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Testing Threshold Cointegration and Threshold Granger Causality between Stock Price and Exchange Rate in Turkey

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Abstract

This paper investigates the relationship between stock prices and exchange rates in the Turkish economy during the period from 1990:01 to 2011:04 by using the threshold error correction model and the threshold granger causality test. According to empirical evidence which was obtained from this paper, there is a bidirectional causality between stock prices and exchange rate of Turkey. This evidence implies that the crisis in the stock market can be partially prevented by controlling the exchange rate and authorities can focus on domestic economic policies to stabilize the stock markets.

Keywords: threshold error correction, threshold granger causality, exchange rate, stock price

1. Introduction

A linkage between stock price and exchange rates is popular among the economists, international investors and policy makers. Exchange rates and stock price play an important role on the country's economy. During the last three decades with the respect of globalization, capital flows can be utilized for growth but are coupled with instability. International capital flows are often thought to play a destabilizing role in developing economies, especially in the case of a financial crisis precipitated by sudden reversals of capital flows. (Neumann et al., 2009). During the crises period the currency and the stock market prices of countries can be affected. At this period, the causality relationship between exchange rates and stock prices has been growing attention. If stock prices and exchange rates are related and the causation runs from exchange rates to stock prices, then the crisis in the stock markets can be prevented by controlling the exchange rates. Similarly, if the causation runs from stock prices to exchange rates then authorities can focus on domestic economic policies to stabilize the stock markets (Muhammad & Rasheed, 2002).

There are two theories about the relationship between exchange rates and stock prices (You & Nieh, 2006). First theory is traditional approach. This approach claims that a depreciation of domestic currency makes local firms more competitive, leading to an increase in their export, and consequently higher stock prices. Second theory is portfolio approach. According to this theory, an increase in stock prices induces investors to demand more domestic assets and thereby causes an appreciation in the domestic currency, implying that stock prices lead exchange rates and they are negatively related.

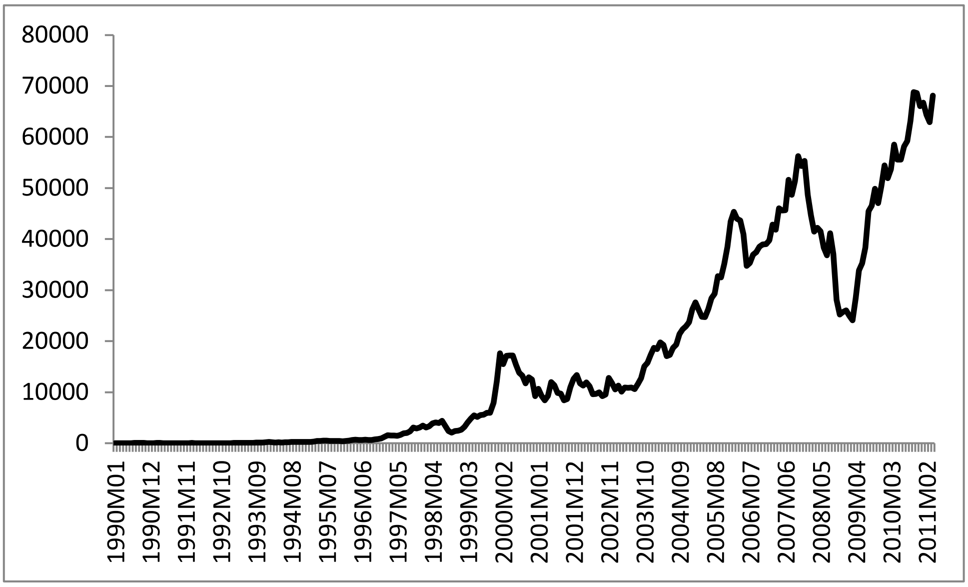

Figure 1. Istanbul stock exchange

When looking at the Turkish economy, with the Turkish Lira (TL) becoming convertible, the Turkish economy became entirely liberalized in 1989. As seen in Figure 1, Istanbul Stock Exchange (ISE) showed an upward trend after the financial liberalization. After the financial sector became liberalized, the Turkish economy was able to provide enough foreign capital inflow, except during the Gulf crisis in 1991 and the Russian crisis in 1998. The Turkish economy witnessed two financial crises in the near past. While the first crisis occurred in January 1994, the second occurred in February 2001. Both crises were followed by rapid reserve depletions, a sharp and unexpected devaluation and a switch to a new exchange rate regime (Kasman & Ayhan, 2008).

