FRACTIONAL COINTEGRATION ANALYSIS OF STOCK MARKET AND EXCHANGE RATES: THE CASE OF TURKEY[1]

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Abstract

The fluctuations and responses between the exchange rate and the stock market has been a topic of interest for both policy makers and market participants for a long time. The aim of the study is to examine so-called relationship using fractional cointegration analysis. For this purpose, we utilized from Borsa İstanbul and daily exchange rates USD/TRY and EUR/TRY for period 2002:01–2015:04 to determine this relationship. Fractional cointegration analysis indicates presence of an equilibrium in the long term in series and fractional integrated errors show persistent characteristics which indicate long memory. Therefore instead of using classical cointegration we have decided using Geweke and Porter-Hudak fractional cointegration for more accurate results. Results indicate that there is a significant positive cointegration between exchange rates and stock prices in Turkish market Borsa İstanbul. This study contributes to literature by analyzing the phenomenon under long memory conditions in Borsa Istanbul.

Keywords: Financial Markets, Fractional Integration, Fractional Cointegration

JEL Classification: G1, A1, C22, C32

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1. Introduction

Stock market and exchange rate interaction is a crucial factor in determining foreign currency policies and regulating the stock market prices, even though a substantial quantity of studies analyze this relationship, there is not a commonly accepted theory that command the majority of literature. As explained by Kim (2003: pp. 304), the relationship between exchange rate and stock market is of importance owing to the fact that they have a vital effect on the development of a country's economy. Besides, this relationship is followed by investors in respect of forecasting the future trends. The interaction of these two financial variables become especially fundamental when evaluating the 1997 Asian crisis. During this crisis, both stock prices and exchange rate went down. In other words, decrease in stock prices was replied with a volatile decrease in exchange rates. In the recent years, this relationship has gained importance on account of developing international diversification, cross-market return correlations, gradual abolishment of capital inflow barriers and more flexible exchange rate arrangements in emerging and transition countries (Agrawal, Srivastav and Srivastava, 2010: pp. 64). In addition, these markets are immediately influenced by changes in economic policy due to being sensitive parts of financial markets. So, this relationship is of interest to investigators (Mishra, 2004: 210). However, there is no theoretical and empirical consensus regarding the presence and the way of the relationship between exchange rates and stock returns (Nieh and Lee, 2001, pp. 477-478).

The relationship between exchange rates and stock prices is mainly investigated under "classical approach" and "portfolio balanced approach" in literature. The two widely recognized approaches have emerged significant in the literature on this subject which conflict with each other, one being the classical economic theory that suggests flow oriented models, claiming that movements in exchange rate is a leading factor in stock price movements. As for the other view, Bronson (1977) has emphasized the portfolio balance approach. The approaches differ in the way they explain the direction of the relationship. According to the classical approach, changes in exchange rate have an impact on stock prices by affecting international competitive structure and balance of trade. The causality goes from exchange rates to stock prices as stated by Dornbusch and Fischer in 1980 (pp. 962). Increasing world trade and growing capital movements bring about that exchange rates become one of the main factors which affect profitability and equity prices (Kim, 2003: pp. 304). Additionally, the movements in exchange rates affect the future cash flows of the firms, their competitive capacity in international market, their sales (Yau and Nieh, 2006: pp. 537). Exchange rate fluctuations cause change for firms' foreign operations. In this respect, the value of firms' foreign operations has a bearing on stock prices. As a consequence of currency appreciation, imported inputs become more expensive while exported goods become cheaper. This case enhances economic value, profitability of firms and also their stock returns (Aggarwal, 1981). Therefore it is suggested in classical theory that the direction of relationship is positive.

In portfolio balance approach, investors diversify their portfolio with various equities. Exchange rate balances supply and demand for domestic and foreign financial equities. Increasing domestic stock prices attract investors to invest in domestic equity shares and lead to capital inflow. As a result of this capital inflow, the demand for domestic currency rises. This situation creates a downward pressure in exchange rates. According to this approach, there is an inverse relationship between exchange rates and stock prices. The causality goes from stock prices to exchange rates. An increase in stock prices causes an increase in stock market prices and bring about a raise in aggregate welfare affecting domestic interest rate, thus the exchange rate falls while demand for domestic currency goes up (Branson, 1983; Dornbusch and Fischer, 1980).

