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A COINTEGRATION TEST FOR TURKISH FOREIGN EXCHANGE MARKET EFFICIENCY

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ABSTRACT

This study examines the within-country market efficiency of the Turkish foreign exchange markets on the basis of the forward rate unbiasedness hypothesis, in case of the Turkish lira/US dollar and the Turkish lira/Euro for the period February 5, 2005 through July 26, 2013 by Johansen cointegration method. Unit root test results support the market efficiency in its weak-form. However, the existence of cointegration between the forward rates and its corresponding future spot rates with a unitary cointegrating vector and there exists no systematic expectation errors provide evidence for forward rate unbiasedness hypothesis and thus against market efficiency in semi-strong form. In the Turkish lira/US dollar foreign exchange market, the speed of adjustment towards long run equilibrium is a bit faster, and also the forward rates explain a bit more proportion of the movements of the spot rates in comparison with the Turkish lira/Euro market.

Keywords: Market efficiency, Forward rate unbiasedness, Spot exchange rates, Forward exchange rates, Financial markets, Turkey.

JEL Classification Codes: G1, G14, F31.

1. INTRODUCTION

There has been growing interest in whether or not the exchange rates are determined efficiently in the markets among academicians, currency traders and economic policy makers. A widely cited definition of market efficiency was originated by Fama (1970). In an efficient market, prices do fully reflect all available information relevant for the pricing process (Fama, 1970), and none of the market players can earn excess profits by exploiting the known information set (Jensen, 1978). To be more precise, market efficiency is referred as an informationally efficient market (Fama, 1970). The efficient market hypothesis therefore implies that future changes in exchange rates should be unpredictable. In that case, because the return is not predictable in an efficient foreign exchange market, it is imposible for exchange rate trader to earn excess returns using speculation. Conversely, if the market is inefficient, the exchange rate traders can attempt to profit from their transactions through speculating and predicting the future prices. In addition, in an inefficient foreign exchange market, economic policy makers can have an influence on the exchange rates, such as the volatility of the exchange rates. In these aspects, the aims of this study are to assess whether there exist profitable trading strategies in the Turkish foreign exchange markets and to have an opinion about economic policy implications, focusing on the "forward rate unbiasedness hypothesis". For that purpose, the Johansen (1991; 1995) is conducted.

Fama (1970) subdivides market efficiency into three categories in terms of the information that security prices should reflect, namely, "weak,""semi-strong,"and"strong" forms. In the weak-form efficiency, the information set only comprises past prices and prices fully and instantly reflect all available (historical) information. Consequently, a market is said to be weak-form efficient if past prices are useless in predicting future prices, i.e., technical analysis is of no use. In the semi-strong form, the information set additionally comprises all publicly available information relevant for the pricing process. In addition to the weak-form, the semi-strong form includes information on the fundamentals determining the price, i.e., fundamental analysis is of no use. A market is semi-strong efficient if all publicly available information has no predictive power. Finally, a market is strong-form efficient if all information is reflected on prices, including the insider information. Thus, a market is said to be efficient if trading on the basis of insider information cannot yield higher profits, i.e., even insider information is of no use.

The issue of foreign exchange market efficiency has been tested by several recent studies employing the cointegration analysis especially at the end of the 1980s and 90s. The analysis of market efficiency in the foreign exchange market adopted a new approach after an article by C. Granger was published in 1986. According to (Granger, 1986), the spot foreign exchange market may said to be (informationally) efficient if the set of spot rates (or any asset prices) were shown to be non-cointegrated. Thus, to test the efficiency of markets, it is needed to show that cointegration does not exist. In other saying, if they were cointegrated, there would be a market inefficiency since there would be Granger causality running at least in one direction and thus one price could be used to forecast the other. The existence of cointegration and of an error correction mechanism have been interpreted as evidence of inefficiency in the markets. Short run deviations from long run relationship result in an automatic adjustment process that cause the variables to return to their long run equilibrium relationship. The error correction term contains information regarding the future movements of one variable based on past prices, and thus the deviations from this long-run relationship can be used in the prediction of future exchange rates.

On the other hand, it is controversially discussed in the literature that whether or not finding cointegration is not a measure of efficiency. For example, Dwyer and Wallace (1992), among the others, argue that cointegration of exchange rates does not necessarily imply an inefficient market. Even so, Copeland (1991), and Hakkio and Rush (1989) argue that exchange rates cannot be cointegrated in an efficient market if the currencies are different assets. Furthermore, Baffes (1994) shows that market efficiency requires a cointegration vector that is consistent with the no-arbitrage condition.

This paper is organized in seven sections. Section II reviews the literature. Section III discusses the relationship between the forward rate unbiasedness hypothesis and the efficient market hypothesis shortly. Section IV describes the data and Section V shows the econometric methodology. The empirical results are presented in Section VI. Finally, Section VI gives conclusions and remarks.

2. LITERATURE

Much of the literature on testing the market efficiency has relied on cointegration tests. The existence of cointegrating relationships among exchange rates have been extensively examined by many authors, but their results remain controversial. Foreign exchange market efficiency can be considered in two aspects: (i) within-country efficiency, and (ii) across-country efficiency. First one tests for cointegration between a single country's spot and forward exchange rates. If the forward exchange rates served as unbiased predictor of future spot exchange rates, foreign exchange market is within-country inefficient. The latter uses the prices of at least two currencies and tests cointegration among exchange rates in different countries. Across-country efficiency implies that one country's spot exchange rates cannot be used to predict another country's spot exchange rates.

Hakkio and Rush (1989) use monthly data from 1975 to 1986 to test for market efficiency by examining the cointegration of forward and spot rates within United Kingdom and Germany, and find the results consistent with market efficiency, ie., no evidence of cointegration both within and across the countries. Rapp and Sharma (1999) investigate the efficiency of the spot and forward exchange markets across and within countries for the G-7 countries. Performing cointegration methodology on the data, consist of the daily spot and one-month forward exchange rates with respect to the US dollar, from June 1, 1973 through December 31, 1996, authors conclude that the findings support market efficiency across countries but the efficiency test results within countries are highly mixed. Regarding within-country efficiency, although the evidence that cointegration existed between the forward rate and the corresponding future spot rate of the same country, this also supports market efficiency. Coleman (1990), using daily data for 18 foreign currencies, finds no evidence of cointegration, and thus claims that foreign exchange rates follow a random walk process. Lajaunie and Naka (1997) examine the cointegration relationships in the seven foreign exchange rates for the period from 1974 to 1991 using Johansen (1991) method, and find that there is no cointegration in the exchange rate pairings. Ahmad *et al.* (2012) examine the within and across-country market efficiency for 12 Asia-Pasific foreign currency markets using daily spot and one-month forward exchange rates from January 1, 1997 to June 30, 2010 during the 1997-98 Asian and the ongoing global financial crises. Authors conclude that foreign exchange markets are generally efficient from within-country and across-country perpectives according to the results of Johansen cointegration test and others. This study confirms the findings of Pilbeam and Olmo (2011).

