZET

Döviz yatırımlarında en önemli etken yatırım yapılan dövizin fiyatının değişeceği öngörüsüdür. Bu nedenle yatırımcı, yatırım yapmadan önce yatırım yapmak istediği dövizin fiyatının ilerde artıp atmayacağı hakkında önceden fikir sahibi olmak istemektedir. Bu çalışmanın amacı, gri tahmin yöntemi ile oyun teorisi yöntemini birlikte kullanarak başarılı bir döviz kuru yatırım stratejisi ortaya koymaktır. Bu amaçla; sekiz adet döviz kurunun Ocak 2010'dan Mart 2016'ya kadar olan haftalık kapanış verileri kullanılarak gri sistem teorisi ile döviz kuru tahmini yapılmış ve oyun teorisi ile de yatırım kararı alınmıştır. Çalışmanın sonunda, yöntemlerde kullanılan veri sayısı azaltıldıkça daha başarılı sonuçlar elde edildiği görülmüştür.

Anahtar Kelimeler: Döviz Tahmini, Oyun Teorisi, Gri Sistem Teorisi.

Jel Kodları: C53, F31.

1. INTRODUCTION

Foreign currency; is the currency of foreign countries or any other means of payment in place of money. The exchange rate is expressed as the rate of change between one country's currency and another country's currency. For this purpose, foreign exchange can be used for investment purposes in order to show the amount of payments to be made in that currency to that country as a result of purchasing goods from other countries, as well as to invest in a foreign exchange which is considered to rise in value and to make a profit from it as a result of future value increase.

The increase in the value of the exchange rate has different meanings both for buying goods and for investors. Increasing the value of the exchange rate allows investors to make more profits while making purchasers likely to pay more. Predicting the exchange rate within these two opposite poles is important for foreign users to make the right decision today.

Foreign exchange users may have to use one or more currencies according to their future expectations. Foreign currency users keep their currency they expect to rise in the future in their hands or dispose of the currency they expect to decrease in value in the future. According to another aim, foreign exchange users want to import more in foreign exchange which they expect to increase in future, or they want to import less in the foreign

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currency they expect to decrease in future. With this expectation, foreign exchange users want to estimate the future price of the exchange rate in order to protect against future risks.

Foreign exchange rates are immediately affected by developments in the economy. Therefore, an investor who follows the economy can predict more or less how the exchange rate that he invested will follow. He can keep his damage at a lower level by abandoning immediately from the investment that he makes a loss, or he can make more profit by deciding that the profitable investment will continue. Besides, by using numerical methods, he may prefer the foreign exchange rate that he may increase his gain more by analyzing a number of foreign exchange rates at the same time, or he may gain more profit with less risk by distributing the risk.

In the globalizing world, exchange rates are at the center of economic crises. Since the end of the 20th century, public and private sectors have been influenced by the crises, as well as influencing individuals' lives, and this has brought forecasting of foreign exchanges and foreign regimes to the foreground. That the exchange rate's effect on macroeconomic data is not negligible play an important role in developing countries' Exchange rate policies (Bayraktutan & Özkaya, 2009: 51).

Future forecast is an indispensable element of socio-economic development. It is possible that all private or public institutions that are in a decision-making situation can preserve and improve their future situation, by predicting future events, and finding suitable solutions within a good plan (Bircan & Karagöz, 2003: 49).

It is important to estimate the exchange rate because of the adverse effects of international financial currents on foreign trade, investment and production, as it disturbs long-term investment decisions and raises uncertainty. Because the significant changes in the exchange rate also affect imports and exports, it causes international trade to decrease. For this reason, the exchange rate prediction is also very important for official and private institutions dealing with international trade and financial transactions (Kıran, 2008: 5).

The reasons for estimating the exchange rates of multinational companies can be generally expressed as follows (Tetik & Kanat, 2016: 124):

✓ Hedge against exchange rate risk: It is the desire of companies to hedge against Exchange rate risk arising from commercial debt and receivables based on Exchange rate.
✓ Short-term financing decision: Companies want to borrow from countries that have a low-interest rate and a currency that is expected to decline in value.
✓ Short-term investment decision: If an increase in the currency value of an individual country is anticipated, it will increase the demand for investment in that country and its value is expected to increase throughout the investment period.
✓ Capital budgeting decision: Future cash flows should be evaluated both by the money values of the country invested and by the money values of the home country.
✓ Long-term financing decision: Companies and organizations always prefer to borrow in the form of money they expect to lose value in the future.

