

Interest Rates and Exchange Rate Relationship in BRIC-T Countries

BRIC-T Ülkelerinde Faiz Oranı ve Döviz Kuru İlişkisi

Selim KAYHAN¹, Tayfur BAYAT², Ahmet UĞUR³

ABSTRACT

This study examines the dynamic relationships between the real exchange rate and the real interest rate in the BRIC-T (Brazil, Russia, India, China and Turkey) countries by employing monthly data from the beginning of flexible exchange rate regime to July 2011. For this aim, non-linear causality test and frequency domain causality test approaches are used. According to frequency domain causality test results, interest rate affects exchange rate in only China and this effect exist only in the long run. On the other hand, exchange rate shocks induce changes in interest rate in the shorter period.

Keywords: Interest rate, real exchange rate, BRIC-T, Frequency domain, nonlinear causality.

ÖZET

Bu çalışmada BRIC-T (Brezilya, Rusya, Hindistan, Çin ve Türkiye) ülkelerinde Mart 1993-Temmuz 2011 döneminde reel döviz kuru ile reel faiz arasındaki dinamik ilişkiyi incelemektedir. Bu amaçla doğrusal olmayan nedensellik testi ile frekans dağılım nedensellik testi uygulanmıştır. frekans dağılım nedensellik testi sonuçlarına göre sadece Çin ekonomisinde faiz oranları döviz kurunu uzun dönemde etkilemektedir. diğer bir ifadeyle kısa dönemde döviz kurundaki şoklar faiz oranındaki değişiklikleri azaltmaktadır.

Anahtar Kelimeler: Reel faiz oranları, reel döviz kuru, BRIC-T, frekans dağılım, doğrusal olmayan nedensellik.

1. INTRODUCTION

The BRIC is a grouping acronym that refers to the countries of Brazil, Russia, India and China, which are deemed to be at a similar stage of economic development. According to the report of Goldman and Sachs (2009), it is expected that the BRIC countries will be as big as the G7 by 2032. Not only the population and land area features of the BRIC countries, but also the speed of the growth rate and increasing proportion in the international trade have made them significant actors in the global economy.

Turkey has some common aspects with the BRIC countries. The Turkish economy, along with the Chinese economy, has been experienced fast and stable growth period during the last decade. Besides the growth performance, Turkey, Brazil and India seem to have similar processes of economic development and integration to the world economy. Once they are widely co-integrated to the global system and they are members of the international organizations such as IMF, IBRD and GATT. However, these countries had applied state protectionism until 1990s. In this context, we might employ BRIC-T acronym to include Turkey in BRIC countries.

By the 1980s, BRIC-T countries integrated into the global economy through liberalization of financial markets and participation to international trade. de Paula (2007) states that, during the transition period to liberal economy, they put into effect the institutional changes and market friendly policies such as privatization, trade liberalization, stimulus to more flexible exchange rates, foreign direct investment, social security reforms and price stabilization.

Shifting from state protected economic structure to market oriented economy and implementation of more flexible exchange rate regime have caused volatilities in exchange rates which lead to question of which factors drive exchange rates as well as its volatility. Determining the factors behind the real exchange rate movements deepens our insights for better understanding the dynamics of exchange rates. Thereby, it provides information for policy makers in designing monetary policies. The real return of a portfolio which holds a large quantity of foreign currency is determined by the exchange rate of that currency. A possible reduction in exchange rate would affect the rate of return of the investment. So, by determining the extent to which they are exposed to the exchange rate risk, traders also benefit from

¹ Assist. Prof., Bozok University, Faculty of Business and Administration, Department of Economics, selim.kayhan@bozok.edu.tr

² Assist. Prof., İnönü University, Faculty of Business and Administration, Department of Economics, tayfur.bayat@inonu.edu.tr

³ Assist. Prof., İnönü University, Faculty of Business and Administration, Department of Economics, ahmet.ugur@inonu.edu.tr

such information in international trade. Besides, financial market actors and speculators could be able to identify portfolio diversification options in foreign exchange markets.

The potential reasons for fluctuations in exchange rates have been highly debated theoretically and empirically in the literature. Dornbusch (1980), Sargent and Wallace (1981) and Branson (1981) present alternative models explaining movements in the nominal exchange rate. In the latter studies, some other factors which lead to exchange rate fluctuations have been examined empirically. Feldstein (1989), Pindyck and Rotemberg (1990), Bergstrand (1991), Clarida and Gali (1994), Glick et al. (1995), Faruqee (1995), Mark and Choi (1997) and Chinn (1999) imply some of these factors as follow; budget deficits, resource endowments, changes in terms of trade and labor productivity differentials.

There has been a special interest in theoretical as well as empirical relationship between the exchange rate and interest rate, as a result of the fact that the exchange rate and interest rate play an important role in determining the developments in the nominal and real side of the economy. Also, the determination of the relationship plays crucial role in application of monetary policies.

There is a debate on the role of interest rate on equilibrium of exchange rate. In the empirical study of Frenkel (1979), he argues that interest rate differentials among countries determine exchange rates. Results of Sargent and Wallace (1981) and Cumby and Obstfeld (1982) support the existence of causality between these variables. In other studies, Feldstein (1986) and Hakkio (1986) attributes a role to interest rate differential in determination of exchange rate parity. In contrary to findings of authors mentioned above, Hooper and Morton (1980), Woo (1985), Campbell and Clarida (1987), Meese and Rogoff (1988) and Edison and Pauls (1991) do not imply any relationship between exchange rate and neither interest rates nor interest rate differentials.

