

Chapter 13

Determining Influencing Factors of Currency Exchange Rate for Decision Making in Global Economy Using MARS Method

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ABSTRACT

The aim of this study is to identify the determinants of US Dollar/Turkish Lira currency exchange rate for strategic decision making in the global economy. Within this scope, quarterly data for the period between 1988:1 and 2016:2 was used in this study. In addition to this aspect, 10 explanatory variables were considered in order to determine the leading indicators of US Dollar/Turkish Lira currency exchange rate. Moreover, Multivariate Adaptive Regression Splines (MARS) method was used so as to achieve this objective. According to the results of this analysis, it was defined that two different variables affect this exchange rate in Turkey. First of all, it was identified that there is a negative relationship between current account balance and the value of US Dollar/Turkish Lira currency exchange rate. This result shows that in case of current account deficit problem, Turkish Lira experiences depreciation. Furthermore, it was also concluded that when there is an economic growth in Turkey, Turkish Lira increases in comparison with US Dollar. While taking into the consideration of these results, it could be generalized that emerging economies such as Turkey have to decrease current account deficit and investors should focus on higher economic growth in order to prevent the depreciation of the money in the strategic investment decision.

DOI: 10.4018/978-1-5225-2673-5.ch013

INTRODUCTION

Globalization means that eliminating economic barriers between countries (Dunning, 2002). It was effective almost all over the world especially after 1970. As a result of this aspect, economies of different countries became interconnected. This situation brought many advantages to the countries with respect to the economic growth. On the other hand, globalization also led to many risks for these countries, such as volatility in the market. In other words, economies of the countries became more fragile to the extraordinary changes in other countries owing to the globalization. In addition to the negative effects for the economic stability of the country, these kinds of problems also affect the decisions of the investors negatively (Yüksel et. al., 2015).

Within this context, the stability of the currency exchange rate is very significant for the economies of the countries. The main reason behind this situation is that the exchange rate affects many important factors in the economy such as export, economic growth, and foreign direct investments (Bacchetta and Van Wincoop, 2000). Therefore, countries always prefer a stable exchange rate in order to prevent volatility in the market. Otherwise, countries may experience important losses due to high amount of increase or decrease in the value of exchange rate. In the past, there were many economic crises which were occurred because of this problem. For example, Southeast Asian countries had important losses in 1998 due to the high amount of changes in currency exchange rate (Corsetti et. al., 1999).

Turkey is also a country which experienced two different economic crises in 1994 and 2000. During this period, Turkey had significant amount of losses due to high amount of increase in US Dollar/Turkish Lira currency exchange rate. Many companies went bankruptcy owing to the fact that they cannot manage this increase. As a result of this situation, a lot of people lost their jobs. The effect of this crisis was so severe that lots of banks were taken over by the Savings Deposit Insurance Fund (SDIF) in this period (Yüksel, 2016b).

Because of this situation, it can be said that the studies aimed to identify the determinants of the exchange rate is essential. Parallel to this aspect, the purpose of this study is to define the influencing factors of US Dollar/Turkish Lira currency exchange rate. In order to achieve this objective, Multivariate Adaptive Regression Splines (MARS) method was used in this study. With respect to the originality concept, the most important property of this analysis is that MARS method was used for this subject firstly in this study. As a result of this analysis, it will be possible to make recommendation so as to have more stable US Dollar/Turkish Lira currency exchange rate.

The paper is organized as follows. After introduction part, information about the similar studies in the literature was given. Additionally, the third part gives information about Multivariate Adaptive Regression Splines (MARS) method. In this part, firstly general information and model creation process will be explained. After that, studies in which this method was used will be explained. Moreover, fourth part includes research and application to understand the determinants of US Dollar/Turkish Lira currency exchange rate. Finally, the results of the analysis were given at conclusion.

BACKGROUND

Because the subject of determining the value of the exchange rate is very important, there were many studies in the literature which focused on this subject. Some of these studies were explained on Table 1.

