Original Article

Informational dependency between spot and futures markets: Evidence from Turkish foreign exchange markets

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ABSTRACT The main aim of this article is to detect any informational dependency between spot and futures contracts in foreign exchange markets in Turkey. We employ the Granger causality test based on the threshold error-correction model in order to analyze the dynamics of the foreign exchange markets. The empirical results display the fact that there exists an asymmetric causal relationship between spot and futures contracts in the Turkish foreign exchange markets. The price transmissions are asymmetric in the futures and symmetric in the spot markets. The article makes a contribution to the finance literature in that it provides empirical evidence for newly emerging futures markets in Turkey and explains the relevance of the empirical findings to practitioners for trading in emerging markets.

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INTRODUCTION

Futures contracts are priced based on both expectations in the markets and the cost of carrying the position, that is, opportunity cost. Earlier research on the relationship between spot and futures contracts prices mainly relied on the cost of carry model (Wahab and Lashgari, 1993; Brenner and Kroner, 1995). The cost of carry model is based on the calculation of the opportunity cost that reflects the interest rate paid for holding the position. Early research papers formulate futures prices by using the cost of carry model without analyzing any informational dependency between spot and futures time series data (Gibson and Schwartz, 1990; Amin *et al.*, 1995; Clewlow and Strickland, 2000; Burger *et al.*, 2004).

Recent literature in finance has focused more closely on the expectations theory, and employs time-varying models. Routledge *et al.* (2000), for example, state that the correlation between spot and futures prices might vary over time. Najand (2002) uses linear and non-linear ARCH models to examine the time-varying effect of spot prices on futures contracts. They state that the EGARCH model, as a non-linear one, performs better than the other ARCH models. Tang and Shieh (2006) employ non-linear FIGARCH (1, d , 1) and HYGARCH (1, d , 1) models to model the futures contracts in different markets. The results of the recent research show that the non-linear models perform better than linear models to predict the prices of futures contracts.

In emerging markets, there might be asymmetric information in the marketplace because of the fact that the risk-return linearity of the investors might be defected. The main drivers for the asymmetric information can be barriers to market entrance, thin trading, regulatory changes, transaction costs and so on. In general,

empirical evidence argues that prices in the financial markets show an asymmetric adjustment process (Pippenger and Goering, 1993; Balke and Fomby, 1997). Enders and Granger (1998) and Enders and Siklos (2001) state that the classical or symmetric unit root and cointegration tests might give insufficient results, if an asymmetric adjustment process exists in the time series data.

Enders and Granger (1998) extended the Dickey-Fuller (1979) test to construct the unit root test under asymmetric adjustment, and Enders and Siklos (2001) developed the cointegration test, which is capable of capturing the asymmetric adjustment processes. Chang and Lee (2008) use the asymmetric adjustment process suggested by Enders and Siklos (2001) to examine the relationship between spot and futures prices of Taiwan stock markets with intra-day data.

In Turkey, the futures market (Izmir Futures Market) was opened in 2005. As it is a newly established market, academic research on the price patterns in the futures markets in Turkey is rare. Baklacı (2007) examines the volatility of futures prices of exchange rates on the spot prices and concludes that futures prices have structural change effects on the spot markets. Baklacı (2007) argues that as the information is reflected on the prices more rapidly, the futures markets have a leading role in price dynamics. Özün and Türk (2008) successfully use a stochastic process model set up by Borovkova and Geman (2006) to model the futures prices in Turkish equity and exchange rate markets.

In this research article, we employ the threshold error-correction model (TECM) proposed by Enders and Granger (1998) and the asymmetric cointegration test developed by Enders and Siklos (2001) to examine the price transmissions between spot and futures in Turkey

for the foreign exchange contracts (USD/Turkish Lira). The empirical results show that there is an asymmetric price transmission from futures markets to spot markets in Turkish foreign exchange markets. The findings have practical implications for foreign exchange trading in emerging markets. The article has a separate section that discusses the empirical results of the study on trading strategies. In the next section, we introduce data and basic descriptive statistics for the spot and futures time series data used in the empirical tests.

DESCRIPTIVE STATISTICS FOR THE TIME SERIES DATA

For the empirical analysis, we use daily data from 4 February 2005 to 28 March 2008. The sources of the data are presented in Table 1.