Theoretically, the relationship between the exchange rates and the interest rates can be examined in two conditions and in two periods. The first condition is the fixed exchange rate and the other is the floating exchange rate. As stated in the Mundell-Fleming model (Mundell, 1962; Fleming, 1962), in the case of fixed exchange rate regime, the central bank sells (and buys) foreign exchange in order to maintain the nominal exchange rate fixed. As a result, country's international reserves decrease or increa-

se, this leads to a decrease (increase) in the money supply. Serrano and Summa (2011) state that the increase (decrease) in money supply decreases (increases) the domestic interest. In the Mundell-Fleming model with floating exchange rates, it is assumed that the exchange rate appreciates when the domestic interest rate is above the international level and vice versa. An increase in interest rate is necessary to stabilize the exchange rate depreciation and to curb the inflationary pressure. However, it is unlikely to accept the changes in interest rate policy to be purely exogenous to stabilize the exchange rates because the monetary authorities in many countries resort to high interest rate policy when the currency is under pressure and low interest rate policy when the currency is in normal levels. In other words, decline in the value of the exchange rate may themselves prompt monetary authorities to raise domestic interest rates (Serrano and Summa, 2011).

Theoretical relationship between exchange rate and the interest rate would also be examined in the short and long-run. The exchange rate and the interest rate are typically considered to be negatively related in the short-run when product prices are sticky and positively related in the long-run when they are not. An increase in a country's interest rate relative to the other countries will induce financial capital flows to this country, which creates pressure for that country's currency to appreciate. Since this effect occurs in the short-run, there is a negative relationship in the short-run. However, in the long-run there is a positive relationship, which can be explained by the intuition that the home-country interest rate increasing relative to the foreign countries frequently reflects an increase in the conditions for higher inflation in the home country (Hacker et al., 2010).

The integration of BRIC-T to global economy provides researchers to examine the nature of causal linkages between interest rate and exchange rate in depth. This study therefore examines the dynamic relationship between real exchange rate and real interest rate in the BRIC-T countries by employing monthly data from the beginning of flexible exchange rate regime in each country to July 2011.

The causal relationship between variables is identified by the multiple testing approaches which allow to test the existence of nonlinear causality between variables and to investigate the relationship in different time frequencies. As indicated in the second section, the literature presents inconclusive results about the causation linkage between exchan-

ge rate and interest rate. In the light of theoretical explanations, the asymmetric behavior of economic variables in the short and long run is possible and the asymmetric behaviors of interest rate and exchange rate induce non-robust results. By employing non-linear causality and frequency domain causality analysis tests different from existing literature, we take asymmetric behaviors into account in the Turkish economy and analyze the causality in different time periods.

The rest of the paper is organized as follows. The next section is devoted to summarize the existing literature investigating the relationship between real exchange rate and interest rate. In the third section, econometric methodology and the data are described. In the fourth section, empirical results are presented. We summarize and conclude empirical findings in the last section.

2. LITERATURE REVIEW

In the aftermath of the Asian crises, the relationship between higher interest rates and the exchange rate has become the focus of a spirited policy debate (Lahiri and Vegh, 2001). A large number of studies investigate the causality between variables in order to test the effectiveness of monetary policy of the government to reduce volatility of exchange rate. The studies investigating the relationship between interest rate and exchange rate have conflicting results. Eichenbaum and Evans (1995) find evidence in favor of causation linkage for Japan, Germany, Italy, France and United Kingdom; in the same way, Furman and Stiglitz (1998) find evidence in favor of causation linkage for 9 East Asian countries. On the other hand, Kaminsky and Schumulker (1998) for Indonesia, Korea, Malaysia, Philippines, Thailand and China, Goldfajn and Baig (1998) for Asian countries and Kraay (1998) for 54 industrial and middle income developing countries find results contrary to Furman and Stiglitz (1998) and Eichenbaum and Evans (1995).

The studies of Goldfajn and Gupta (1999) for 80 countries, Park et al. (1999) for Korea, Basurto and Ghosh (2000) for Indonesia, Korea and Thailand, Dekle et al (2002) for Korea, Malaysia and Thailand, Gould and Kamin (2001) for Korea, Indonesia and Thailand with Malaysia, Philippines, Mexico, Chortareas and Driver (2001) for 18 OECD countries, Reinhart and Reinhart (2001) for both G3 countries and developing countries and Pattanoik and Mitra (2001) for India find results supporting the existence of relationship between interest rate and exchange rate. However, Calvo and Reinhart (2002) find results

contrary to Reianhart and Reinhardt (2001) for developing economies.

Likewise, recent studies have conflicting results although newly developed empirical techniques are utilized. Chow and Kim (2004) for Indonesia, Korea, Philippines and Thailand, Coporale et. al (2005) for Thailand, Korea, Indonesia and Philippines, Bautista (2006) for six East Asian countries, Belke et. al (2004) for Mercosur countries, Hratkowska et. al (2008) for Brazil, Korea, Mexico, Thailand, Peru and Philippines and four developed countries, Canada, Germany, Italy and U.S.A find similar results indicating the relationship between interest rate and exchange rate. Contrary to findings of studies listed above, Choi and Park (2008) for Indonesia, Korea, Malaysia and Thailand, Goderis and Ioannidou (2008) for 22 countries and Hamrita and Trifi (2011) for U.S. economy find no relationship between these variables.

As can be seen above, the results for both developing and developed countries are inconclusive. The reason might be stem from non-linear causation linkage between variables. Another deficiency in the literature is the absence of distinction between short and long term. So, the causation linkage between variables may change over time. Using the non-linear causality and frequency domain causality analysis methods provide us with fresh and more robust information about the relationship between interest rate and exchange rate.