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Table 1. Similar studies in the literature

Author	Scope	Method	Result
Edwards (1988)	12 developing countries	Regression	It was concluded that macroeconomic factors influence real exchange rate.
Gagnon (1993)	USA	Descriptive Statistics	Exchange rate variability has a negative effect on the level of trade.
Campa (1993)	USA	Tobit	It was identified that there is negative correlation between exchange rate volatility and with the number of foreign investors.
Devereux (1997)	Canada	Regression	Macroeconomic factors such as GDP growth and inflation rate affect real exchange rate.
MacDonald (1998)	G7 countries	VAR	Foreign trade and real interest rate are the significant determinants of real exchange rate.
Darby et. al. (1999)	France, Germany, Italy, UK and USA	Regression	They analyzed the situations in which exchange rate uncertainty affect the level of investment or not for different countries.
Berument (2002)	Turkey	VAR	There is a direct relationship between inflation rate and foreign exchange rates.
Juhn and Mauro (2002)	IMF member countries	Probit	The size of the economy has a significant effect on exchange rate.
Bilgin (2004)	Turkey	Regression	It was defined that there is a strong relationship between foreign exchange rate and unemployment.
Şimşek (2004)	Turkey	ARDL Test	It was concluded that net foreign assets, M2 money supply ¹¹ and trade balance influence the real exchange rate in Turkey.
Morales-Zumaquero (2006)	Canada, Japan, USA	SVAR	Fluctuations in real exchange rate are explained by inflation rate.
Gül and Ekinçi (2006)	Turkey	Granger Causality Test	It was determined that there is a relationship between exchange rate and inflation.
Candelon et. al. (2007)	8 EU member countries	Regression	It was analyzed that higher inflation affects exchange rate.
Mark (2009)	USA	Regression	Output gaps and expected inflation are the main determinants of exchange rate.
Cayen et. al. (2010)	Australia, Canada, New Zealand	Regression	Commodity price levels are very significant so as to determine real exchange rate.
Savaş and Can (2011)	Turkey	Granger Causality Test	Changes in BIST 100 Index affect foreign exchange rate.
Hamori and Hamori (2011)	Japan	SVAR	Real shocks play a dominant role in explaining the real exchange rate fluctuations.
Dilbaz Alacahan (2011)	Turkey	Descriptive Statistics	High interest rate causes a decrease in foreign exchange rates.
Acar Balaylar (2011)	Turkey	Descriptive Statistics	It was identified that foreign currency rate is affected by unemployment rate.
Chowdhury (2012)	Australia	ARDL Test	It was determined that government expenditures affect real exchange rate.
Berke (2012)	Turkey	Engle Granger Causality Test	There is a negative relationship between foreign exchange rate and BIST 100 index.
Kia (2013)	Canada	Regression	The change in interest rate, the growth of money supply and the US debt per GDP have a negative impact on the growth of the real exchange rate.
De Grauwe and Markiewicz (2013)	USA, UK and Germany	Regression	It was analyzed that the exchange rate behaves as a random walk.
Rossi (2013)	20 different countries	VECM	The success of exchange rate prediction depends on the time.
Altıntaş (2013)	Turkey	ARDL Test	Increase in oil prices leads to rise in foreign exchange rate for oil-importing countries.
Gabaix and Maggiori (2014)	USA	Regression	There is no relationship between exchange rates and inflation rate.
Kaplan and Yapraklı (2014)	Turkey	Panel Data Analysis	Current account deficit, public debt amount and reserves are important indicators of foreign currency rate.
Ferraro et. al. (2015)	USA	Regression	It was identified that commodity prices can predict exchange rates at a daily frequency.
Brdys et. al. (2016)	Poland	Monte Carlo	A non-parametric prediction technique was created.
Chaudhury et. al. (2016)	India	GARCH	They created a model in order to predict the value of the Indian rupee.

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Devereux (1997) tried to analyze real exchange rates in Canada by using regression analysis. As a result of this analysis, it was concluded that macroeconomic factors such as GDP growth and inflation rate affect real exchange rate. Berument (2002), Candelon and others (2007) and Morales-Zumaquero (2006) reached the same conclusion by using different VAR analysis. Similar to these studies, Gül and Ekinci (2006) identified that high inflation rates are the main cause of exchange rate depreciation in Turkey. Nevertheless, Gabaix and Maggiori (2014) concluded that there is no relationship between exchange rates and inflation rate.