On the other hand, the exchange rate is one of the important decision mechanisms for investors. Because the exchange rate changes with short periods and is volatile, investors need an effective method to reduce risks. Therefore, exchange rate estimates are crucial for assessing the benefits and risks associated with the international business environment.

Methods for estimating exchange rate are classified into two categories as qualitative methods and quantitative methods. Qualitative methods consist of the basis of managerial opinions, surveys, Delphi method and expert panel methods. On the basis of qualitative methods are subjective estimates for the future with the help of the knowledge people have gained from past Exchange rate experience. Quantitative methods consist of the arithmetic average method, moving average method, exponential correction method, least squares (regression) method, Box-Jenkins prediction method, vector auto-regression prediction method, artificial neural networks and grey system theory methods. On the basis of quantitative methods are the objective results found with the past Exchange rate data gained with the help of the simple and complex mathematical equations for the future.

However, forecasting methods cannot provide accurate information to the investor. Exchange rate forecasting methods help the investor to make the decision easier when investing in the future. However, not all forecasting methods can be used in investment decisions. Some forecasting methods estimate the exchange rates with high accuracy, while some prediction methods estimate the same exchange rates with low accuracy. This means that if the investor is going to use the forecasting method, he has to test it with the past data and then use it if it gives a high accuracy of prediction.

In this study, it was tried to determine the most effective foreign exchange investment strategy in the research period by using game theory and by making an exchange rate prediction with grey prediction method, one of the quantitative prediction methods.

2. LITERATURE SURVEY

When the literature is examined, it is seen that various studies have been carried out on different topics, especially the stock market index and exchange rates by using grey prediction and game theory methods. This section will contain a brief summary of the literature related to the studies in question. Lin et al. (2001), tried to estimate the future of the stock market by using the grey prediction method over the 1000-day closing prices. Artificial neural networks as well as grey prediction method, Wang-Mendel and Fourier models were used for prediction. As a result of the studies, the researchers have found that models gained from the short-run estimated value obtained from the Fourier series and the error-prone composition obtained from the Markov model, in the long run, predict the future more accurately. Lin et al. (2004) used the Taiwan Stock Exchange index as a sample to test the multi-factor grey prediction model. Factor weights in the study were calculated using the fuzzy analytical hierarchy process method. They have turned these weights into grey values and made estimates. They used regression and artificial neural network methods for the same data for comparison purposes. According to empirical results, they have proved that multi-factorial grey prediction model is more successful than other methods. Chin-Tsai et al. (2009) estimated income from medical tourism requests with foreign patients treated in Thailand hospitals with the grey prediction model. As a result, the researchers stated that GM (1,1) model gained an accuracy of the prediction over 97 %. Huang and Jane (2009) developed a hybrid model for stock forecasting and portfolio selection using the extrinsic autoregressive moving average (ARX), grey system, and coarse cluster (RS) approaches. As a result of the study, they found that return rates are higher in selected stocks. Yu (2009) has attempted to achieve the optimum balance between minimum risk and maximum return by transforming the data obtained with grey prediction into a hybrid model with the Grey Relational Analysis / Markowitz Mean Variance model. As a result of the study, he found that by using the proposed stock forecasting and portfolio selection model, an efficient optimum portfolio instrument is provided. Askari and Askari (2011) conducted a study on the prediction of gold prices with the grey time series model. They evaluated the performances with the grey time series model that they developed by using the Fourier Series and the ARIMA (Box-Jenkins) model. As a result of the study, they showed a numerical example that the developed grey method is better. Musolino (2012) proposed a methodology to stabilize the financial markets with the model he created with the help of game theory. The researcher aimed to prevent arbitrary and uncontrolled speculative attacks with this model. Ardison and Costa (2014) aimed to establish the Nash equilibrium with a game theory approach to lending securities in the Brazilian stock market. Xie et al. (2014) used the DGM (1,1) model and the GM (1,1) models to predict China's gross domestic product. Ge and Xie (2015) attempted to reduce education costs and activate management by predicting university education costs with the grey prediction model in their research. They aim to increase the efficiency of the use of funds as a result of the work. Nguyen and Tran (2015) tested ARIMA, GM (1,1), Verhulst, DGM (1,1), and DGM (2,1) models for estimating the most accurate inflation in developing countries over the Vietnam sample. San Cristóbal (2015) stated that GM (1,1) model could be used to forecast the actual cast and the cast at the completion of vessel drydockings. Results show that the accuracy of the GM (1,1) forecasting model is highly efficient. Sun et al. (2016) aimed to establish a Nash equilibrium point with data envelopment analysis and game theory to assess China's urban infrastructure investment efficiency and achieve a scientific method for effective fund distribution. Çukur et al. (2007) tried to predict the future with GM (1,1) model in their study. Using this model, they predicted the stock market and the US Dollar one period later on a daily and monthly basis. As a result of the work, they point to an average success for Turkey, which is a very volatile market, unlike previous studies and models. According to the results, the change direction of these values can be estimated more than 50 %. Evyapan (2009), has used a game theory to develop a strategy for an investor to buy stocks from any of the 20 sectors in the BIST for each month. Keskin (2009), in his research using game theory, obtained a maximum return portfolio at the minimum risk level for the period 2000-2007. The result of the study is that the portfolio created by game theory is clearly superior to the other portfolios. Özkök (2009), proposed a model that enables the investment alternatives to be evaluated effectively and productive investment decisions to be taken in order to solve the portfolio selection problem through game theory. With this model, he created a portfolio of traded stocks at the BIST-30 and calculated the weight of the stocks in the portfolio. Kayacan et al. (2010), estimated the Euro and Dollar parity by grey-based time series analysis, covering 2005-2007. As a result, the grey-based system makes the better prediction than Fourier series. Gedikoğlu (2012) applied linear programming model of game theory to monthly opening and closing data of BIST National Industrial, National Services, National Financial and National Technology indices between 2001 and 2010. The study revealed that game theory model is effective in creating portfolio.