There is far greater empirical evidence which rejects the hypothesis of efficiency. Hakkio (1981) examines five exchange rates against US dollar from 1973:4 to 1977:5, and reject the market efficiency hypothesis. Taylor (1989) examines the US dollar/UK pound exchange rate from January 1981 to July 1985, and finds the evidence that reject the efficiency hypothesis. Baillie and Bollerslev (1989) use daily data on seven spot exchange rates against the US dollar, the British pound, the German mark, the French franc, the Italian lira, the Swiss franc, the Japanese yen and the Canadian dollar, from March 1, 1980 to January 28, 1985 (totalling 1245 observations) with the Johansen (1988) test for cointegration. They find that spot exchange rate movements must be at least partly predictable, the deviations from this long run relationship can be used in the prediction of the future exchange rates, which is a violation of weak-form market efficiency. Diebold *et al.* (1994) reject the initial findings of Baillie and Bollerslev (1989) using the same data and come to different conclusion that there is no cointegration. Authors find the evidence much weaker than earlier reported. According to these authors, the cointegration model is sensitive to the assumption regarding the presence of a drift in the data and has no predictive power for exchange rate movements in an out-of-sample experiment. Then, Baillie and Bollerslev (1994) provide some additional evidence on the existence of cointegration in the same dataset. Sephton and Larsen (1991) show the evidence of cointegration in a system of four exchange rates using data from 1975 to 1986, and conclude that market efficiency tests which use cointegration among different exchange rates are sensitive to the chosen period or the model specified, causing the results to be inconclusive. Similarly, Barkoulas and Baum (1997) support this conclusion. Norrbin (1996) finds that The EuropeanMonetarySystem (EMS) rates, as an example of an officially coordinating system, are cointegrated. Aroskar *et al.* (2004) find strong evidence of market inefficiency in the EMS currencies before the introduction of the Euro, in which parities were strongly fixed. Copeland (1991) finds markets to be inefficient, using forward and spot rates of six currencies. Kühl (2010) investigates whether the Euro/US dollar exchange rate cointegrates with the four most important exchange rates for the period from January 3, 1994 to June 29, 2007, and finds that the Euro/US dollar cointegrates with the Australian dollar/US dollar and with the British pound/US dollar after the introduction of the Euro. According to this study, the introduction of the Euro has not resulted in a cross-sectionally inefficient market.

Some authors, including Crowder (1994), Dwyer and Wallace (1992), and Engel (1996) criticize the role of cointegration in market efficiency tests and demonstrate that cointegration doesn’t neccessarily imply market inefficiency. Among them, Crowder (1994) presents weak evidence of cointegration among different nominal spot exchange rates, the British pound, German Deutsche mark, and Canadian dollar, all relative the US dollar, over the period 1974 to 1991. He claims that lack of cointegration does not imply efficient markets and the exchange rate could be predictable because of the properties of the risk premium in an efficient market. Dwyer and Wallace (1992), and Engel (1996) demonstrate that there is no connection between market inefficiency and cointegration of spot exchange rates or, for that matter, a lack of cointegration. Wu and Chen (1998) support the hypothesis of foreign exchange market efficiency for nine OECD countries, employing a more powerful unit root test. According to Wu and Chen (1998), the cointegration of spot rates is neither necessary nor sufficient to rule out foreign exchange market

efficiency, foreign exchange markets are efficient even though the presence of cointegration (or lack of cointegration) is not examined. Phengpis (2006), employing several verification testing procedures, concludes that additional tests are needed to validate Johansen test results, because Johansen tests can result in incorrect inferences about efficiency. Author re-examines cointegration among daily spot exchange rates for the British pound, French franc, German mark and Italian lira during the 1992-93 European currency crisis and during the 1997-98 Asian currency crisis, and infers the existence of market inefficiency. Zivot (2000) tests the foreign exchange market efficiency for the British pound, Japanese yen, and Canadian dollar against US dollar in monthly basis from 1976:01 to 1996:06, and strongly rejects the efficiency hypothesis in all exchange rates, estimating a Vector Error Correction Model (VECM). The findings of market efficiency tests are often ambiguous, as the researchers are unable to discern whether the rejection of market efficiency is due to irrationality, mis-specification of expected returns, or a risk premium (Nguyen, 2000).
MacDonald and Taylor (1989) find cointegration for the exchange rate pairings French franc/US dollar and Deutsche mark/US dollar, Masih and Masih (1994) find cointegration using Canadian spot and forward rate along with those of six other major European currencies. Karfakis and Parikh (1994) find an evidence against market efficiency by employing the Johansen and Juselius (1990) multivariatecointegration technique to test for cointegration among the monthly data for five different Australian rates against the US dollar, Japanese yen, UK pound, German mark and French franc, for the period of 1975-1990. Callen *et al.* (1989) find that foreign exchange markets within-country are inefficient, focusing on six foreign exchange rates. Hansen and Hodrick (1980), and Pope and Peel (1991) are other some studies rejecting efficient market hypothesis. Hansen and Hodrick (1980)nd against evidence on the belief that the forward rate must be an unbiased predictor of the future spot rate for seven currencies relative to the US dollar, using weekly spot and three-month forward exchange rates. Authors conclude that this can be the result of either market inefficiencies or the existence of a risk premium. Pope and Peel (1991) reject the existence of a risk premium. Theobald (1991) concludes that the existence of a risk premium can make an efficient market appear to be inefficient. Liu and Maddala (1992) find that the spot and futures exchange rates are cointegrated, and failure of the market efficiency hypothesis is due to a risk premium rather than non-rational expectations, using weekly data for four currencies.