In addition to them, there are also some studies that analyzed the relationship between interest rate and exchange rates. MacDonald (1998) made a study about the exchange rate values in G7 countries and determined that real interest rate is the significant determinant of real exchange rate. Dilbaz Alacahan (2011) and Kia (2013) made similar conclusions in their studies with the help of different methods. On the other hand, Bilgin (2004) identified that there is a strong relationship between foreign exchange rate and unemployment.

Additionally, some studies in the literature also focused on the relationship between exchange rate volatility and investment decisions. Campa (1993) tried to analyze this relationship in the USA. According to the results of tobit analysis, it was concluded that there is negative correlation between exchange rate volatility and with the number of foreign investors. Similar to this study, Gagnon (1993) also determined that exchange rate variability has a negative effect on the level of trade. Moreover, Darby and others (1999) defined the situations in which exchange rate uncertainty affect the level of investment or not for different countries.

Furthermore, it was also seen that some studies in the literature focused on the prediction of the currency exchange rate. De Grauwe and Markiewicz (2013) created a model for USA, UK and Germany in order to estimate future values of exchange rate. Rossi (2013) also made similar studies for 20 different countries by using vector error correction method. Additionally, Ferraro et. al. (2015) used regression analysis so as to predict exchange rate in USA. Parallel to these studies, Chaudhury and others (2016) also focused on the prediction of the value of the Indian rupee.

RESEARCH AND APPLICATION

Data and Variables

In this study, quarterly data for the period between 1988:1 and 2016:2 was used. The data was provided from the internet pages of World Bank, Borsa İstanbul, Turkish Statistical Institute and Central Bank of America. In addition to the data, Eviews8 program was used for unit root test. Moreover, MARS 2.0 program of Salford Company was used in MARS method.

The aim of this study is to determine the leading indicators of US Dollar/Turkish Lira currency exchange rate. Therefore, this rate was used as a dependent variable. Additionally, by analyzing similar studies in the literature, 10 different explanatory variables that may affect the value of exchange rate were defined. The details of these variables were emphasized in Table 2.

GDP growth rate is the first independent variable in this study. The effect of economic growth on exchange rate depends on the source of the growth. If the main source of GDP growth is household consumption, this will increase import and local currency will depreciate. On the other hand, if GDP growth is mainly provided by exports and investments, then local currency will appreciate (Candelon et.

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Table 2. The details of independent variables

Variable	References
GDP Growth Rate	Şimşek (2004), Kia (2013), Mark (2009), Devereux (1997), Candelon et. al. (2007), Edwards (1988), Hamori and Hamori (2011), MacDonald (1998), Juhn and Mauro (2002)
Foreign Capital Inflows	Şimşek (2004), Chaudhury et. al. (2016), Edwards (1988), MacDonald (1998), Juhn and Mauro (2002)
Current Account Deficit	Şimşek (2004), Bilgin (2004), Kaplan and Yapraklı (2014), Chaudhury et. al. (2016), Chowdhury (2012), Edwards (1988), Morales-Zumaquero (2006), Juhn and Mauro (2002)
Inflation	Şimşek (2004), Gül and Ekinci (2006), Berument (2002), Savaş and Can (2011), Chaudhury et. al. (2016), Gabaix and Maggiori (2014), Rossi (2013), De Grauwe and Markiewicz (2013), Mark (2009), Devereux (1997), Cayen et. al. (2010), Hamori and Hamori (2011), MacDonald (1998), Morales-Zumaquero (2006), Juhn and Mauro (2002)
Reserves	Kaplan and Yapraklı (2014), Chaudhury et. al. (2016), Juhn and Mauro (2002)
Interest Rate	Dilbaz Alacahan (2011), Chaudhury et. al. (2016), Gabaix and Maggiori (2014), Rossi (2013), De Grauwe and Markiewicz (2013), Kia (2013), Mark (2009), Cayen et. al. (2010), Chowdhury (2012), MacDonald (1998)
External Debt	Şimşek (2004), Kaplan and Yapraklı (2014), Kia (2013), Cayen et. al. (2010), Chowdhury (2012)
Unemployment	Bilgin (2004), Acar Balaylar (2011), Mark (2009)
BIST 100 Index	Savaş and Can (2011), Berke (2012)
Oil Price	Altıntaş (2013), Chaudhury et. al. (2016), Ferraro et. al. (2015), MacDonald (1998)

al., 2007). Similar to this situation, it can also be said that there is a positive correlation between foreign direct investment and the reserves with the value of local currency (Edwards, 1988).