There is no general agreement among the economists about the relationship between exchange rates and stock prices. Alagidede et al. (2011) investigates the nature of the causal linkage between stock markets and foreign exchange markets in Australia, Canada, Japan, Switzerland, and UK from January 1992 to December 2005. No evidence of a long-run relationship between the variables is found. Rahman and Uddin (2008) investigated the interactions between stock prices and exchange rates in the Bangladesh economy. They show that there is no cointegrating relationship between stock prices and exchange rates and the Granger causality test shows that stock prices Granger cause exchange rates of US dollar and Japanese yen but there is no way causal relationship between stock prices and exchange rates of euro and pound. Granger et al. (2000) applied unit root and cointegration models to appropriate Granger relations between stock prices and exchange rates using Asian flu data. They found that data from South Korea are in agreement with the traditional approach. Data of the Philippines suggest the result expected under portfolio approach. Yau and Nieh (2006) investigated the relationship between stock price and exchange rates in for Taiwan and Japan economies. They found that the stock price of Taiwan and Japan impact each other for short term on the other hand they also found that with regard to relationship between stock prices and exchange rates, the portfolio approach is supported for the short term and the traditional approach is more plausible for the long-term in the Taiwanese market, whereas the portfolio approach is not suitable for the Japanese stock market. Zhao (2010) empirically analyzed the relationship between Renminbi exchange rate and stock prices. The results show that there in not a stable long-term equilibrium relationship between the exchange rate and stock price.

The aim of this paper is to investigate whether or not there exists a long term relationship between stock markets and exchange rates of Turkey. Unlike most of the existing literature, which uses linear technique, this paper attempts to use nonlinear technique.

The remainder of this paper is organized as follows. Section 2 briefly discuses methodology. Section 3 presents the data and the empirical evidences. Section 4 provides concluding remarks.

2. Methodology

To investigate the relationship between Exchange rate and stock price, the empirical studies have commonly used a linear model such as:

$$SP = \alpha + \beta\ ER + \varepsilon_t$$

where SP is the stock price and ER the exchange rate. Alternatively, this relationship might be written as a bivariate linear cointegrating VAR model with one lag such as:

$$\begin{pmatrix} \Delta SP \\ \Delta ER \end{pmatrix} = \mu + \alpha w_{t-1} + \Gamma \begin{pmatrix} \Delta SP_{t-1} \\ \Delta ER_{t-1} \end{pmatrix} + \varepsilon_t$$

where $w_{t-1} = SP_{t-1} - \beta ER_{t-1}$. This type of models assume linearity and symmetric adjustment which can be interpreted adjustment occur every time period.

Balke and Fomby (1997) point out the possibility that this movement towards the long run equilibrium might occur in every time period, due to the presence of some adjustment costs on the side of economic agents. Threshold cointegration characterizes discrete adjustment as follows: the cointegratting relationship does not hold inside a certain range, but holds if the system gets too far from equilibrium; cointegration would hold only if the system exceeds a certain threshold (Esteve, 2006).

Balke and Fomby (1997) combine nonlinearity and cointegration as the concept of threshold cointegration. This model allows for nonlinear adjustment to long run equilibrium. A threshold VECM can be written as:

$$\Delta x_t = \begin{cases} A_1' X_{t-1}(\beta) + u_t & if \quad w_{t-1}(\beta) \leq \gamma \\ A_2' X_{t-1}(\beta) + u_t & if \quad w_{t-1}(\beta) > \gamma \end{cases}$$

Where,

$$X_{t-1}(\beta) = \begin{pmatrix} 1 \\ w_{t-1}(\beta) \\ \Delta x_{t-1} \\ \Delta x_{t-2} \\ \vdots \\ \vdots \\ \Delta x_{t-l} \end{pmatrix}$$

γ is a threshold parameter, x_t is a p-dimensional I(1) time series which is cointegrated with one $p\ x\ 1$ cointegrating vector β, $w_t(\beta) = \beta' x_t$ is the I(0) error correction term A_1 and A_2 are coefficient matrices, u_t is an error term.