For Turkish foreign exchange markets, Özün and Erbaykal (2009) analyze cointegration and causality relationships between spot and futures markets by Bounds cointegration test and Toda-Yamamoto causality test for the period from January 2, 2006 to March 25, 2008 using daily data. Authors find that there is unidirectional causality running from future exchange rate market to spot market, and then conclude that foreign exchange markets have informational efficiency in Turkey. Korkmaz *et al.* (2009) find that futures contracts return series have a random walk pattern consistent with the weak-form efficient market hypothesis in the Turkish Derivatives Exchange, applying unit root tests, structural breaks and long memory models. Authors find no evidence of long memory in the futures contracts return series, implying the series are not fractionally integrated. Çağlı and Mandacı (2013) find that spot and futures prices of Turkish lira/US dollar and

Turkish lira/Euro foreign exchange rates are cointegrated under multiple structural breaks in the long run, examining the period from February 9, 2005 to October 17, 2012 with weekly data. Authors conclude that these markets are still efficient in the long run.

3. THE RELATION BETWEEN MARKET EFFICIENCY AND FORWARD RATE UNBIASEDNESS HYPOTHESIS

Market efficiency in the foreign exchange markets has been linked to the market agents are risk neutral, so that no risk premium exists, the market agents use all available information rationally, the market is competitive, information costs and transaction costs are minimal. In such a world, the forward rate fully reflects available information about the exchange rate expectations, thus the forward rate is usually viewed as an unbiased predictor of the future spot rate (Chiang, 1988). This means that examining the theory of market efficiency in the foreign exchange market from the perspective of the forward rate unbiasedness hypothesis. The cointegration relation between the spot rate and forward rate has several important implications for tests of the unbiased forward rate hypothesis. Johansen technique is a suitable test for unbiasedness. Rejection of the hypothesis implies that the forward rate does not represent the market expectations of the future spot rate. Mathematically, the forward rate unbiasedness hypothesis can be expressed as:

$$E(s_{t+1} - f_t / I_t) = 0 \quad (1)$$

In Equation (1), s_{t+1} is the one period ahead spot rate, f_t is the current forward rate at time t for the delivery of a currency at time $t+1$, given the information available in the same period, i.e., I_t. $E$is the expectations notation.

In test form, Equation (1) becomes:

$$s_{t+1} = a_0 + \beta f_t + \varepsilon_{t+1} \quad (2)$$

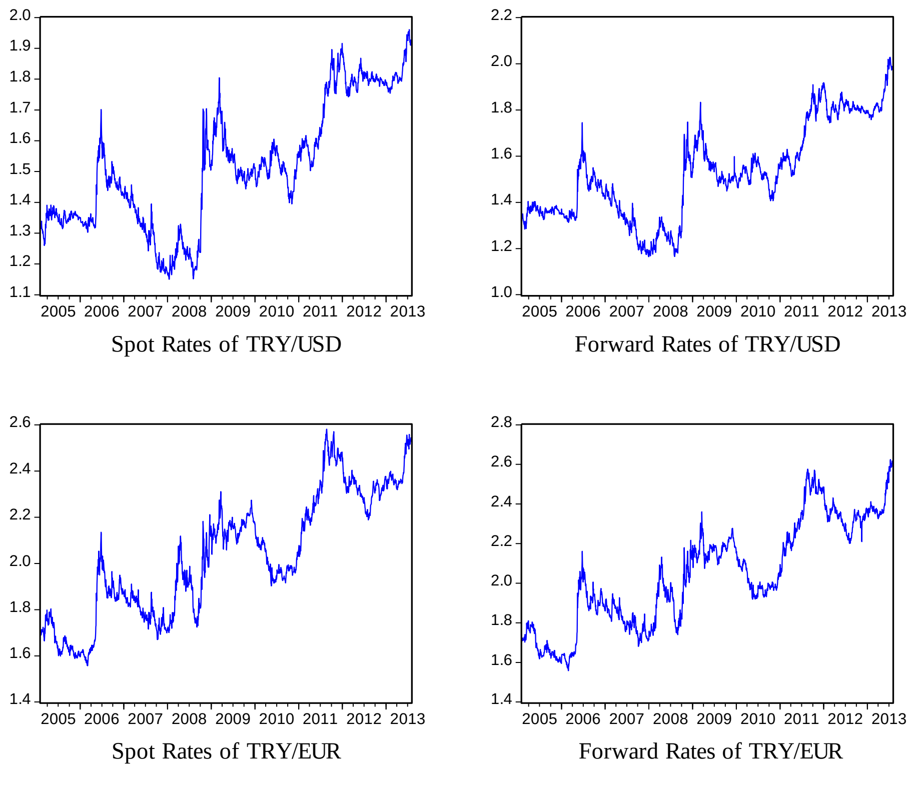
If market agents have rational expectations and there exists no risk premium, the future spot rate equals current forward rate plus random error term ε_{t+1}. Consistent with rational expectations, forecasts errors are equal to zero, i.e., there are no profit making opportunities. If the market is efficient, the residual ε_{t+1} should contain no information. The efficient foreign exchange market indicates that the risk premium is zero.

The forward rate unbiasedness hypothesis requires that there be a linear combination of non-stationary spot and forward rates is stationary Enders (1995). In more detail, given that s_{t+1} and f_t are cointegrated, unbiased forward rate hypothesis requires that s_{t+1} and f_t be cointegrated with the cointegrating vector (1,-1), that is, $a_0 = 0$ and $\beta = 1$ in Equation (2). Under these restrictions, the forward rate does not systematically under or over predict the future spot rate. In order to support the hypothesis emprically, the realized forecast error $s_{t+1} - f_t$ should be stationary, i.e., be a white noise process. In that case, the cointegration between s_{t+1} and f_t with a unitary cointegrating vector is neccessary condition for the unbiased forward rate hypothesis. Baillie and Bollerslev (1989), and Hai *et al*. (1997) find cointegration of s_{t+1} and f_t with a unitary cointegrating vector and the forward rate is an unbiased predictor of the future spot rate. On the other hand, Copeland (1991), Lai and Lai (1991), and Luintel and Paudyal (1998) although still find the existence of cointegration relationship between $s_{t+1}$and f_t,they reject the null of a unitary cointegrating vector. The results of these authors imply that one cannot use the forward rate directly as a measure for the spot rate expectations.

4. DATA

In this study, the data set consist of 2209 observations of nominal daily closing spot and one-month forward exchange rates expressed in units of Turkish lira per US dollar (TRY/USD) and Turkish lira per Euro (TRY/EUR). Market efficiency is tested for each Turkish foreign exchange market in an attempt to compare. All the spot and forward rates are in logarithms. The sample period ranges from February 7, 2005 to July 26, 2013. Turkey has been implemented floating exchange rate regime since February, 2001. The forward rate data start first from the date of February 7, 2005. The spot rate data are obtained from the Central Bank of Republic of Turkey, the forward rate data are obtained from Turkish Derivatives Exchange (TURKDEX). Figure 1 portrays the raw data.