The aim of this study is to investigate the relationship between US/TL exchange rate and BIST 100 stock prices. For this purpose, Geweke and Porter-Hudak fractional cointegration test considering long memory is used. This study contributes to literature by analyzing the phenomenon under long memory conditions in Borsa Istanbul.

2. Literature review

In the literature, there are a large number of studies examining the relationship between the stock market and exchange rate. Some of these studies show that so-called relation is valid while other studies state that there is no such relation.

Solnik (1987) examined the connection between US dollar and Canada, France, Germany, Japan, Netherlands, Switzerland, U.K., and U.S.A. stock markets via multivariate regression. Rahman ve Uddin (2008) investigated the relationship between US dollar, Euro, Japanese yen, pound sterling and monthly values of Dhaka Stock Exchange General Index with Johansen cointegration and Granger causality test. Rahman and Jashim (2009) considerate this relationship for Pakistan, India and Bangladesh and used Engle-Granger procedure. Zia and Rahman (2011) used Engle-Granger cointegration to analyze the relationship between US dollar and monthly Karachi Stock Exchange 100 Index in Pakistan. None of these studies were able to reveal a significant relationship between the between stock prices and exchange rates.

Nieh and Lee (2001) analyzed the short and long run relationship between exchange rates and stock prices in G-7 countries through Engle-Granger and Johansen maximum likelihood test and vector error correction model. Their study did not find any long-run relationship between the two variables while finding a positive relationship in the short run within G7 countries. Naeem and Rasheed (2002) studied the dynamic relationship between exchange rate and stock markets in Asian countries using Johansen and Juselius bivariate cointegration tests and vector error correction model together. As a conclusion, even though short-run relationship between exchange rates and stock prices is not found for all of the countries, there is bi-directional long-run relationship for Bangladesh and Sri-Lanka contrary to Pakistan and India.

Aggarwal (1981) analyzed the relationship between US dollar and US stock market prices with OLS. Phylaktis and Ravazzolo (2005) considered the relationship among Taiwan and Japanese stock prices, and New Taiwan Dollar/Yen exchange rate via bivariate, trivariate cointegration test and multivariate Granger causality test for pacific Basin countries. These studies show that there is a positive relationship between these two financial variables. Yau and Nieh (2009) researched the connection between New Taiwan and Japanese exchange rates and Taiwan and Japanese stock markets by using threshold error correction model. The results of the study show that there is positive long-run relationship in contrast to short-run relationship.

Soenen and Hennigar (1988) studied the connection between exchange rate and stock prices for US. Erbaykal and Okuyan (2007) examined this relationship in terms of portfolio approach for emerging markets by using Granger causality method. These studies show that there is negative relationship between two financial variables.

Some studies support portfolio balance approach. Kasman (2003) indicated that causality relationship exists from exchange rate to stock prices in terms of causality. Aydemir and Demirhan (2009) found that there is bidirectional relationship between exchange rate and stock market indices. Köse, Doğanay and Karabacak (2010) took into account five currencies, which are US dollar, Euro, Japanese Yen, Pound Sterling and Swiss Franc, and used Granger causality test to test this relationship. The result of the analysis indicates unidirectional causality from stock prices to exchange rates and negative relationship between two financial variables. Rjoub (2012) examined the dynamic relationship between the Turkish stock prices and exchange rate and US stock prices with vector autoregressive model. Study finds bidirectional relationship between exchange rate and stock price as well as the negative effects exchange rate has on Turkish stock prices. Kaya et. al. (2013) analyzed the stock prices and macroeconomic variables by using OLS. According to the result of this study, there exists negative relationship between these variables.

As for the studies that support the classical approach. Altıntaş and Tombak (2011) tested the connection between exchange rate and stock prices with VAR and Granger causality methods. In conclusion, it is revealed that there is a positive relationship between these variables. Kıran (2009) used data ranging from 1990-1994 and 2001-2008 and used bound test developed by Pesaran, Shin and Smith and Toda Yamamoto causality test. For 1990-1994 period, he has found that there is a positive long-run relationship. Sevüktekin and Nargeleçekenler (2007) used Engle-Granger test, Johansen co integration test and Phillips-Oulliaris test to analyze the connection between two variables. Although bidirectional relationship exists in long-run, there is no causality relationship in short-run. However, positive relationship between exchange rate and stock price is somewhat observed.