The threshold error correction model can alternatively be written as

$$\Delta x_t = A_1' X_{t-1}(\beta) d_{1t}(\beta,\gamma) + A_2' X_{t-1}(\beta) d_{2t}(\beta,\gamma) + u_t$$

Where,

$$d_{1t}(\beta,\gamma) = 1(w_{t-1}(\beta) \leq \gamma)$$
$$d_{2t}(\beta,\gamma) = 1(w_{t-1}(\beta) > \gamma)$$

$1(.)$ denotes the indicator function.

Hansen and Seo (2002) proposed a method to implement maximum likelihood estimation of the threshold model and they developed a test for the presence of a threshold effect under the null hypothesis, there is no threshold so the model reduces to a conventional linear VECM. This test statistic can be denoted as,

$$\sup LM = \sup_{\gamma L \leq \gamma \leq \gamma U} LM(\tilde{\beta}, \gamma)$$

Where $\tilde{\beta}$ is the estimate of β. $[\gamma_L, \gamma_U]$ is the serch region set so that γ_L is the π_0 percentile of $\tilde{w}_{t-1}$, and γ_U is the $(1-\pi_0)$ percentile. Andrews (1993) suggests setting π_0 between 0.05 and 0.15. To calculate the asymptotic critical values and p-values of the sup LM test, Hansen and Seo (2002) develop two bootstrap methods.

Threshold model and granger causality analysis have been combined by Li (2006). Two regime threshold autoregressive distributed lag TADL(p,q,τ,d) model can be shown

$$y_t = \sum_{m=1}^{2} \left(a_m + \sum_{i=1}^{p} b_{mi} y_{t-i} I_{mt} + \sum_{j=1}^{q} c_{mj}' x_{t-j} I_{mt} \right) + e_t$$

where $I_{1t} = I(y_{t-d} > \tau)$ and $I_{2t} = 1 - I_{1t}$, $x_t = (x_{1t}, \dots., x_{kt})'$ is a kx1 vector at time t. Li (2006) consider three null hypotheses given by

$$H_0^0 = c_{11} = c_{21} \dots . . = c_{1q} = c_{2q}$$
$$H_0^1 = c_{11} = \cdots = c_{1q}$$
$$H_0^2 = c_{21} \dots . . = c_{2q}$$

Where H_0^0 impies that none of the covariates has predictive content in the two regimes, H_0^i implies no predictive content in regime i, i=1,2.

According to Li (2006) all hypotheses are tested based on the Wald statistic, written as

$$W = (R\hat{\theta})' \left[R \left(\sum z_t z_t' \right)^{-1} \left(\sum \hat{e}_t^2 z_t z_t' \right) \left(\sum z_t z_t' \right)^{-1} R' \right]^{-1} (R\hat{\theta})$$

Where R is the selection matrix for the null hypotheses, θ are parameters estimates, $z_t = \partial f(\theta)/\partial\theta$, $f = E(y_t/\Omega_{t-1})$ and $\hat{e}_t$ is the OLS os NLS residuals. Li (2006) also showed that $W \sim \mathcal{X}^2(m)$, where m is the number of restrictions and standard asymptotic results are applicable.

3. Data and Empirical Evidence

The empirical analysis in this study is based on Istanbul Stock Exchange price and Exchange rates monthly data for Turkey over the period 1990:01 to 2011:04. All data have been collected from the Central Bank of the Republic of Turkey and were converted into natural logarithmic form before the empirical analysis.

As a first stage of empirical analysis, stationary properties of the series which are used in this paper are examined by using Augmented Dickey Fuller (ADF), Philips Perron (PP), Kwiatkowski-Phillips-Schmidt-Shin (KPSS) and Ng-Perron tests. Table 1 presents these test results.

Table 1. Unit root test results

	ADF	PP		KPSS
LNISE	-1.247724	-1.112936		0.443468
LNER	0.052484	0.130292		0.51527
ΔLNISE	-12.56[a]	-12.56[a]		0.06092[a]
ΔLNER	-10.13243[a]	-10.13198[a]		0.131988[c]
	Ng - Perron			
	MZa	MZt	MSB	MPT
LNISE	-3.86999	-1.25026	0.32307	21.7972
LNER	0.40033	0.28931	0.72268	115.665
ΔLNISE	-53.541[a]	-5.15919[a]	0.09636[a]	1.77491[a]
ΔLNER	-99.3768[a]	-7.03892[a]	0.07083[a]	0.95561[a]

a, b and c indicate a 1%, 5% and 10% level of significance, respectively.