Figure- 1. Spot and Forward Exchange Rates for Turkey (Raw Data)



5. METHODOLOGY

The Johansen cointegration procedure is seen as a robust and powerful technique for testing the efficient market hypothesis in the foreign exchange markets. The theory of cointegration was essentially pioneered by Engle and Granger (1987) and improved by Johansen (1988; 1991). In this study, bivariate Johansen technique is conducted using EViews econometric software package which implements VAR-based cointegration tests using the methodology developed in Johansen (1991; 1995). If non-stationary time series have the same order of integration and if a linear combination of these time series exists that is stationary, these series are referred to as being cointegrated (Engle and Granger, 1987). Cointegration means that time series move together in the long run. In contrast, lack of cointegration implies that the variables have no link in the long run.

Johansen's methodology takes its starting point in the vector autoregression (VAR) of order p given by:

$$y_t = \mu + A_1 y_{t-1} + \cdots + A_p y_{t-p} + Bx_t + \varepsilon_t \quad (3)$$

where y_t is k-vector of non-stationary I(1) variables, x_t is a d-vector of deterministic variables and ε_t is a vector of innovations. This VAR can be written as:

$$\Delta y_t = \Pi y_{t-1} + \sum_{i=1}^{p-1} \Gamma_i \Delta y_{t-i} + Bx_t + \varepsilon_t \quad (4)$$

where:

$$\Pi = \sum_{i=1}^{p} A_i - I, \Gamma_i = -\sum_{j=i+1}^{p} A_j \quad (5)$$

If the coefficient matrix Π has reduced rank $r < k$, then there exist kxr matrices α and β each with rank r such that $\Pi = \alpha\beta'$ and $\beta' y_t$ is I(0). r is the number of cointegrating relations (the cointegrating rank) and each column of β is the cointegrating vector. The elements of α are known as the adjustment parameters in the VECM. Johansen proposes two different likelihood ratio tests of significance the reduced rank of the Π matrix: The trace test and the maximum eigenvalue test. These test are computed as shown in Equation (6) and (7), respectively.

$$LR_{tr}(r|k) = -T \sum_{i=r+1}^{k} \log(1 - \lambda_i) \quad (6)$$

$$LR_{max}(r|r+1) = -T(1 - \lambda_{r+1}) = LR_{tr}(r|k) - LR_{tr}(r+1|k) \quad (7)$$

for $r = 0, 1, \ldots, k - 1.$

Here T is the sample size. The trace test tests the null hypothesis of r cointegrating vectors against the alternative hypothesis of k cointegrating vectors. The maximum eigenvalue test tests the null hypothesis of r cointegrating vectors against the alternative hypothesis of $r + 1$ cointegrating vectors.[1] Asymptotic critical values can be found in Johansen and Juselius (1990).

6. EMPIRICAL RESULTS

6.1. Unit Root Test Results

There is a need to test whether the spot rates and forward rates are stationary before estimating the long run equilibrium relation. There are some common methods for testing whether a series is stationary or not. In this paper, the Augmented Dickey-Fuller (ADF) (Dickey and Fuller, 1979; 1981) and the Phillips-Perron (PP) (Phillips and Perron, 1988) tests which are most commonly used are applied to the spot and forward rates of TRY/USD and the spot and forward rates of the TRY/EUR for levels and first differences of the natural log values. Enders (1995) states that when analysing the foreign exchange market efficiency, PP test is more appropriate. The results of the unit root tests are presented in Table 1, 2, 3 and 4. Both the ADF and the PP tests are not able to reject the null hypothesis of non-stationary in levels. The reported results indicate the rejection of non-stationarity and acception the alternative hypothesis that is stationarity in first differences at 1% significance level. In other words, the null hypothesis of unit root in first differences is rejected for the two spot rates as well as for the two forward rates. Therefore, the series are integrated order of one, I(1). Unit root tests that allow for a time trend are conducted also. It must be noted that the ADF test result with constant and trend for the TRY/EUR forward rates and the PP test result with constant and trend for the TRY/EUR spot rates show that the null hypothesis of unit root can be rejected in levels only at 10% significance level.

When testing market efficiency,first methodis to implement a simple test of the exchange rate for unit root. The unit root test results indicate that the spot and the forward rates under consideration in Turkey follow a random walk in consistent with the weak-form efficiency. In this regard, it can be said that past foreign exchange rates cannot be used to predict future foreign exchange rates. Consequently, foreign exchange market participants cannot devise any statistical technique to earn from their tradings constantly.

[1] For details, see Johansen (1995).

Table- 1.ADF Test for Spot Rates

	In Levels		In First Differences	
Currency	**t-statistic**	**Prob.[a]**	**t-statistic**	**Prob.[a]**
Constant				
TRY/USD	-1.1176	0.7109	-46.1341	0.0001***
TRY/EUR	-1.1433	0.7005	-45.1872	0.0001***
Constant and Trend				
TRY/USD	-2.4197	0.3691	-46.1286	0.0000***
TRY/EUR	-3.1160	0.1027	-45.1785	0.0000***

Notes: *** denotes significance at 1% level.
[a]is MacKinnon (1996) one-sided p-values.

Table- 2.ADF Test for Forward Rates

	In Levels		In First Differences	
Currency	**t-statistic**	**Prob.[a]**	**t-statistic**	**Prob.[a]**
Constant				
USD/TRY	-1.0841	0.7241	-47.8040	0.0001***
EUR/TRY	-1.1578	0.6946	-47.9683	0.0001***
Constant and Trend				
USD/TRY	-2.4479	0.3544	-47.8015	0.0000***
EUR/TRY	-3.2117	0.0823*	-47.9606	0.0000***

Notes: *** and * denote significance at 1% and 10% levels, respectively.
[a]is MacKinnon (1996) one-sided p-values.

Table- 3.PP Test for Spot Rates

	In Levels		In First Differences	
Currency	**t-statistic**	**Prob.[a]**	**t-statistic**	**Prob.[a]**
Constant				
USD/TRY	-1.1645	0.6918	-46.1357	0.0001***
EUR/TRY	-1.1433	0.7005	-45.1872	0.0001***
Constant and Trend				
USD/TRY	-2.4989	0.3287	-46.1299	0.0000***
EUR/TRY	-3.1514	0.0947*	-45.1460	0.0000***

Notes: *** and * denote significance at 1% and 10% levels, respectively.
[a]is MacKinnon (1996) one-sided p-values.