Additionally, when there is current account deficit in a country, international reserves of this country will decrease and this situation will decrease the value of local currency (Morales-Zumaquero, 2006). Parallel to this aspect, there is also negative relationship between the foreign debt and the value of local currency (Chowdhury, 2012). Furthermore, higher inflation rate also decreases the value of local currency (Devereux, 1997). The main reason behind this issue is that the goods of this country become more expensive in comparison with import goods. Owing to this situation, higher demand on import goods leads to decrease in the value of local currency. Because of the same reason, there should also be negative relationship between oil price and local currency value (Ferraro et. al., 2015).

Moreover, higher interest rate causes the demand of local currency to increase. As a result of this situation, US Dollar/Turkish Lira currency exchange rate is expected to decrease (Rossi, 2013). In addition to this aspect, unemployment rate is also another determinant of the value of exchange rate. Because unemployment rate is a significant indicator of the economy, the relationship between unemployment rate and US Dollar/Turkish Lira currency exchange rate should be positive (Mark, 2009). Due to the same reason, when there is an increase in BIST 100 index, the value of this exchange rate should decrease (Berke, 2012).

MARS Method

Multivariate Adaptive Regression Splines (MARS) method was firstly introduced by Jerome Friedman in 1991. Mainly, it was used in order to determine the relationship between dependent variable and independent variables. The equation of MARS method is given below.

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$$Y = B_0 + \sum_{n=1}^K a_n B_n(X_t) + \varepsilon \quad (1)$$

In the equation above, “Y” shows dependent variable while “X” refers to the independent variable. Moreover, “B₀” gives information about the constant term. Additionally, “a_n” shows the coefficient of the basis function. Furthermore, “ε” explains error term of the equation whereas “K” demonstrates the number of basis functions.

There are many advantageous of MARS method by comparison with other regression methods. In this method, smoothing splines are used instead of simple regression line. Owing to this situation, it will be possible to have more accurate results by using this method. In addition to this issue, there is no multicollinearity problem that demonstrates the relationship among explanatory variables in MARS method. Because of this aspect, high number of independent variables can be used in the analysis. The final advantage of this model is that explanatory variables can take part more than once in equation with different coefficients. Hence, results of this analysis will be more explanatory in comparison with other methods (Friedman, 1991).

With respect to the model creation process, there are two different stages. First of all, system produces all possible basis functions by using different combination of independent variables. After achieving the most complex model which has maximum number of basis functions, system starts to eliminate some basis functions from this complex model. In this process, the basis functions which have the highest error value (GCV-generalized cross validation) will be removed from this model. As a result of this process, the most ideal model, which has the highest R² and lowest GCV values, can be achieved (Friedman, 1991).

MARS is a very new model, so there are few numbers of studies in which this model was used. In addition to this aspect, this model was rarely used in finance and economics area. Sephton (2001) tried to identify the determinants of the recession in USA and concluded that MARS method gives more accurate results than probit method. Tunay (2001) made a study about the velocity of circulation of money and identified that it is not stable in Turkey. Moreover, Bolder and Rubin (2007) aimed to determine the best lending strategy of USA and defined that MARS method is the most efficient method with respect to determining the best lending strategy.

Also, Muzır (2011) measured the credit risk of the banks in Turkey and concluded that MARS method measures credit risk better than logit and artificial neural networks. Additionally, Tunay (2011) determined that MARS method is very successful in order to predict recession. Moreover, Oktar and Yüksel (2015) explained the leading indicators of Turkish banking crisis by using MARS method. Yüksel (2016a) also identified the determinants of current account deficit by using this method.

Analysis Results and Findings

In order to understand the relationship between dependent variable and independent variables by using MARS method, first of all, stationary analysis of these variables should be made. For this purpose, Augmented Dickey Fuller (ADF) and Philips Peron (PP) tests were used. The results of these tests were given in Table 3.

As it can be seen from Table 3, level values of two independent variables (Growth Rate and Current Account Balance) are less than 0.05 according to the results of both two tests. This situation shows that only these two variables are stationary at their level values. Because level values of other 8 variables are more than 0.05, their first differences were used in the analysis. After stationary analysis, MARS method gave us 8 different models which were explained in Table 4.