3. Methodology

Fractional integration process was initially discussed by Granger and Joyeux (1980) and Hosking (1981). Granger-Joyeux (1980) and Hosking (1981) said that integrated degree concerning time series always cannot be integer in contrast to traditional unit root tests, integrated degree can only have decimal value and thus fractional structure should be preferred. Fractional integrated processes have long memory and long-run dependence as defined by Hurst (1957) and Mandelbrot (1968). Fractional integrated processes $[1-L^d]$ is described with fractional difference operator. Here, L is lag operator $L^k x_k = x_{t-k}$.. Lag operator is written again by using binomial series as below :

$$[1-L]^d = 1 - dL - \cdots - \frac{\Gamma(\mathrm{k}-\mathrm{d})}{\Gamma(\mathrm{k}+1)\Gamma(-\mathrm{d})} L^k + 0(L^{k+1}) \qquad (1)$$

This operator is used to define fractional integrated process. If $[1-L]^d x_t = u_t,\ x_t, t = 1, \ldots, n$ process follows autoregressive fractional integrated mean process (ARFIMA). Where u_t exhibits ARMA(p,q). $\varphi_p(L)u_t = \theta_q(L)\varepsilon_t, \varepsilon_t$ has a white noise structure with zero mean and σ_ε^2 variance. u_t is stationary and satisfies the reversible conditions (Diebolt ve Guiraud, 2005: pp. 828; Xu, Liu, Nie, 2006: pp. 485). Fractional differenced processes are efficient to model long run permanence (Hosking, 1981: pp. 167).

In fractional unit root analysis, the calculated d value is tested to be bigger than 1. Null hypothesis is H_0: d<1 (series is stationary) while alternative hypothesis is H_1: d>1 (series is not stationary). The critical values regarded t value to be compared ae taken from Sephton's article named "Fractional Cointegration: Monte Carlo Estimates of Critical Values, With an Application" (Hepaktan, 2009: pp. 47-48).

Table 1

Memory Characteristic Related to Series According to d Parameter

Range	Memory Feature
$-0.5 < d < 0$	The series has short memory and permanent effect isn't observed
$0 < d < 0.5$	The series has long memory and is stationary
$d = 0$	The series has short memory and is stationary
$0.5 \leq d < 1$	The series isn't covariance stationary, but it turns back its mean and has finite impulse-response weights
$d \geq 1$	The series isn't stationary and doesn't turn back its mean

x_t refers to fractional cointegration, if

$$\alpha \in IR^a, a \neq 0,\ \alpha' x_t \sim I(d)\ 0 < d < 1 \qquad (2)$$

d refers to long memory parameter and is written as $x_t \sim FCI(d)$ (Dittmann, 2000: pp. 3).

The main characteristic of this test is that fractional difference parameter (d) depends on slope of spectral density function around angular frequency=0. Geweke, Porter and Hudak suggested to take first difference of the series to guarantee stationary and reversibility.

$$\ln\left(I(w_j)\right) = \theta + \lambda \ln\left(4sin^2\left(\frac{w_j}{2}\right)\right) + v_j; \quad j = 1, \ldots, J \tag{3}$$

Where, is constant, indicates Fourier frequency. . J is increasing function of T, and T shows number of observation. . is periodogram concerned with the time series at frequence. For sample series with T observations, is calculated as below:

$$\hat{I}(w_j) = \frac{1}{2\pi} \sum_{k=-T+1}^{T-1} \widehat{\gamma_j} e^{-iw_j k}, i^2 = -1 \tag{4}$$

$$\hat{I}(w_j) = \frac{1}{2\pi} (\widehat{\gamma_0} + 2 \sum_{k=1}^{T-1} \gamma_k \cos(w_j k)) \tag{5}$$

Where, is j. order sample autocovariance,

$$\widehat{\gamma_j} = \begin{cases} T^{-1} \sum_{t=j+1}^{T} (y_t - \bar{y})(y_{t-j} - \bar{y}), & j = 0,1,2, \ldots, T-1 \\ \widehat{\gamma_{-j}}, & j = -1, -2, \ldots, -T+1 \end{cases} \tag{6}$$

The presence of fractional integrated degree can be tested by investigating statistical significance of d parameter (Cooray and Felmingham, 2008: 50; Geweke and Porter, 1993). The hypothesis used in GPH cointegration test is as follows:

$H_0 = \gamma_{GPH} = 0$

$H_1 = \gamma_{GPH} \neq 0 H_1 = \gamma_{GPH} < 0$

Because the values of error terms cannot be observed directly and they are obtained by minimizing the variance of error term in cointegration equation, t critical values are biased toward the presence of cointegration at the hypothesis tests. Critical values are generated with Monte Carlo simulation so as to prevent this situation.