According to unit root test results which are presented in table 1, Istanbul Stock Exchange(ISE) and Exchange rate(ER) series of Turkey are order one(I(1)). The next step of empirical analysis is to test the presence of a threshold effect. Selection of the lag lengths is an important stage of the TAR methodology. It can be estimated with the help of information criteria. The order of the lag selected by Akaike Information Criterion (AIC) is estimated 3. To test the presence of threshold effect, sup LM test proposed by Hansen and Seo (2002) is used. Table 2 shows this test results.

Table 2. Sup LM test result

		ISE - ER	
Test Statistic	31.74033	p value	0.0198
Critical Values	0.90%	27.69821	
	0.95%	29.66783	
	0.99%	33.507	

Bootstrap p-values calculated from 5,000 replications.

As can be shown in table 2, sup LM test result indicates the presence of threshold cointegration. In the light of this finding, the threshold error correction model can be conducted. The estimates of the threshold error correction model are given in table 3.

Table 3. Threshold error correction model result

Dependent Variables:	ΔLNISE		ΔLNER	
Variables	$w_{t-1} \leq \gamma$	$w_{t-1} > \gamma$	$w_{t-1} \leq \gamma$	$w_{t-1} > \gamma$
w_{t-1}	0.3950[b]	-0.0018	0.0228[a]	-0.0042[a]
Constant	0.1373[a]	0.0253	0.0855[a]	0.0490[a]
$\Delta LNISE_{t-1}$	0.1060	0.3526[a]	-0.0582	-0.0096
$\Delta LNISE_{t-2}$	-0.3124[b]	-0.1266	-0.1567[a]	0.0497
$\Delta LNISE_{t-3}$	-0.0046	0.0995	0.0958[b]	-0.0727[b]
$\Delta LNER_{t-1}$	-0.9939[a]	0.3780[c]	0.2727[a]	0.5461[a]
$\Delta LNER_{t-2}$	0.3627	0.1076	-0.1092	-0.2653[a]
$\Delta LNER_{t-3}$	-0.4747	-0.0200	-0.3645[a]	0.1023
γ	2.010741			
% of Observations	20.6	79.4		

[a], [b] and [c] indicate a 1%, 5% and 10% level of significance, respectively.

The estimated threshold is 2.010741. Based on this threshold parameter, the threshold error correction model is partitioned into the regimes. When the deviation from long run equilibrium is below threshold parameter, the first regime would occur. While, the first regime can be called typical regime because of it captures 20.6 of observations, the second regime can be called unusual regime. There is a statistically significant error correction term in the first regime of ISE equation. On the contrary, there is a statistically insignificant error correction term in the second regime. In exchange rate equation, there are statistically significant error correction terms in both regimes.

The next step of empirical analysis is to investigate causality relationship between ISE and Exchange Rate of Turkey. In order to achieve this, threshold granger causality test proposed by Li (2006) has been used. Table 4 indicates this test results.

Table 4. Granger causality test results

	H_0^0	H_0^1	H_0^2
LNISE - LNER	17.35429[a]	12.53123[a]	4.823066
LNER - LNISE	29.82768[a]	22.76549[a]	7.062192[c]

[a], [b] and [c] indicate a 1%, 5% and 10% level of significance, respectively.

As can be shown in table 4, except in the second regime of ISE equation, there is a bidirectional causality between ISE and exchange rate series of Turkey. This findings interpreted that ISE and exchange rate are jointly determined and affected, except when the threshold parameter exceed 2.010741 in the ISE equation.

4. Conclusion

The aim of this paper was to investigate whether or not there exists a long term relationship between stock markets and exchange rates of Turkey. To achieve this, this paper applied the threshold vector error correction model proposed by Hansen and Seo (2002) and the threshold granger causality test proposed by Li (2006). To test the presence of a threshold effect, sup LM test has been used. According to this test result, there is a threshold cointegration relationship between stock prices and the exchange rate of Turkey. Using this finding, a threshold error correction model has been conducted. As a final step of this paper, the threshold granger causality test has been employed. According to empirical evidence which was obtained from this paper, there is a bidirectional causality between stock prices and exchange rate of Turkey except when the threshold parameter exceed 2.010741 in the ISE equation. This evidence implies that the crisis in the stock market can be partially prevented by controlling the exchange rate and authorities can focus on domestic economic policies to stabilize the stock markets.

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