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Table 3. Unit root test results of independent variables

Variable	Augmented Dickey Fuller (ADF) Test		Philips Peron Test	
	Level Value (Probability)	First Difference Value (Probability)	Level Value (Probability)	First Difference Value (Probability)
Growth Rate	0.0000	-	0.0000	-
Foreign Direct Investment	0.4313	0.0125	0.3927	0.0419
Current Account Balance	0.0097	-	0.0040	-
Inflation Rate	0.6563	0.0000	0.3677	0.0000
Reserve	0.4313	0.0000	0.6118	0.0000
Interest Rate	0.4040	0.0000	0.0953	0.0000
Government Debt	0.9309	0.0295	0.8366	0.0000
Unemployment Rate	0.6302	0.0000	0.6035	0.0000
BIST 100 Index	0.3104	0.0000	0.4391	0.0000
Oil Prices	0.6533	0.0000	0.1440	0.0000

Table 4. All models created by MARS method

Number of Basis Functions	Number of Variables	GCV	GCV R ²
8	3	0.373	0.502
7	3	0.356	0.525
6	2	0.345	0.540
5	2	0.336	0.552
4	2	0.334	0.555
**3	2	0.333	0.556
2	2	0.341	0.546
1	1	0.449	0.401

As it can be understood from Table 4, each row represents different model. The undermost line shows us the starting model that has only one variable and basis function. In the analysis, the system added some basis functions to this starting model. This process went on until the system reaches the most complex model. The first row in Table 4 represents the most complex function in the analysis. It has 8 basis functions and 3 different explanatory variables. After that, the system eliminated some unnecessary basis functions from the most complex model. As a result of this process, the system achieved the best model. In Table 4, the model, which has the sign of “**”, explains the best model. It has 3 basis functions and 2 independent variables. On the other hand, it can also be seen that the best model has the lowest GCV value and highest GCV R² value. The details of the best model were given on Table 5.

As it can be seen from Table 5, the p values of all basis functions in the best model are less than 0.05. This means that all of the functions are statistically significant. In addition to this situation, the probability value of F test (0.000) is also less than 0.05. This aspect shows that the model is also meaningful as a whole. Moreover, the value of adjusted R² (0.597) indicates that independent variables can

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Table 5. Statistical information about the best model

Variable	Coefficient	p Value
Constant	1.755	0.000
Basis Function 3	0.253	0.008
Basis Function 7	-0.085	0.000
Basis Function 9	-0.281	0.000
F Test 56.717 [0.000] p Value 0.000 R² 0.607 Adj. R² 0.597		

explain 59.7% of the dependent variable. Furthermore, the details of the basis functions in the model were explained on Table 6.

From Table 6, it can be understood that two independent variables affect US Dollar/Turkish Lira currency exchange rate. The variable of current account balance was stated in both basis function 3 and 9. The coefficients of these functions are 0.253 and -0.281. Because the absolute value of negative coefficient is higher, this means that there is a negative relationship between the current account balance and US Dollar/Turkish Lira currency exchange rate. In other words, when there is a current account deficit, the value of US Dollar/Turkish Lira currency exchange rate will be higher. The main reason behind this situation is that international reserves of this country will decrease and foreign debt will increase in case of current account deficit. As a result of this issue, value of local currency will decrease. This conclusion is similar to many studies in the literature (Chowdhury, 2012), (Edwards, 1988), (Morales-Zumaquero, 2006), (Juhn and Mauro, 2002).

Another significant variable according to the analysis is the economic growth. This variable was stated in basis function 7 in the best model. On the other side, the coefficient of this variable is -0.085. That is to say, there is a negative relationship between GDP growth rate and US Dollar/Turkish Lira. This situation shows us that when there is an economic growth in a country, Turkish Lira gains more value in comparison with the US Dollar. The reason for this aspect is that when GDP growth is mainly provided by exports and investments, then local currency will appreciate in that country. Devereux (1997), Candelon et. al. (2007), Edwards (1988), Hamori and Hamori (2011), MacDonald (1998) and Juhn and Mauro (2002) also reached the same conclusion. The importance levels of these variables were given on Table 7.