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3. DATA SET AND METHOD

3.1. Data Set

Weekly closing data for the exchange rates of Euro (EUR), American Dollar (USD), Swiss Franc (CHF), British Pound (GBP), U.A. Emirates Dirham (AED), Brazilian Real (BRL), Chinese Yuan (CNY) and Saudi Riyal (SAR) from January 2010 to March 2016 are used in the study. With this data, the weekly closing data from April 2010 to March 2016 is estimated and the weekly investment strategy is determined by with this estimated data. The grey forecasting model of the grey system theory is used to estimate weekly closing data of exchange rates and the linear programming method of game theory is used to determine investment strategies.

3.2. Grey Prediction

The grey prediction method is a prediction method that can produce satisfactory results when there is insufficient experience with system behavior and when a limited number of data can be reached. This method has been developed to estimate the future with the aid of the grey model GM (1,1) using the available data. (The transfer from Gu & Xu, 1999: Köse, 2010: 30-31).

The grey prediction method consists of the basic steps described in detail below (Köse, 2010: 32);

- ✓ Grey production
- ✓ Establishing the forecasting model
- ✓ Determination of the parameter values in the model
- ✓ Model test
- ✓ Production of required forecast values

The steps of the grey prediction method are explained in detail below.

Step-1: Creation of the raw data set $X^{(0)}$ shown below using the start data.

$$X^{(0)} = (x^{(0)}(1), x^{(0)}(2), x^{(0)}(3), \ldots\ldots, x^{(0)}(n)) \quad (1)$$

In the equation shows the data used in the prediction of "*x*".

Step-2: Formation of $X^{(1)}$ using the first-order total production operator.

$$x^{(1)}(k)=\sum_{i=1}^{k} x^{(0)}(i),\ (i=1,2,\ldots,n) \quad (2)$$

$$X^{(1)} =(x^{(1)}(1), x^{(1)}(2), x^{(1)}(3), \ldots\ldots, x^{(1)}(n)) \quad (3)$$

Step-3: Creation of $Z^{(1)}$ using the first-order average value production operator.

$$z^{(1)}(k)=0.5x^{(1)}(k)+0.5x^{(1)}(k-1) \quad (4)$$

$$Z^{(1)} =(z^{(1)}(2), z^{(1)}(3), z^{(1)}(4), \ldots\ldots, z^{(1)}(n)) \quad (5)$$

In the equation, $Z^{(1)}$ represents the consecutive average sequence, $z^{(1)}(k)$ represents the average of the two consecutive data.

Step-4: Prediction of parameter values of *a* and *b* in equality of $x^{(0)}(k) + az^{(1)}(k) = b$.

In order to make an estimate with the help of GM (1,1), parameter values of *a* and *b* must be determined first. The two methods that can be used when determining the parameter values are the least squares method and the parametric method.