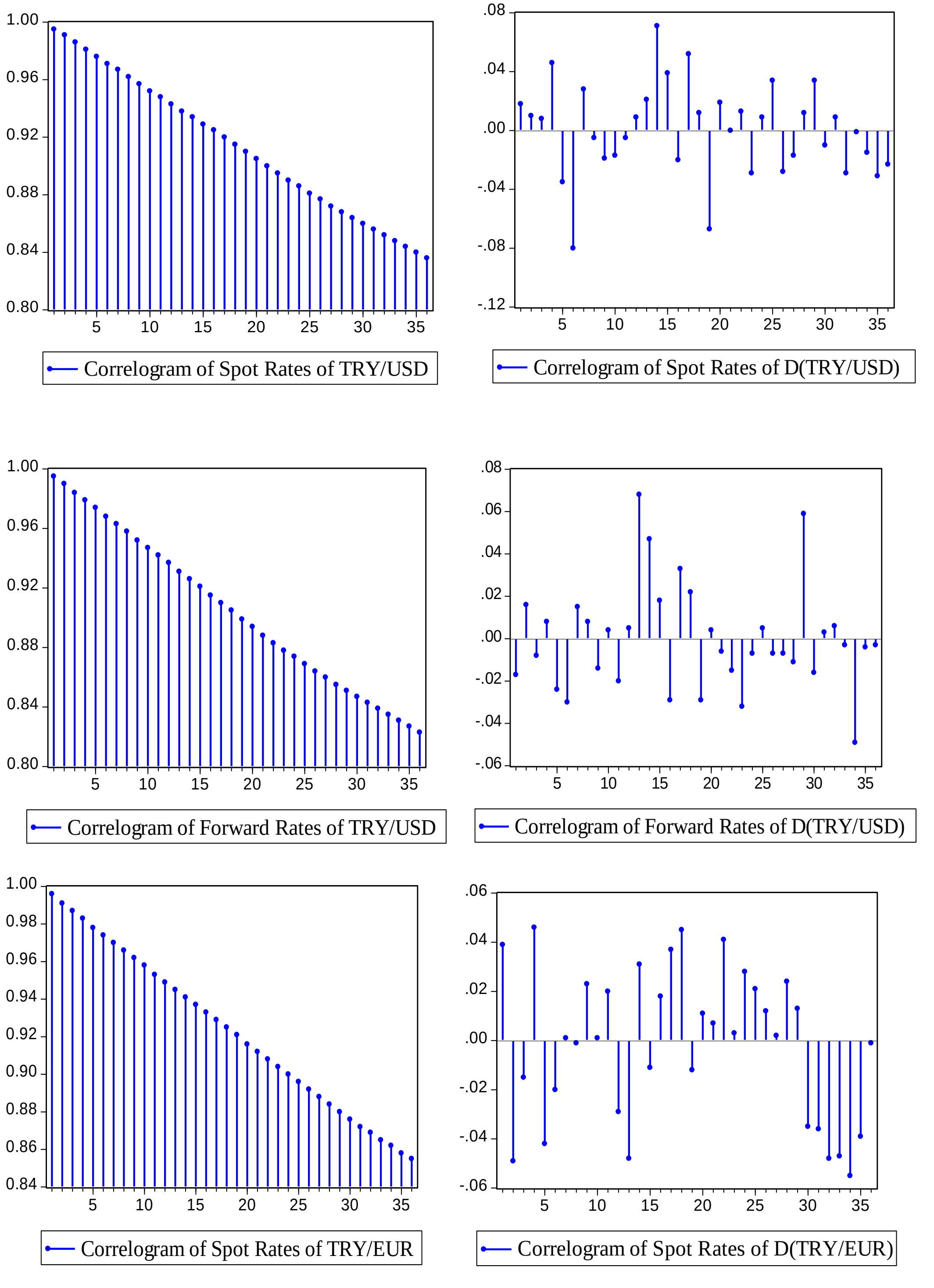
Table- 4.PP Test for Forward Rates

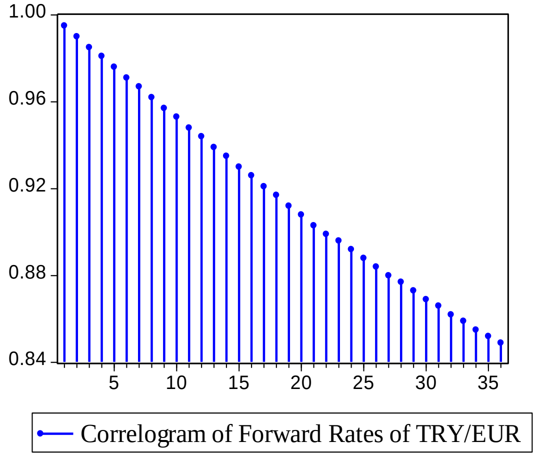
	In Levels		In First Differences	
Currency	**t-statistic**	**Prob.[a]**	**t-statistic**	**Prob.[a]**
Constant				
USD/TRY	-1.0558	0.7349	-47.8082	0.0001***
EUR/TRY	-1.0542	0.7355	-48.0512	0.0001***
Constant and Trend				
USD/TRY	-2.4401	0.3585	-47.8061	0.0000***
EUR/TRY	-3.0668	0.1146	-48.0442	0.0000***

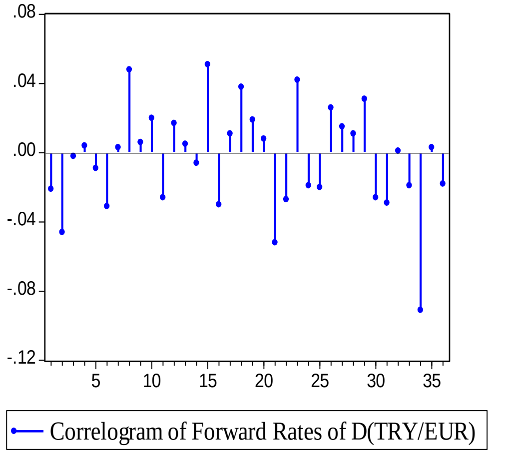
Notes: *** denotes significance at 1% level.
[a]is MacKinnon (1996) one-sided p-values.