4. Data and Emprical Results

In order to analyze the cointegration relationship between exchange rate and stock prices in Turkish stock market, monthly data including Dollar, Euro and BIST 100 closing prices are used. Monthly data are taken from TCMB statistical database for period 2002:01 - 2015:04. The variables used in the study are as following:

Table 2

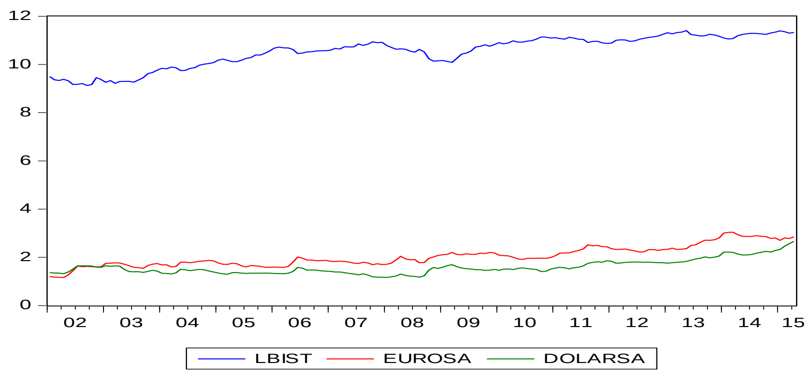
The Variables Used In The Study

Variables	Definition
Lbist	Log of Borsa Istanbul Stock Exchange closing prices
Dollarsa	TL/US exchange rate (Seasonality Eliminated)
Eurosa	TL/Euro exchange rate (Seasonality Eliminated)

In first stage of the analysis, dollar and Euro exchange rates are rendered pure from seasonality by adjustment via moving average method. The time-line graph concerning the financial variables is presented in Figure 1. According to Figure 1, these financial variables act parallel with each other. Also, the effects of 2008-2009 global financial crisis on dollar, Euro and BIST 100 index are clearly observable.

Figure 1

The Time-Line Graph



In seconds stage, we apply ADF, KPSS and Phillps-Perron unit root tests to these series to detect the presence of cointegration relationship between exchange rate and stock prices. The results are shown in Table 3.

Table 3

The Results of Unit Root Tests for I(0) and I(1)

	ADF-Dickey Fuller	***Philips-Perron***	***KPSS***
I(0)			
lbist	-2.147437	-2.126455	0.202751***
dollarsa	-1.706085	-0.420654	0.337742***
eurosa	-0.950594	-0.959521	1.433374***
I(1)			
Δlbist	-10.41243***	-10.39730***	0.045924
Δdollarsa	-8.488923***	-8.195854***	0.061976
Δeurosa	-9.428702***	-9.194538***	0.044632

*Note: *, ** and *** represent %1, %5 and %10 significance level.*

As demonstrated in Table 3, all series are seen to be stationary at I(1) level. As long as series have long memory properties, traditional unit root tests lead to the biased results in favor of the presence of unit root. Therefore, fractional unit root tests are applied to series. Presence of fractional stationarity in all series is tested with quasi parametric GPH method. The results are as shown Table 4. In Table 4, λ values and d values regarding λ can be found.

Table 4

GPH Fractional Unit Root Test

Critical Values	**λ**	**Asymptotic Standard Deviation**	**Dollarsa**	
			D	$H_0: t_d = 0$ $H_1: t_d < 0$
2.306	0.40	0.3787	1.06054***	2.8001
2.228	0.45	0.3021	0.861618***	2.8523
2.160	0.50	0.2214	0.751405***	3.3938
2.120	0.55	0.159	0.665292***	4.1843
2.080	0.60	0.09287	0.790384***	5.4324