3. METHODOLOGY AND DATA

3.1. Nonlinear Granger Causality Test

In order to test for nonlinear Granger causality, various non-parametric methods are developed. In an early study, Baek and Brock (1992) propose a nonparametric statistical method for detecting nonlinear Granger causality by using correlation integral between time series. In the Baek and Brock's test, the time series are assumed to be mutually and individually independent and identically distributed. By relaxing this strict assumption, Hiemstra and Jones (1994) develop a modified test statistic for the non-linear causality which allows each series to display short-term temporal dependence. However, Diks and Panchenko (2005) show that the test advocated by Hiemstra and Jones (1994) may over reject the null hypothesis of non-causality in the case of increasing sample size since it ignores the possible variations in conditional distributions. In a recent study, Diks and Panchenko (2006)(hereafter DP) develop a new nonparametric test for Granger causality that overcomes the over-rejection problem in the Hiems-

tra and Jones’s test. In what follows, following Diks and Panchenko (2006) and Bekiros and Diks (2008) outline the details of the DP nonparametric causality test.

Testing granger causality from one time series (X) to another (Y) is based on the null hypothesis that X does not contain additional information about Y_{t+1} which is specified as:

$$H_0: Y_{t+1} | (X_t^{\ell_x}; Y_t^{\ell_y}) \sim Y_{t+1} | Y_t^{\ell_y} \quad (1)$$

Where ℓ_x and ℓ_y respectively denote the past observations (i.e., lag length) of X and of Y. By assuming $Z_t = Y_{t+1}$ and by dropping time index and lags in the equation (1), the conditional distribution of Z given $(X, Y) = (x, y)$ is the same as that of Z given $Y = y$ under the null hypothesis. Hence, the equation (1) can be restated in terms of joint distributions that the joint probability density function $f_{X,Y,Z}(x, y, z)$ and its marginals must satisfy the following condition which explicitly states that X and Z are independent conditionally on $Y = y$ for each fixed value of y.

$$\frac{f_{X,Y,Z}(x, y, z)}{f_Y(y)} = \frac{f_{X,Y}(x, y)}{f_Y(y)} \cdot \frac{f_{Y,Z}(y, z)}{f_Y(y)} \quad (2)$$

Diks and Panchenko (2006) then re-specify the null hypothesis of no nonlinear Granger causality as follows:

$$q \equiv E[f_{X,Y,Z}(X, Y, Z)f_Y(Y) - f_{X,Y}(X, Y)f_{Y,Z}(Y, Z)] = 0 \quad (3)$$

where $\hat{f}_W(W_i)$ is a local density estimator of a d_w - variate random vector W at W_i defined by $\hat{f}_W(W_i) = (2\varepsilon_n)^{-d_w} (n-1)^{-1} \sum_{j \neq i} \mathbb{I}_{ij}^w$ that $\mathbb{I}_{ij}^w = \mathbb{I}(\|W_i - W_j\| < \varepsilon_n)$ with the indicator function and the bandwidth ε_n , depending on the sample size n. Given this estimator, the test statistic which is a scaled sample version of q in the equation (3) is developed as:

$$T_n(\varepsilon_n) = \frac{n-1}{n(n-2)} \sum_i (\hat{f}_{X,Y,Z}(X_i, Z_i, Y_i) \hat{f}_Y(Y_i) - \hat{f}_{X,Y}(X_i, Y_i) \hat{f}_{Y,Z}(Y_i, Z_i)) \quad (4)$$

$$\text{If } \varepsilon_n = Cn^{-\beta} (C > 0, \frac{1}{4} < \beta < \frac{1}{3}) \text{ for one lag}$$

($\ell_X = \ell_Y = 1$), the test statistic in equation (4) satisfies:

$$\frac{\sqrt{n}(T_n(\varepsilon_n) - q)}{S_n} \xrightarrow{D} N(0,1)$$

Where \xrightarrow{D} denotes convergence in distribution and S_n is an estimator of the asymptotic variance of $T_n(\cdot)$. Accordingly, the DP test statistic in the equation (4) for nonlinear causality is asymptotically distributed as standard normal and diverges to positive infinity under the alternative hypothesis. Thereby, the statistic greater than 1.28 rejects the null hypothesis at 10 percent level of significance and supports evidence in favor of a nonlinear Granger causality.

3.2. Frequency Domain Causality Test

Frequency domain causality were developed by Granger (1969), Geweke (1982), Hosoya (1991), Breitung and Candelon (2006). In his work, Geweke (1982) defined two-dimensional vector of time series $z_t = [x_t, y_t]'$ and z_t has a finite-order VAR;

$$\Theta(L)z_t = \varepsilon_t \quad (5)$$

where $\Theta(L) = I - \Theta_1 L - \dots - \Theta_p L^p$ and lag polynomial with $L^k z_t = z_{t-k}$. Breitung and Candelon (2006) assume that ε_t is white noise with $E(\varepsilon_t) = 0$, $E(\varepsilon_t, \varepsilon_t') = \Sigma$ where Σ is positive definite. Let G be the lower triangular matrix of the Cholesky decomposition $G'G = \Sigma^{-1}$ such that $E(\eta_t \eta_t') = I$ and $\eta_t = G\varepsilon_t$. If the system is stationary, let $\phi(L) = \Theta(L)^{-1}$ and $\psi(L) = \phi(L)G^{-1}$ the MA representation;

$$z_t = \phi(L)\varepsilon_t = \begin{pmatrix} \phi_{11}(L) & \phi_{12}(L) \\ \phi_{21}(L) & \phi_{22}(L) \end{pmatrix} \begin{pmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \end{pmatrix} = \begin{pmatrix} \psi_{11}(L) & \psi_{12}(L) \\ \psi_{21}(L) & \psi_{22}(L) \end{pmatrix} \begin{pmatrix} \eta_{1t} \\ \eta_{2t} \end{pmatrix} \quad (6)$$