In addition, to detect non-stationarity via graphical representation, the correlograms for the series both in levels and in first-differenced are presented in Figure 2. Figure 2 shows that the correlograms don't damp or die out very slowly, thus indicate non-stationarity for the series in levels, while the low and erratic autocorrelation coefficients confirm the hypothesis that the first-differenced series (denoted as D) are stationary. Also, as is seen from Figure 2, the auto-correlation function (ACF) declines toward zero rapidly and the correlograms have no significant spikes at many lags, providing the support for the first differences of the series are stationary.

Figure- 2. Correlograms of the Spot and Forward Rates in Level and First-differenced Forms







6.2. Johansen Cointegration Test Results

The empirical results from previous section show that the spot and forward rates in Turkey present I(1) process. The variables have unit root and the cointegration technique can be used to model the long run relations. The aim here is to investigate whether the current forward rate on Turkish Lira per US dollar and the current forward rate on Turkish Lira per Euro are cointegrated with their corresponding future spot rates. Thus, if the current forward rate and its corresponding future spot rate are not cointegrated, it is concluded that the foreign exchange market is efficient. Firstly, the results from the lag order selection based on Akaike Information and Final Prediction Error (AIC and FPE) criteria are presented in Table 5. According to Table 5, AIC and FPE both yield optimal lag length is set to 7 for the TRY/USD exchange rates and to 5 for the TRY/EUR exchange rates. Other criteria give mixed results.

Table- 5. Lag Order Selection using the AIC and FPE Criteria

VAR Order								
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
For TRY/USD Spot and Forward Rates								
AIC	-14.131	-14.252	-14.276	-14.273	-14.279	-14.280	-14.281*	-14.280
FPE	2.51×10^{-9}	2.25×10^{-9}	2.16×10^{-9}	2.17×10^{-9}	2.16×10^{-9}	2.15×10^{-9}	2.15×10^{-9}*	2.15×10^{-9}
For TRY/USD Spot and Forward Rates								
AIC	-14.356	-14.407	-14.412	-14.410	-14.417*	-14.415	-14.412	-14.412
FPE	2.00×10^{-9}	1.90×10^{-9}	1.89×10^{-9}	1.89×10^{-9}	1.88×10^{-9}*	1.88×10^{-9}	1.89×10^{-9}	1.89×10^{-9}

Note: * indicates Minimum.

The statistical results of Johansen cointegration test to determine the number of cointegrating vectors are reported in Table 6. Here the linear deterministic trend assumption is used for the unrestricted cointegration rank test. It must be stated that the alternative selections don't make any difference in the empirical results. Both the results for trace and maximum eigenvalue tests reject the null hypothesis of zero cointegrating vectors between s_{t+1} and f_t at 5% critical level. For example, because the trace statistic at $r = 0$ of 97.690 exceeds its critical value of 15.494, the null hypothesis of no cointegration is rejected. On the other hand, the hypothesis that there is one cointegrating vector cannot be rejected. For example, because the trace statistic at $r = 1$ of 1.165 is less than its critical value of 3.841, the null hypothesis that there is one cointegration vector is cannot be rejected. Based on the evidence in Table 6, it can be concluded that there exists one cointegrating relationship between the log of future spot rates and the log of current forward rates. In other words, the value of future spot rates can be predicted using the value of current forward rates.

Table- 6. Results from Johansen Cointegration Test

Null Hypothesis	**Trace Statistic**	**5% Critical Value**	**Maximum Eigenvalue Statistic**	**5% Critical Value**
Between TRY/USD Spot and Forward Rates				
$r = 0$	97.690** (0.0001)	15.494	96.524** (0.0000)	14.264
$r = 1$	1.165 (0.2802)	3.841	1.165 (0.2802)	3.841
Between TRY/EUR Spot and Forward Rates				
$r = 0$	133.197** (0.0001)	15.494	132.023** (0.0001)	14.264
$r = 1$	1.174 (0.2785)	3.841	1.174 (0.2785)	3.841

Notes: ** denotes rejection of the hypothesis at the 5% critical level.
p-value in parentheses ().

From Johansen technique, the normalized cointegration coefficients are described as is seen from Table 7. The estimated value of β is negative, approximately equal to 1 and significant both in the two markets.

Table-7. Normalized Cointegration Coefficients

Currency	$\mathbf{s_t}$	$\mathbf{f_{t-1}\ (\beta)}$	**Constant Term (μ)**
TRY/USD	1	-1.0030 (0.0044) [-225.41]	0.0092
TRY/EUR	1	-1.0150 (0.0038) [-261.49]	0.0183

Standart errors in () and t-statistics in [] parentheses.

6.3. VECM Results

There is sufficient evidence to proceed the analysis with one cointegration vector in the Vector Error Correction Model in order to evaluate the short run properties of the cointegrated series. VECM representation provides testing for the temporal causal dynamics (in the Granger sense) through both short run and error correction channels of causation. The VECM results are provided in Table 8 and 9. The VECM is based on 7 lags for the TRY/USD and 5 lags for the TRY/EUR foreign exchange markets. In the VECMs, the change in the spot rate is regressed on the lagged forward-spot differential $(s_t - f_{t-1})$ and lagged changes in the spot and the forward rates. The VECM in this study takes the following form for the TRY/USD foreign exchange market:

$$\Delta s_{t+1} = c_0 + \alpha_0(s_t - \beta f_{t-1} - \mu) + \gamma_1 \Delta s_{t-1} + \gamma_2 \Delta s_{t-2} + \cdots + \gamma_7 \Delta s_{t-7} + \delta_1 \Delta f_{t-1} + \delta_2 \Delta f_{t-2} + \cdots + \delta_7 \Delta f_{t-7} + \varepsilon_{st+1}. \quad (8)$$

And, for the TRY/EUR foreign exchange market:

$$\Delta s_{t+1} = c_0 + \alpha_0(s_t - \beta f_{t-1} - \mu) + \gamma_1 \Delta s_{t-1} + \gamma_2 \Delta s_{t-2} + \cdots + \gamma_5 \Delta s_{t-5} + \delta_1 \Delta f_{t-1} + \delta_2 \Delta f_{t-2} + \cdots + \delta_5 \Delta f_{t-5} + \varepsilon_{st+1}. \quad (9)$$

The error correction term (denoted as α_0 in Equation 8 and 9), i.e. the speed of adjustment term, should be negative and significant if the series are cointegrated. The interpretation of inefficient foreign exchange market is a result of the significant error correction term. As is seen from the Table 8 and 9, both the speed of adjustment terms statistically significant at 1% level and have a negative sign.