Critical Values	λ	Asymptotic Standard Deviation	Eurosa D	$H_0: t_d = 0$ $H_1: t_d < 0$
2.306	0.40	0.168	0.820317***	4.8838
2.228	0.45	0.1566	0.872364***	5.5702
2.160	0.50	0.1116	0.868169***	7.7768
2.120	0.55	0.08349	0.858435***	10.2819
2.080	0.60	0.06157	0.831854***	13.5110
Critical Values	**λ**	**Asymptotic Standard Deviation**	**Lbist D**	$H_0: t_d = 0$ $H_1: t_d < 0$
2.306	0.40	0.2491	1.03126***	4.1407
2.228	0.45	0.1861	1.02181***	5.4911
2.160	0.50	0.133	.980012***	7.3661
2.120	0.55	0.1016	1.07413***	10.5711
2.080	0.60	0.07862	1.07413***	13.7083

*Note: it shows t table values for %5 critical value. *, ** and *** represent %1, %5 and %10 significance level.*

As seen in Table 4, null hypothesis claiming that d values concerning dollarsa, eurosa and lbist variables are equal to zero, is rejected at %5 significance level. So, dollarsa, eurosa and lbist variables are understood to have long memory and not being covariance stationary. Besides, dollarsa and eurosa don't turn back to mean in contrast to lbist. These results are similiar to ADF, Phillips Perron and KPSS tests.

Equation (7) is estimated to test cointegration relationship between stock prices and dollar, it is tested whether the residuals from this equation are stationary with GPH test.

$$lbist = \beta_0 + \beta_1 dollarsa + e_t \tag{7}$$

$$lbist = 8.950197 + 1.001478\, dollarsa + e_t$$

(0.0000) (0.0000)

Secondly, equation (8) is estimated to test cointegration relationship between stock prices and eurosa, and then it is tested whether the residuals from this equation are stationary with GPH test.

$$lbist = \beta_0 + \beta_1 eurosa + e_t \tag{8}$$

$$lbist = 8.232649 + 1.135323\, eurosa + e_t$$

(0.0000) (0.0000)

Cointegration relationship between stock prices and both exchange rates (dollar and euro) is investigated with GPH cointegration test. Fractional cointegration shows the long-run relationship among economic variables. The results concerning GPH cointegration test are indicated in Table 5. It is inferred from Table 5 that there is cointegration relationship between stock prices and both exchange rates.

Table 5

GPH Fractional Cointegration Test

Critical Values	λ	Asympt. Standard Deviation	Dollar-Residuals		Asympt. Standard Deviation	Euro-Residuals	
			d	H_0: t_d=0 H_0: t_d<0		D	H_0: t_d=0 H_0: t_d<0
-2.79	0.40	0.236	0.889558	3.7688	0.2495	.519733	2.0833
-2.86	0.45	0.3089	1.20428	3.8985	0.3743	1.11998	2.9924
-2.87	0.50	0.2182	1.11282	5.1002	0.2687	1.14784	4.2726
-2.86	0.55	0.1648	1.14973	6.9749	0.2038	.966588	4.7421
-2.83	0.60	0.1478	1.21937	8.2524	0.158	.99132	6.2725

Note: Critical values for %5 significance level are taken from Sephton (2002).

After finding out long-run relationship between stock prices and exchange rates, the direction of so-called relationship is examined via Granger Causality. The results is showed in Table 6.

Table 6

The Results of Granger Causality

Null Hypothesis	Chi-square	Decision
lbist is not Granger causality of dollarsa	3.627173	Not rejection
dollarsa is not Granger causality of lbist	4.480363*	Rejection
lbist is not Granger causality of eurosa	1.272599	Not rejection
eurosa is not Granger causality of lbist	3.172032*	Rejection

*Note: *, ** and *** represent %1, %5 and %10 significance level.*

As seen in Table 6, dollarsa and eurosa is Granger Casuality of lbist. In other words, direction of so-called relationship is from exchange rates to stock market prices. This situation represents that classical approach is valid in Turkish financial market.

5. Conclusions

The results of the analysis indicates that there is a cointegration relationship between stock prices and exchange rates. In respect of the nature of relationship, a positive relationship between exchanges rate and stock prices is detected. The direction of the relationship supports the classical approach and therefore it can be gathered that the causality of the relationship is from exchange rates to stock prices. Therefore using these results as baseline for Turkish market, it can be argued that the classical approach is valid in case of Turkish financial market. These results are aligned with the studies made by Sevüktekin and Nargeleçekenler (2007), Kıran (2009), Altıntaş and Tombak (2011) in the literature. It is hoped that these results will aid the policy makers to design their decision making processes concerning the relationship between the financial markets and exchange rates.

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