Let we can use this representation for the spectral density of x_t ;

$$f_x(\omega) = \frac{1}{2\pi} \{ |\psi_{11}(e^{-i\omega})|^2 + |\psi_{12}(e^{-i\omega})|^2 \} \quad (7)$$

Geweke (1982) and Hosoya (1991) are defined causality;

$$M_{y \rightarrow x}(\omega) = \log \left[\frac{2\pi f_x(\omega)}{|\psi_{11}(e^{-i\omega})|^2} \right] = \log \left[1 + \frac{|\psi_{12}(e^{-i\omega})|^2}{|\psi_{11}(e^{-i\omega})|^2} \right] \quad (8)$$

if $|\psi_{12}(e^{-i\omega})|^2 = 0$ that y does not cause x at frequency ω . If components of z_t are $I(1)$ and cointegrated, $\Theta(L)$ has a unit root. Breitung and Candelon (2006) investigate the causal effect of $M_{y \rightarrow x}(\omega) = 0$ if $|\psi_{12}(e^{-i\omega})|^2 = 0$. The null hypothesis is equivalent to a linear restriction on the VAR coefficients. $\psi(L) = \Theta(L)^{-1}G^{-1}$ and $\psi_{12}(L) = -\frac{g^{22}\Theta_{12}(L)}{|\Theta(L)|}$, with g^{22} as the lower diagonal element of G^{-1} and $|\Theta(L)|$ as the determinant of $\Theta(L)$, it follows y does not cause at frequency ω if

$$|\Theta_{12}(e^{-i\omega})| = \left| \sum_{k=1}^p \theta_{12,k} \cos(k\omega) - \sum_{k=1}^p \theta_{12,k} \sin(k\omega) \right| = 0 \quad (9)$$

with $\theta_{12,k}$ denoting the (1,2)-element of Θ_k . Thus for $|\Theta_{12}(e^{-i\omega})| = 0$,

$$\sum_{k=1}^p \theta_{12,k} \cos(k\omega) = 0 \quad (10)$$

$$\sum_{k=1}^p \theta_{12,k} \sin(k\omega) = 0 \quad (11)$$

Breitung and Candelon’s (2006) applied to linear

restrictions (10) and (11) for $\alpha_j = \theta_{1,j}$ and $\beta_j = \theta_{2,j}$. Then the VAR equation for can be implied as

$$x_t = \alpha_1 x_{t-1} + \dots + \alpha_p x_{t-p} + \beta_1 y_{t-1} + \dots + \beta_p y_{t-p} + \varepsilon_{1t} \quad (12)$$

and the null hypothesis $M_{y \rightarrow x}(\omega) = 0$ is equivalent to the linear restriction with $\beta = [\beta_1, \dots, \beta_p]'$

$$H_0: R(\omega)\beta = 0 \quad (13)$$

and

$$R(\omega) = \begin{bmatrix} \cos(\omega) & \cos(2\omega) & \dots & \cos(p\omega) \\ \sin(\omega) & \sin(2\omega) & \dots & \sin(p\omega) \end{bmatrix} \quad (14)$$

The causality measure for $\omega \in (0, \pi)$ can be tested a Standard F-test for the linear restrictions imposed by Eq.(10) and Eq. (11). The test procedure follows an F- distribution with (2, T-2p) degrees of freedom.

3.3. Data

The data set contains the real interest rate (RINT) and real exchange rate (RER) series for the BRIC-T countries. They are obtained from International Financial Statistics database. We employ monthly data from the beginning of the flexible exchange rate regime in each country to July 2011 and the series are transformed into logarithmic form. India, Brazil and Turkey have shifted from fixed to floating exchange rate regime in March 1993, January 1999 and 2001 February, respectively. On the other hand, the People's Bank of China (PBC, hereafter) shifted from fixed exchange regime to managed floating regime in July 2005. From this date, the exchange rate of the RMB against the U.S. dollar has been moving both upward and downward with greater flexibility (PBC, 2005). So, for China, we include the data from the beginning of managed floating exchange rate regime. Although the Russian crisis induced dramatic

depreciation of the national currency (Ruble), Russian Ruble appreciated almost on 80 % along with the increasing oil prices (Suseeva, 2010). The depreciation and appreciation of the Ruble allows investigating the effects of interest rate on the exchange rate. In this regard, we use the data from the beginning of flexible exchange rate regime in Russia as indicated by Araki (2001). The data for Russia covers December 1998-July 2011 period.

4. EMPIRICAL FINDINGS

Prior to the identification of possible causality between the real exchange rates and the real interest rate, it is necessary to determine the integration degree of series. In this respect, the unit root tests developed by Dickey and Fuller (1979 and 1981) (henceforth ADF), Phillips and Perron (1988) (henceforth PP) and Elliot et al. (1996) (henceforth DF-GLS) are employed. According to the results shown in Table 1, for the levels, both in having an intercept and having an intercept and trend, the interest rate series for Brazil rejects the null hypothesis of a unit root at the 1% significance level in ADF test. However, it couldn't reject the null of a unit root in DF-GLS test. Moreover, the interest rate series for Turkey rejects the the null hypothesis of a unit root at the 1% significance level in PP test for the intercept and a trend. In the levels, the other series couldn't reject the unit root null hypothesis in all the countries. When the ADF, PP and DF-GLS tests are applied to the first differences of the series for each country, the results indicate that all series are stationary. Thus, the unit root analysis implies that the variables, except for INT for Brazil, are integrated of order one. Accordingly, the series in the first difference will be used in the DP test.