As a result of the analysis, the best model in our analysis was formed as following.

$$Y = 1.755 + 0.253 * BF3 - 0.085 * BF7 - 0.281 * BF9$$

Table 6. Details of the basis functions in the model

Basis Functions	Details	Coefficient
Basis Function 3	max (0, Current Account Balance + 0.110)	0.253
Basis Function 7	max (0, GDP Growth – 1.000)	-0.085
Basis Function 9	max (0, Current Account Balance + 4.610)	-0.281

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Table 7. Variable importance in the model

Variable	Cost of Omission	Importance (%)
Current Account Balance	0.592	100.00
GDP Growth	0.381	42.845

FUTURE RESEARCH DIRECTIONS

In this study, determinants of US Dollar/Turkish Lira currency exchange rate were tried to be analyzed. As it can be understood from this aspect, volatility of the exchange rate for only one country was evaluated. Because this subject is very significant for the countries, another research for this issue which includes many different countries will be very beneficial for the economies to make strategic decisions. While making this kind of analysis, it will be possible to consider different situations in order to understand the volatility of the exchange rates.

CONCLUSION

It was aimed to analyze the determinants of US Dollar/Turkish Lira currency exchange rate in this study. Within this context, 10 independent variables were taken into the consideration. In addition to this situation, quarterly data of these variables for the period between 1988:1 and 2016:2 was used in this study. Furthermore, Multivariate Adaptive Regression Splines (MARS) method was used so as to achieve this objective.

First of all, unit root test was made for the independent variables to understand whether they stationary or not. Within this scope, Augmented Dickey Fuller (ADF) and Phillips Perron (PP) tests were used. As a result of this analysis, it was understood that only two independent variables (Growth Rate and Current Account Balance) are stationary on their level values. Because other 8 independent variables are not stationary on their level values, the first difference of these variables were used in the analysis.

After stationary analysis, the influencing factors of US Dollar/Turkish Lira currency exchange rate were determined by using MARS method. MARS model provided 8 different models to us. Out of them, one model was chosen as the best model by the system. This model has 3 basis functions and two different independent variables. Moreover, it has the lowest GCV value and highest GCV R2 value.

According to the results of the analysis, it was determined that two independent variables affect US Dollar/Turkish Lira currency exchange rate. The first significant variable in the analysis is current account balance which was stated in basis function 3 and 9. While considering the value of the coefficients, it was identified that there is a negative relationship between the current account balance and US Dollar/Turkish Lira currency exchange rate. This means that the value of US Dollar/Turkish Lira currency exchange rate will be higher in case of current account deficit. When there is a current account deficit, there will be decrease in the amount of the reserves and the demand for US Dollar will increase. Therefore, the value of Turkish Lira will decrease in comparison to US Dollar.

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In addition to this situation, it was also concluded that economic growth is also another important indicator of US Dollar/Turkish Lira currency exchange rate. This variable was stated in basis function 7 and the coefficient of this variable is -0.085. Since the coefficient is negative, it can be understood that there is an inverse relationship between economic growth and US Dollar/Turkish Lira currency exchange rate. In other words, when GDP growth is mainly provided by exports and investments, the value Turkish Lira will increase by comparison with US Dollar.

The value of exchange rate affects many important factors in the economy such as export, economic growth, and foreign direct investments. Owing to this situation, it can be said that the value of the exchange rate plays a very important role for the economies. Hence, countries try to determine the way of providing a stable exchange rate in order to prevent volatility in the market. According to the results of this analysis, the reasons of the volatile US Dollar/Turkish Lira currency exchange rate were determined. Therefore, it can be recommended that Turkey has to decrease current account deficit and should focus on higher economic growth in order to prevent the depreciation of Turkish Lira. Thus, volatility in Turkish economy will be minimized. In addition to this situation, these conclusions will be also helpful for investor so as to make strategic investment decision.

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KEY TERMS AND DEFINITIONS

Currency Exchange Rate: It shows the ratio of local currency of a country to a foreign currency.

Foreign Direct Investment (FDI): Investment made by a company in another country.

Global Economy: The economies of the whole countries, considered as a single economic system.

Strategic Decision: Action of a company that affects key factors and long run performance.

Vector Autoregression (VAR): An econometric method used to understand the interdependencies among multiple time series.

ENDNOTES

- ¹ M2 Money supply includes cash, deposits, money market securities, mutual funds and other time deposits.