To estimate the parameter values with the least squares method, the equality of $x^{(0)}(k) + az^{(1)}(k)=b$ is rewritten for all values in the dataset.

$$x^{(0)}(2) + az^{(1)}(2)=b \quad (6)$$

$$x^{(0)}(3) + az^{(1)}(3)=b \quad (7)$$

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$$x^{(0)}(n) + az^{(1)}(n)=b \quad (8)$$

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When the above-mentioned systems of equations are to be transformed into a matrix form, Y=Bâ equality will be obtained. The equivalents of values of â, B and Y in the matrix representation are as shown below.

$$B = \begin{bmatrix} -Z^{(1)}(2) & 1 \\ -Z^{(1)}(3) & 1 \\ -Z^{(1)}(4) & 1 \\ \dots\dots\dots & 1 \\ -Z^{(1)}(n) & 1 \end{bmatrix} \quad (9)$$

$$Y = \begin{bmatrix} x^{(0)}(2) \\ x^{(0)}(3) \\ x^{(0)}(4) \\ \dots\dots \\ x^{(0)}(n) \end{bmatrix} \quad (10)$$

$$\hat{a} = \begin{bmatrix} a \\ b \end{bmatrix} \quad (11)$$

In order to obtain the vector â corresponding to the parameter values of GM (1,1), the matrix operations described below must be performed respectively.

$$Y=B\hat{a} \quad (12)$$

$$B^TY= B^TB\hat{a} \quad (13)$$

$$\hat{a}=\begin{bmatrix} a \\ b \end{bmatrix}=(B^TB)^{-1}B^TY \quad (14)$$

In the equation, "*B*" represents the successive mean matrix and "*Y*" represents the raw data matrix.

Step-5: Obtaining the solution of the first-order derivatable equation shown as $\frac{dx^{(1)}(k)}{dk}+ax^{(1)}(k)=b$ and the prediction model.

$$\hat{x}^{(1)}(k+1)=(x^{(0)}(1))e^{-ak}+\frac{b}{a}(1-e^{-ak}) \quad (15)$$

$$\hat{x}^{(0)}(k+1)=(1-e^{a})[x(0)(1)-\frac{b}{a}]e^{-ak} \quad (16)$$

In the equation "$\hat{x}^{(0)}(k+1)$" represents the cumulative value of x estimated for time k+1, the improvement coefficient "a" indicates the amount of gray effect "b".

Step-6: Producing forecast values using the forecasting model.

3.3. Game Theory

Game theory is a discipline that examines the process of sharing two or more decision makers in an environment where resources are scarce. Decision makers in game models are called "players". These players prefer to earn a certain gain. In order to make a player's choice have a strategic meaning, a player must carry an aim to obtain a certain gain, and the determination of the gain is determined not only by his own preference but by the decisions of other players who are also interacted with at the same time. In real life, the decision making processes related to any event and the change in the players' earnings are analyzed as a game. There is interdependence among players, and decision-makers who are seeking to maximize their share of the resource are in conflict or cooperation. According to game theory terminology, the competition of the players means "conflict" on the sources (Bierman & Fernandez, 1998: 4).

There are some assumptions that must be fulfilled during modeling of the game in order to reduce the effects of complex situations that may arise during the application of theory. These assumptions can be listed as follows (Esin, 1981: 322):

1. The players are in a limited number,
2. All possible strategies of the players are limited,
3. Every player knows all possible strategies for himself and his opponent. However, the players do not know which strategies will be applied by their opponents,
4. No matter which strategy a player chooses, each player's profit or loss is limited,
5. The profit or loss of a player depends on his decisions as well as on the decision his opponent will make,

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6. All possible behaviors or strategies to be played should be computable in the same unit of measure.

Regardless of the type of the game and the features of the game matrix, the linear programming method a solution for all zero or constant sum games without equilibrium points. If the payoff matrix (mxn) cannot be solved with graphical or algebraic methods, or if it cannot be reduced by peer and superior strategies, linear programming approach can be used. In game theory developed by Neumann and Morgenstern (1944), that the linear programming model can be solved by the simplex method is demonstrated by George B. Dantzig (1949). In a two-person or zero or constant sum game without equilibrium points, if the players have more than two acceptable behaviors, the most appropriate strategies are determined by linear programming (Gedikoğlu, 2012: 35).

The main theme of linear programming is about the problem of how best to allocate limited resources among alternative activities. Linear programming is a mathematical method used to solve optimization problems. Some assumptions must be made in order to form and implement any linear programming model. These assumptions are expressed as linearity, summability and certainty (Öztürk, 2009: 38-40).