Table 1: Unit Root Test Results

	Country	Variable	ADF	DF-GLS	PP
Levels					
Intercept	Brazil	RINT	-4.152(2)***	-0.500(2)	-2.779(6)*
		RER	-0.632(0)	-0.707(0)	-0.748(2)
	Russia	RINT	-2.723(0)*	1.694(0)	-2.474(7)
		RER	-1.476(2)	1.661(2)	-1.746(3)
	India	RINT	-1.367(3)	0.916(3)	-1.307(30)
		RER	-0.031(3)	0.893(3)	0.279(5)
	China	RINT	-1.631(0)	-1.618(0)	-1.832(2)
		RER	-1.021(0)	-0.223(1)	-1.073(1)
	Turkey	RINT	-0.051(2)	1.847(2)	-2.216(4)
		RER	-2.174(4)	-0.674(4)	-1.202(1)

Intercept and Trend	Brazil	RINT	-4.843(1) ^{***}	-2.322(2)	-3.137(6)	
		RER	-2.587(0)	-1.465(0)	-2.729(3)	
	Russia	RINT	-1.842(0)	-0.704(0)	-1.984(7)	
		RER	-2.467(2)	-1.556(2)	-2.622(1)	
	India	RINT	-0.628(3)	-0.902(3)	-1.031(24)	
		RER	-1.008(3)	-1.398(3)	-0.694(5)	
	China	RINT	-1.719(0)	-1.74(0)	-1.96(2)	
		RER	-1897(1)	-1.955(1)	-1.416(0)	
	Turkey	RINT	-1.72(2)	-1.566(2)	-4.318(6) ^{***}	
		RER	-2.072(4)	-2.496(4)	-2.261(3)	
First-differences						
Intercept	Brazil	RINT	-6.482(1) ^{***}	-3.715(1) ^{***}	-7.379(2) ^{***}	
		RER	-11.635(0) ^{***}	-1.087(2)	-11.635(0) ^{***}	
	Russia	RINT	-7.077(1) ^{***}	-6.648(1) ^{***}	-12.571(7) ^{***}	
		RER	-8.680(1) ^{***}	-5.876(0) ^{***}	-7.623(8) ^{***}	
	India	RINT	-11.602(2) ^{***}	-11.37(2) ^{***}	-13.733(33) ^{***}	
		RER	-6.871(2) ^{***}	-6.8(2) ^{***}	-11.53(3) ^{***}	
	China	RINT	-6.991(0) ^{***}	-7.042(0) ^{***}	-6.993(1) ^{***}	
		RER	-6.55(0) ^{***}	-6.596(0) ^{***}	-6.545(6) ^{***}	
	Turkey	RINT	-5.992(1) ^{***}	-0.105(2)	15.766(2) ^{***}	
		RER	-6.013(3) ^{***}	-1.06(2)	-8.457(5) ^{***}	
	Intercept and Trend	Brazil	RINT	-6.702(1) ^{***}	-4.906(1) ^{***}	-7.62(3) ^{***}
			RER	-11.602(0) ^{***}	-2.577(2)	-11.602(0) ^{***}
Russia		RINT	-12.595(0) ^{***}	-6.915(1) ^{***}	12.765(7) ^{***}	
		RER	-8.710(1) ^{***}	-7.434(1) ^{***}	-7.59(9) ^{***}	
India		RINT	-11.679(2) ^{***}	11.5(2) ^{***}	-13.975(36) ^{***}	
		RER	-6.983(2) ^{***}	-6.856(2) ^{***}	-11.575(2) ^{***}	
China		RINT	-6.942(0) ^{***}	-7.043(0) ^{***}	-6.945(1) ^{***}	
		RER	-6.511(0) ^{***}	-6.578(0) ^{***}	-6.503(6) ^{***}	
Turkey		RINT	-6.024(1) ^{***}	-1.35(2)	-16.191(1) ^{***}	
		RER	-6.185(3) ^{***}	-2.134(2)	-8.598(7) ^{***}	

(Notes: The figures in parenthesis denote the lag length selected by the Schwarz criterion.***, **, and * denote statistical significance at the 1%, 5% and 10% level of significance, respectively.)

Following Bekiros and Diks (2008), the nonlinear Granger causality analysis is carried out in two steps. The DP test is first applied to the stationary series to detect nonlinear interrelationships. In the second step, the DP test is reapplied to the filtered VAR residuals to see whether there is a strict nonlinear causality in nature. After removing linear causality with a VAR model, any causal linkage from one residual series of the VAR model to another can be considered as nonlinear predictive power (Hiemstra and Jones, 1994). In the DP test, the value of the bandwidth plays an important role in making a decision about existence of nonlinear causality. Since the bandwidth value smaller (larger) than one generally results in larger (smaller) p-value (Bekiros and Diks, 2008), the bandwidth value is set to one and the results are discussed for one lag ($lx=ly=1$).

According to Table 2, there is bi-directional causality between variables in Turkey. On the other hand, there is only unidirectional causality in India running from real interest rate to real exchange rate. The di-

rection of causality is from real exchange rate to real interest rate in China. Nonlinear causality analysis does not find any relationship between variables in Brazil and Russia.