The Johansen procedure isn't sensitive to the choice of dependent variable, each currency can be regarded as the dependent variable. The error correction terms in these two tables are significant only when the future spot rates are used as dependent variable. This implies that the future spot rates respond to the discrepancy from the long run equilibrium in the previous period, and the forward rates should be able to Granger cause the spot rates. There is a long run causality running from forward rates to spot rates. Put it differently, when the spot rate is defined as the dependent variable, there is an information in the forward rates history that can be used to prediction of the spot rates after controlling the spot rates' own history. For example, the TRY/USD spot rate depreciation or appreciation is predictable by past values of its own spot rates and the past values of the TRY/USD forward rates.

In Table 8, the estimated coefficient of α_0 is -0.1612, meaning that about 16 per cent of disequilibrium is corrected each day by changes in the TRY/USD spot rates. In Table 9, the estimated coefficient of α_0 is -0.1201, meaning that about 12 per cent of disequilibrium is eliminated in each day by changes in the TRY/EUR spot rates. These adjustment parameters may be interpreted as slow adjustment towards long run equilibrium. The speed of adjustment is somewhat faster in the TRY/USD foreign exchange market than the other. Considering the error correction terms, it can be said that if the spot rate exceeds the forward rate, in the next day the spot rate decreases while the forward rate increases to bring the system back into long run equilibrium.

Table- 8.VECM Results with TRY/USD Future Spot Rates as Dependent Variable

Parameter	Coefficient	Std. Error	t-statistic	Prob.
c_0	0.0001	0.0001	0.7879	0.4308
α_0	-0.1612***	0.0292	-5.5168	0.0000
γ_1	-0.3413***	0.0398	-8.5664	0.0000
γ_2	-0.1492***	0.0408	-3.6506	0.0003
γ_3	-0.0328	0.0403	-0.8149	0.4152
γ_4	-0.0086	0.0394	-0.2188	0.8268
γ_5	-0.0531	0.0386	-1.3729	0.1699
γ_6	-0.0561	0.0366	-1.5315	0.1258
γ_7	0.0409	0.0303	1.3489	0.1775
δ_1	0.4168***	0.0380	10.9516	0.0000
δ_2	0.2090***	0.0401	5.2058	0.0000
δ_3	0.0469	0.0399	1.1746	0.2403
δ_4	0.0692*	0.0392	1.7658	0.0776
δ_5	0.0611	0.0385	1.5875	0.1125
δ_6	0.0084	0.0370	0.2277	0.8199
δ_7	-0.0259	0.0323	-0.8042	0.4213

Wald F-Test

Null Hypothesis: $\gamma_1 = \gamma_2 = \gamma_3 = \gamma_4 = \gamma_5 = \gamma_6 = \gamma_7 = 0$
F-Statistic= 13.021 (0.0000)
Chi-Square= 91.153 (0.0000)

Null Hypothesis: $\delta_1 = \delta_2 = \delta_3 = \delta_4 = \delta_5 = \delta_6 = \delta_7 = 0$
F-Statistic= 20.039 (0.0000)
Chi-Square= 140.273 (0.0000)

Q-statistics for Forecast Errors

Q(1)=0.0044 (0.947), Q(3)= 0.0170 (0.999), Q(6)=0.1816 (1.000), Q(12)=3.3640 (0.992)

Notes: *** and * denote significance at 1% and 10% levels, respectively.
p-values in ().

Table-9. VECM Results with TRY/EUR Future Spot Rates as Dependent Variable

Parameter	Coefficient	Std. Error	t-statistic	Prob.
c_0	0.0001	0.0001	0.9706	0.3318
α_0	-0.1201***	0.0283	-4.2344	0.0000
γ_1	-0.1387***	0.0375	-3.7249	0.0002
γ_2	-0.1139***	0.0369	-3.0369	0.0021
γ_3	-0.0549	0.0360	-1.5251	0.1274
γ_4	-0.0397	0.0345	-1.1500	0.2502
γ_5	-0.0572*	0.0306	-1.8648	0.0623
δ_1	0.2394***	0.0362	6.6093	0.0000
δ_2	0.0808**	0.0362	2.2278	0.0260
δ_3	0.0452	0.0353	1.2808	0.2004
δ_4	0.0993***	0.0338	2.9342	0.0034
δ_5	0.0364	0.0306	1.1874	0.2352

Wald F-Test

Null Hypothesis: $\gamma_1 = \gamma_2 = \gamma_3 = \gamma_4 = \gamma_5 = 0$
F-Statistic= 3.523 (0.0036)

Chi-Square= 17.618 (0.0035)	
Null Hypothesis: $\delta_1 = \delta_2 = \delta_3 = \delta_4 = \delta_5 = 0$	
F-Statistic= 10.155 (0.0000)	
Chi-Square= 50.778 (0.0000)	
Q-statistics for Forecast Errors	
Q(1)=2E-07 (1.000), Q(3)=0.0054 (1.000), Q(6)=0.0978 (1.000), Q(12)=3.7899 (0.987)	

Notes: ***, ** and * denote significance at 1%, 5% and 10% levels, respectively.
p-values in ().

The estimated VECMs are written for each foreign exchange market containing only those variables which are significant at least at 10% level of significance. For the TRY/USD foreign exchange market, the estimated VECM is written as:

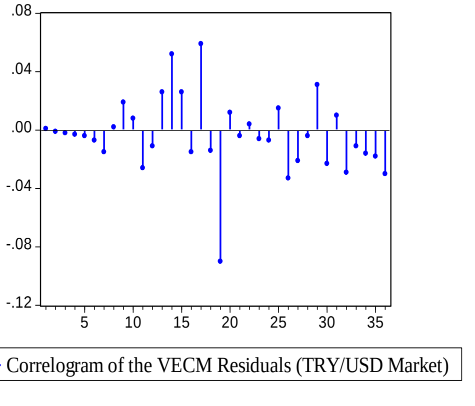
$$\Delta s_{t+1} = -0.1612(s_t - 1.0030f_{t-1} + 0.0091) - 0.3413\Delta s_{t-1} - 0.1492\Delta s_{t-2} + 0.4168\Delta f_{t-1} + 0.2090\Delta f_{t-2} + 0.0692\Delta f_{t-4} + \varepsilon_{st+1} \quad (10)$$