4. RESULTS

The findings of the prediction of the weekly closing prices of the foreign exchange rates by the grey system theory and the determination of the investment strategy by the game theory method are given in Figure 1.

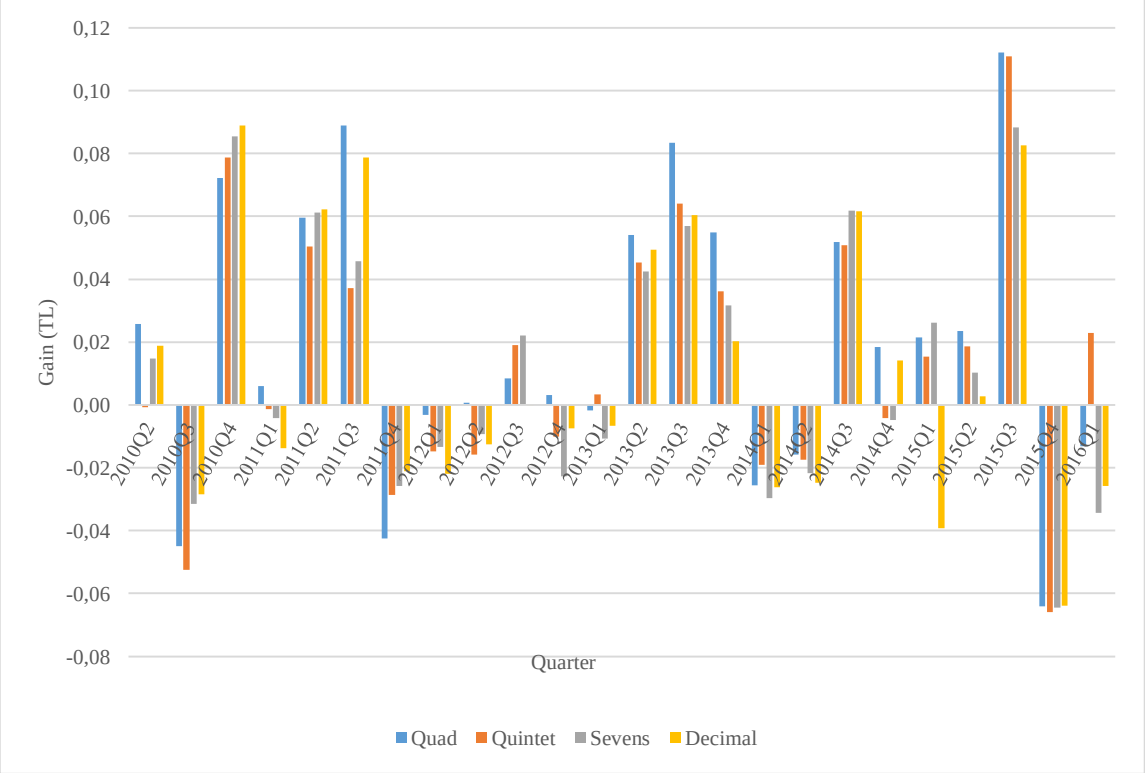

Figure 1. Profit / loss situation of weekly investments

When the quartiles in Figure 1 are examined, it is seen that the maximum gain is obtained as a result of the analysis made with four-week closing data. The second largest gain was obtained after the analysis made with the five-week closing data. The third highest gain was achieved after the analysis made with seven-week closing data. As a result of the analysis made, it seems that the minimum gain is provided by the ten-week closing data.

In the light of these findings; keeping the period short increases the success of the prediction and the accuracy of the decisions on the predictions made about the future and in data sets used in the decisions to be made.

As a result of a long period in data sets; Estimates and decisions can be negatively affected by the difference between the exchange rate value at the beginning of the period and the exchange rate at the end of the period. Foreign currency exchange rate which is high at the beginning of the period can be low at the end of the period or the foreign currency exchange rate is low at the beginning of the period can be high at the end of the period. This leads to erroneous predictions and unsuccessful decisions.

As a result of a short period in data sets; the effect of the difference between the value of the exchange rate at the beginning of the period and the value of the exchange rate at the end of the period decreases on the predictions and decisions. This leads to error-free predictions and successful decisions.

As a result, a large number of historical data should not be used to make successful estimates and decisions. In this way, misleading predictions and decisions can be reduced by avoiding indicators that do not reflect the future in the distant past.

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