Breitung and Candelon's (2006) analysis which permits to decompose the causality test statistic into different frequencies is performed in the end. In order to examine the short-term, medium-term and long-term causality the test statistics are calculated at a high frequency of $\omega_i=2.5$ and $\omega_i=2.0$, $\omega_i=1.00$ and $\omega_i=1.50$, $\omega_i=.1$ and $\omega_i=.5$, respectively. The frequency domain causality test results show that in Turkey and Russia there is no causality in any period and in both direction. The results for Russia are consistent with nonlinear causality analysis results. Unfortunately, the frequency domain causality results for Turkey is conflicting with the previous analysis. In China, causal relationship appears in the medium and long-run in both directions. In addition, causal relationship is valid only in the short-run and from real exchange rate to real interest rate in Brazil and India.

Table 2: Non-linear Granger Causality Test Results

	Real Interest Rate to Real Exchange Rate				Real Exchange Rate to Real Interest Rate			
	R. data ^a	p-value	Residuals ^b	p-value	R. data ^a	p-value	Residuals ^b	p-value
Brazil	0.487	0.313	0.173	0.431	-0.328	0.628	0.276	0.390
Russia	-1.421	0.922	-0.226	0.589	0.137	0.445	0.368	0.356
India	0.972	0.165	1.283*	0.099*	0.724	0.234	0.440	0.329
China	0.755	0.224	0.298	0.382	1.398*	0.081*	0.972	0.165
Turkey	0.100	0.157	1.868**	0.03**	1.67**	0.047**	3.318***	0.000***

(Notes: ^a: the series are in first differences ^b: the residuals of the VAR (p+d) models. ***, **, and * denote statistical significance at the 1%, 5%, and 10% level of significance, respectively.)

Table 3: Frequency Domain Causality Results

ω_i	Real Exchange Rates to Real Interest Rates						Real Interest Rates to Real Exchange Rates					
	Long Term		Medium Term		Short Term		Long Term		Medium Term		Short Term	
	0.01	0.05	1.00	1.50	2.0	2.50	0.01	0.05	1.00	1.50	2.00	2.50
Brazil	1.745	4.473	0.486	1.333	7.858*	5.494	0.465	1.909	3.075	2.971	1.841	0.238
Russia	5.872	3.498	0.454	1.347	0.617	0.005	4.463	0.005	1.5	0.219	2.194	3.587
India	0.681	0.344	0.175	0.072	6.424*	0.343	2.712	3.337	1.531	0.16	0.389	2.596
China	5.529	5.878	7.156*	4.157	1.512	1.474	7.388*	7.217*	1.086	2.788	0.145	0.481
Turkey	0.652	0.425	0.812	0.345	2.355	0.412	0.273	2.071	6.7	0.819	0.233	1.774

(Notes: The lag lengths for the VAR models are determined by SIC. The critical value of Chi-square distribution with (2, T-2p) is approximately 5.99.)

5. CONCLUSION

In this study, the causal relationship between the interest rate and the real exchange rate is analyzed in the context of BRIC-T countries. For this purpose; the non-linear causality analysis is issued to determine the asymmetric causal relationship. We also employ frequency domain causality approach to distinguish short and long-run impact of interest rate and real exchange rate on each other to get more appropriate results.

The non-linear Granger causality test results show that there is bi-directional causality between the real exchange rate and real interest rate in Turkey. However, this result conflicts with the result of frequency domain causality test results which imply that in Turkey there is no causality in any period and in both direction. Moreover, according to the non-linear Granger causality test results there is only unidirectional causality between the variables in China and India. But, for India, the Granger causality test results conflict with the frequency domain causality test results that denote a causal relationship from real exchange rate to real interest rate. However, for China, the frequency test results show bi-directional causality.

Lastly, although the Granger causality test results imply no causality relationship for Brazil and Russia, the frequency domain test results show causation linkage from real exchange rate to real interest rate for Brazil. As Suseeva (2010) states, since Russia is an

oil exporting country, the exchange rate of Russia is driven by the oil prices rather than interest rates. The empirical analysis thereby indicates that the findings from the frequency domain analysis slightly different than the non-linear causality method. The frequency domain analysis finds causality in different time frequencies and gives chance to distinguish short and long run impacts of variables on each other. According to frequency domain approach, it is clear that real interest rate shocks affect real exchange rate in the case of China and it exists in the long run. On the other hand, a change in exchange rate affects interest rate movements in Brazil, India and China. The effect of exchange rate is faster than interest rate and appears in the short run.

Causality running from interest rate to exchange rate in China makes interest rate fluctuations important for the financial market actors, speculators and traders in international market. They should take into account interest rate changes in order to avoid probable losses causing from exchange rate shocks. The existence of causality from real exchange rate to real interest rate in the short run could give some hints explaining the changes in the interest rate.