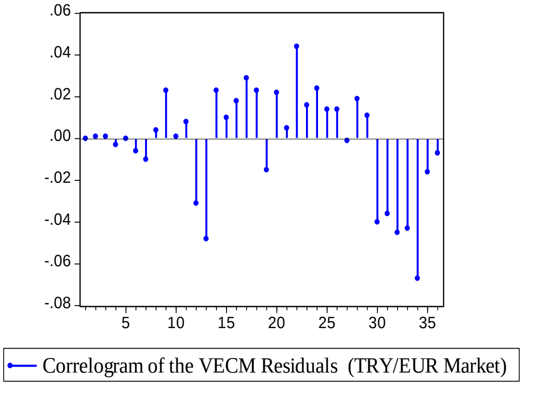
And, the estimated VECM for the EUR/TRY foreign exchange market is written as:

$$\Delta s_{t+1} = -0.1201(s_t - 1.0150f_{t-1} + 0.0183) - 0.1387\Delta s_{t-1} - 0.1139\Delta s_{t-2} - 0.0572\Delta s_{t-5} + 0.2394\Delta f_{t-1} + 0.0808\Delta f_{t-2} + 0.0993\Delta f_{t-4} + \varepsilon_{st+1} \quad (11)$$

Next, the VECMs which are given in Table 8 and 9 are tested for Granger causality using Wald F-test. According to the Wald F-test results, the Chi-square statistics are significant at 1% level in all cases and the null hypothesis that the coefficients are zero can be rejected, meaning that all the variables jointly have a short run causality running from the changes in the lagged values of the spot and forward rates to the changes in the spot rates both in the two markets. The reported Q-statistics that test for serial correlation in the forecast errors (residuals) in Table 8 and 9 are not significant at all lags from 1 to 19, indicating the residuals are not serially correlated or be white-noise process. Also, the correlograms of the VECMs residuals in Figure 3 support the forecast errors are stationary at many lags.

Figure- 3. Correlograms of VECM Residuals





Consequently, the empirical findings show that the future spot and forward rates are cointegrated with the cointegrating vector (1,-1), i.e., the estimates of β approximately equal to one, and the forecast errors are stationary according to the Q-statistics, then the forward rate unbiasedness hypothesis is satisfied both in the two Turkish foreign exchange markets. The existence of cointegration provides strong evidence against market efficiency in semi-strong form, as interpreted in Wickremasinghe (2005). The results of this study conflict with the previous studies on the efficiency of Turkish foreign exchange markets. But these markets have weak-form efficiency according to the unit root test results like in part of their results.

6.4. Variance Decomposition Results

Finally, the variance decomposition analysis results are given in Table 10 in order to supplement the Granger causality test results which show the only in-sample period causal relationships and to reveal the out-of-sample causal relationships, i.e. 48 days. Results presented in columns explain how much of a spot exchange rate's own shock is explained by movements in its own variances and those of the forward exchange rate's for both currency markets.

Table- 10. Variance Decomposition Results for TRY/USD and TRY/EUR Spot Rates

Days	Relative Variance in	Percentage of Variance Explained by Innovation in	
		TRY/USD Spot Rate	**TRY/USD Forward Rate**
1	TRY/USD Spot Rate	100.00	0.00
2		92.06	7.93
3		88.81	11.18
6		83.24	16.75
12		78.29	21.70
24		74.36	25.63
36		72.65	27.34
48		71.74	28.25
		TRY/EUR Spot Rate	**TRY/EUR Forward Rate**
1	TRY/EUR Spot Rate	100.00	0.00
2		96.83	3.16
3		95.11	4.88
6		91.57	8.42
12		89.44	10.55
24		88.18	11.81
36		87.71	12.28
48		87.47	12.52

According to the results in Table 10, the percentage variance of the TRY/USD and the TRY/EUR spot rates explained by itself the most at any horizon, this is more clear in the percentage variance of the TRY/EUR spot rates, and the forward rates explain a little proportion of the variance of the spot rates. The higher time horizon, the more is the variance of the spot rates explained by the forward rates. The TRY/USD spot rates explain more than 92% of its variance, the TRY/USD forward rates explain about 8% of the variance of the TRY/USD spot rates at the two-days forecast horizon. The TRY/EUR spot rates explain more than 96% of its variance, the TRY/EUR forward rates explain more than 3% of the variance of the TRY/EUR spot rates at the same forecast horizon. At the 48-days horizon, about 70% of the variance of the TRY/USD spot rates is explained by its own and about 87% of the variance of the TRY/EUR spot rates explained by its own. These results indicate that the movements of the spot rates are caused mainly by their own more than the forward rates. In addition, the forward rates explain a more proportion of the variance of the spot rates in the TRY/USD currency market.

7. CONCLUSIONS AND REMARKS

In this study, the efficiency of the Turkish foreign exchange markets is investigated that on the basis that if the current forward rate and its corresponding spot rate are cointegrated both in case of the TRY/USD and the TRY/EUR from the within-country perspective. The Johansen cointegration technique is applied to daily data of the spot exchange rates and the forward exchange rates for the period from February 7, 2005 to July 26, 2013. Unit root tests on the spot and forward exchange rates confirm that they are non-stationary but first differencing of these variables makes them stationary. Hence, the unit root test results provide evidence for efficient market hypothesis in its weak form, indicating all exchange rates follow random walk.

However, the Johansen cointegration test results indicate that the forward rates are cointegrated with its corresponding spot rate with a unitary cointegrating vector (1, -1), then for the forward rate unbiasedness hypothesis to hold, and suggest that the failure of market efficiency in its semi-strong form. The evidence presented for the forward rate unbiasedness hypothesis refers that the forward rates is an unbiased predictor of the corresponding future spot rates; market agents can use the forward rates as indicators of the future spot rates. This can be interpreted as it usually has been that market expectations regarding exchange rate movements are rational and/or non-existence of time varying risk premium, i.e. no systematic forecast errors. The sign and the significance of the estimated error correction terms for the two markets show that the changes in the spot exchange rates are predictable based on past disequilibriums, consistent with the lack of a bias. In addition, the results of variance decomposition analysis indicate that the variance of the spot rates explained by its own primarily both in the two spot markets, and the forward rates account a some more proportion of the variance of the spot rates in the TRY/USD currency market as compared to the other.

These are the empirical results that most authors have interpreted as market inefficiency. In Turkey, economic policy makers can take actions to affect the exchange rates and exchange rate traders can devise several trading techniques to make abnormal profits both in the short run and long run, evaluatingly the impact of economic policies on the exchange rates.

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