REFERENCES

- Baek, E. ve Brock, W. (1992) "General Test for Nonlinear Granger Causality: Bivariate Model" Iowa State University and University of Wisconsin-Madison Working Paper.
- Basurto, G. ve Ghosh, A. (2000) "The Interest Rate-Exchange Rate Nexus in Currency Crises" *International Monetary Fund Staff Papers*, 47:99-120.
- Bautista, C. (2006) "The Exchange Rate-Interest Differential Relationship in Six East Asian Countries" *Economics Letters*, 92:137-142.
- Bekiros, S.D. ve Diks, C.G.H. (2008) "The Relationship Between Crude Oil Spot and Futures Prices: Cointegration, Linear and Nonlinear Causality" *Energy Economics*, 30: 2673-2685.
- Belke, A., Geisslreither, K. ve Gros, D. (2004) "On The Relationship Between Exchange Rates and Interest Rates: Evidence from The Southern Cone" *Cuadernos De Economia*, 41:35-64.
- Bergstrand, J.H. (1991) "Structural Determinants of Real Exchange Rates and National Price Levels: Some Empirical Evidence" *American Economic Review*, 81(1):325-334.
- Branson, W.H. (1981) "Macroeconomic Determinants of Real Exchange Rates" *National Bureau of Economic Research Working Paper Series*, No:801.
- Breitung, J. ve Candelon, B. (2006) "Testing for Short and Long-run Causality: A Frequency Domain Approach" *Journal of Econometrics*, 132:363-378.
- Campbell, J. ve Clarida, R.H. (1987) "The Dollar and Real Interest Rates: An Empirical Investigation" *Carnegie-Rochester Conference Series on Public Policy*, 27:103-140.
- Caporale, G.M., Cipollini, A. ve Demetriades, P.O. (2005) "Monetary Policy and The Exchange Rate During The Asian Crisis: Identification Through Heteroscedasticity" *Journal of International Money and Finance*, 24:39-53.
- Cheung, Y.W. ve Ng, L.K. (1996) "A Causality in Variance Test and Its Application to Financial Market Prices" *Journal of Econometrics*, 72:33-48.
- Chinn, M. (1999) "Productivity, Government Spending and The Real Exchange Rate: Evidence for OECD Countries" Macdonald et al.(eds.) *Equilibrium Exchange Rates*, Kluwer Academic Publishers.
- Choi, I. ve Park, D. (2008) "Causal Relation Between Interest and Exchange Rates in The Asian Currency Crisis" *Japan and the World Economy*, 20:435-452.
- Chortareas, G.E. ve Driver, R.L. (2001) "PPP and The Real Exchange Rate-real Interest Rate Differential Puzzle Revisited: Evidence from Non-stationary Panel Data" *Bank of England Working Paper Series*, No:138.
- Chow, H.K. ve Kim, Y. (2004) "The Empirical Relationship Between Exchange Rates and Interest Rates in Post-crisis Asia" *Singapore Management University School of Economics Working Paper Series*, No:11-2004.
- Clarida, R.H. ve Gali, J. (1994) "Sources of Real Exchange Rate Fluctuations: How Important are Nominal Shocks?" NBER Working Paper Series, No:4658.
- Cumby, R.E. ve Obstfeld, M. (1982) "International Interest-rate and Price-level Linkages Under Flexible Exchange Rates: A Review of Recent Evidence" Bilson et al.(eds.) *Exchange Rates: Theory and Practice*, Chicago, University of Chicago Press.
- De Almeida, P.R. (2009) "The Brics' Role in The Global Economy Cebri-Icône-British Embassy in Brasilia" *Trade and International Negotiations for Journalist Rio de Janeiro*, 146-154.
- De Paula, L.F. (2007) "Financial Liberalization, Exchange Rate Regime and Economic Performance in BRICs Countries" *Anais do XXXV Encontro Nacional de Economia Brazilian Association of Graduate Programs in Economics*, No:16.
- Dekle, R., Hsiao, C. ve Wang, S. (2002) "High Interest Rates and Exchange Rate Stabilization in Korea, Malaysia, and Thailand: An Empirical Investigation of The Traditional and Revisionist Views" *Review of International Economic*, 10:64-78.
- Dickey, D.A. ve Fuller, W.A. (1979) "Distribution of The Estimators for Autoregressive Time Series with a Unit Root" *Journal of the American Statistical Society*, 75:427-431.
- Dickey, D.A. ve Fuller, W.A. (1981) "Distribution of The Estimators for Autoregressive Time Series with a Unit Root" *Econometrica*, 49:1057-1072.
- Diks, C.G.H. ve Panchenko, V. (2005) "A Note on The Hiemstra-Jones Test for Granger Non-causality" *Studies in Nonlinear Dynamics and Econometrics*, 9(2):1-7.
- Diks, C.G.H. ve Panchenko, V. (2006) "A New Statistic and Practical Guidelines for Nonparametric Granger Causality Testing" *Journal of Economic Dynamics and Control*, 30:1647-1669.

- Dornbusch, R. (1980) "Exchange Rate Economics: Where Do We Stand?" *Brookings Papers on Economic Activity*, 1: 143-185.
- Edison, H.J. ve Pauls, B.D. (1991) "Re-assessment of The Relationship Between Real Exchange Rates and Interest Rates: 1974-1990" International Finance Discussion Papers No:408.
- Eichenbaum, M. ve Evans, C.L. (1995) "Some Empirical Evidence on The Effects of Shocks to Monetary Policy on Exchange Rates" *Quarterly Journal of Economics*, 110(4):975-986.
- Elliot, G., Rothenberg, T.J. ve Stock, J.H. (1996) "Efficient Tests for an Autoregressive Unit Root" *Econometrica*, 64(4):813-836.
- Faruqee, H. (1995) "Long-run Determinants of The Real Exchange Rate: A Stock-flow Perspective" *International Money Fund Staff Papers*, 42(1):80-107.
- Feldstein, M. (1986) "The Budget Deficit and the Dollar" *NBER Macroeconomics Annual*, 1:355-409.
- Feldstein, M. (1989) "The Case Against Trying to Stabilize The Dollar" *American Economic Review Papers and Proceedings* 79:36-40.
- Fleming, J.M. (1962) "Domestic Financial Policies Under Fixed and Floating Exchange Rates" IMF Staff Papers, 9(3):369-377.
- Frenkel, J. (1979) "On The Mark: A Theory of Floating Exchange Rates Based on Real Interest Differentials" *American Economic Review*, 69:610-622.
- Furman, J. ve Stiglitz, J.E. (1998) "Economic Crises: Evidence and Insights from East Asia" *Brookings Papers on Economic Activity*, 2:1-13.
- Geweke, J. (1982) "Measurement of Linear Dependence and Feedback Between Multiple Time Series" *Journal of the American Statistical Association*, 77:304-313.
- Glick, R., Hutchison, M. ve Moreno, R. (1995) "Is Pegging The Exchange Rate a Cure for Inflation? East Asian Experiences" Pacific Basin Working Paper Series, No:PB95-08.
- Goderis, B. ve Ioannidou, V. P. (2008) "Do High Interest Rates Defend Currencies During Speculative Attacks? New Evidence" *Journal of International Economics*, 74: 158-169.
- Goldman Sachs (2009) "Global Economics" *Goldman Sachs Global Economics*, Commodities and Strategy Research, 192:1-28
- Goldfajn, I. ve Baig, T. (1998) "Monetary Policy in The Aftermath of Currency Crises: The Case of Asia" International Monetary Fund Working Paper Series No:WP/98/170.
- Goldfajn, I. ve Gupta, P. (1999) "Does Monetary Policy Stabilize The Exchange Rate Following a Currency Crisis?" IMF Working Paper Series, No:WP/99/42.
- Gould, D.M. ve Kamin, S.B. (2001) "The Impact of Monetary Policy on Exchange Rates During Financial Crises" Glick et al. (eds.) *Financial Crises in Emerging Markets*, Cambridge, Cambridge University Press.
- Granger, C.W.J. (1969) "Investigating Causal Relation by Econometric and Cross-Sectional Method" *Econometrica*, 37:424-438.
- Hacker, R. S., Huynjoo, K. ve Mansson, K. (2010) "An Investigation of The Causal Relations Between Exchange Rates Interest Rate Differentials Using Wavelets" *CESIS Electronic Working Paper Series*, No:215.
- Hafner, C.M. ve Herwartz, H. (2006) A Lagrange Multiplier Test for Causality in Variance" *Economics Letters*, 93:137-141.
- Hakkio, C.S. (1986) "Does The Exchange Rate Follow a Random Walk? A Monte Carlo Study of Four Tests for a Random Walk" *Journal of International Money and Finance*, 5:221-229.
- Hamrita, M.E. ve Trifi, A. (2011) "The Relationship Between Interest Rate Exchange Rate and Stock Price:A Wavelet Analysis" *International Journal of Economics and Financial Issues*, 1(4):220-228.
- Hiemstra, C. ve Jones, J. (1994) "Testing for Linear and Nonlinear Granger Causality in The Stock Price-volume Relation" *The Journal of Finance*, 49(5): 1639-1664.
- Hnatkovska, V., Lahiri, A. ve Vegh, C.A. (2008) "Interest Rate and The Exchange Rate: A Non-monotonic Tale" NBER Working Paper Series, No:13925.
- Hong, Y. (2001) "A Test for Volatility Spillover with Application to Exchange Rates" *Journal of Econometrics*, 103:183-224.
- Hooper, P. ve Morton, J. (1980) "Fluctuations in The Dollar: A Model of Nominal and Real Exchange Rate Determination" Federal Reserve Board International Finance Discussion Paper, No:168.
- Hosoya, Y. (1991) "The Decomposition and Measurement of The Interdependence Between Second-order Stationary Process" *Probability Theory and Related Fields*, 88: 429-444.
- Kaminsky, G. ve Schumukler, S. (1998) "The Relationship Between Interest Rates and Exchange Rates in Six Asian Countries" World Bank Unpublished Working Paper.

Kraay, A. (1998) "Do High Interest Rates Defend Currencies Against Speculative Attacks?" Policy Research Working Paper Series, No:2267.

Lahiri, A. ve Vegh, C.A. (2001) "On The Non-monotonic Relation Between Interest Rates and The Exchange Rate" *Macroeconomics Workshop*, UCLA.

Mark, N. C. ve Choi, D. Y. (1997) "Real Exchange Rate Prediction Over Long Horizons" *Journal of International Economics*, 43: 29-60.

Meese, R.A. ve Rogoff, K. (1988) "Was It Real? The Exchange Rate-interest Differential Relation Over The Modern Floating Period" *Journal of Finance* 43(4):923-948.

Mundell, R.A. (1962) "The Appropriate Use of Monetary and Fiscal Policy Under Fixed Exchange Rates" IMF Staff Papers, 9(1):70-77.

Pattanoik, S. ve Mitra, A. K. (2001) "Interest Rate Defence of Exchange Rate: Tale of The Indian Rupee" *Economic and Political Weekly November*, 24:4418-4427.

Park, Y.C., Wang, Y. ve Chung, C.S. (1999) "Exchange Rate Policies in Korea: Has Exchange Rate Volatility Increased After The Crisis?" EABER Working Paper Series, No:367.

Phillips, P.C.B. ve Perron, P. (1988) "Testing for a Unit Root in Time Series Regressions" *Biometrika*, 75:335-346.

Pindyck, R.S. ve Rotemberg, J. (1990) "The Excess Co-movement of Commodity Prices" *The Economic Journal*, 100:1173-1189.

Reinhart, C.M. ve Reinhart, V.R. (2001) "What Hurts Most? G-3 Exchange Rate or Interest Rate Volatility" NBER Working Paper Series, No:8535.

Sargent, T.J. ve Wallace, N. (1981) "Some Unpleasant Monetarist Arithmetic" *Federal Reserve Bank of Minneapolis Quarterly Review*, 5:1-18.

Serrano, F. ve Summa, R. (2011) "Mundell-Fleming without The LM Curve: The Exogenous Interest Rate in an Open Economy" *Conferencia Internacional Del Aniversario De La Revista*, September 8, Mexico.

Woo, W.T. (1985) "The Monetary Approach to Exchange Rate Determination Under Rational Expectations" *Journal of International Economics*, 18:1-16.