Table 1: Data sources

<i>Variable</i>	<i>Market</i>	<i>Frequency</i>	<i>Time</i>	<i>Source</i>
USD/TRY spot	Spot	Daily	Closing	Central Bank of Turkey
USD/TRY futures	Futures	Daily	Settlement	Izmir Futures Market

Figure 1: Up is the price of spot and down is the price of USD/TRY futures.

In addition to USD/Turkish Lira, we also analyze Istanbul Stock Exchange (ISE) 30 futures contracts, but as empirical tests show no cointegration we do not publish and discuss the results in the article. There are also contracts underlying interest rates, EUR/Turkish Lira and ISE100. However, as their trading volumes are low and thin trading exists, we are not able to examine the time series of those contracts. The graphical representation of the original time series and return series of the variables is shown in Figure 1 and Figure 2, respectively.

The descriptive statistics for the data are presented in Table 2. The volatility in futures contracts is higher than volatility in the spot market volatility. The distributions of the prices in both markets are positively skewed and have excess kurtosis relative to a normal distribution.

GRANGER CAUSALITY TEST BASED ON THE TECM

In this article, we employ the threshold cointegration test (the threshold autoregressive (TAR) model) proposed by Enders and Granger (1998) and a complementary methodology, namely, the TECM suggested by Enders and Siklos (2001).

Figure 2: Up liner is return of spot and down liner is return of USD/TRY futures.

Table 2: Summary statistics of returns (TRY/USD)

Items	Spot	Futures
Mean	-0.0144	-0.0136
Standard deviation	0.8717	0.9532
Skewness	0.8767	1.0389
Kurtosis	7.0455***	14.3065***
Jarque-Bera test	628.6051***	4272.997***

Notes: *** denote rejection of the hypothesis at the 1 per cent level.

The standard errors of the skewness and kurtosis are $(6/T)^{0.5}$ and $(24/T)^{0.5}$, respectively.

Jarque-Bera test denotes the Jarque-Bera normality test.

Enders and Granger (1998) follow two steps to describe the TAR model. Assuming variables x_{1t} and x_{2t} are $I(1)$ process, the first regression takes the form

$$x_{1t} = \alpha + \beta x_{2t} + \varepsilon_t, \quad (1)$$

where ε_t is the stochastic error. A regression with the form

$$\Delta \varepsilon_t = \rho_1 I_t \varepsilon_{t-1} + \rho_2 (1 - I_t) \varepsilon_{t-1} + \sum_{i=1}^l \gamma_i \Delta \varepsilon_{t-i} + \mu_t, \quad (2)$$

is used where $\{\varepsilon_t\}$ includes the residuals from Equation (1), μ_t is an i.i.d. disturbance with 0 mean and I_t is the Heaviside indicator described in Equation (3).

$$I_t = \begin{cases} 1 & \text{if } \varepsilon_{t-1} \geq 0 \\ 0 & \text{if } \varepsilon_{t-1} < 0 \end{cases}$$

or

$$I_t = \begin{cases} 1 & \text{if } \varepsilon_{t-1} \geq \tau \\ 0 & \text{if } \varepsilon_{t-1} < \tau \end{cases}, \quad (3)$$

In Equation (3), τ denotes the threshold value. When $\varepsilon_{t-1} \geq \tau$, Equation (3) takes the form of $\Delta \varepsilon_t = I_t \rho_1 \varepsilon_{t-1} + \sum_{i=1}^l \gamma_i \Delta \varepsilon_{t-i} + \mu_t$. For other cases, $\Delta \varepsilon_t = \rho_2 \varepsilon_{t-1} + \sum_{i=1}^l \gamma_i \Delta \varepsilon_{t-i} + \mu_t$ is suitable for the analysis. The importance of this representation lies in the fact that it shows the long-term relationship between x_{1t} and x_{2t} , in addition to capturing the asymmetric effect. For any value of τ , Petrucelli and Woolford (1984) show that the ε_t is stationary, if $\rho_1 < 0$, $\rho_2 < 0$ and $(1 - \rho_1)(1 - \rho_2) < 1$.

Enders and Granger (1998) and Caner and Hansen (1998) argue that it is also possible to allow the Heaviside indicator to depend on the change in ε_{t-1} (namely, $\Delta \varepsilon_{t-1}$) rather than on the level of ε_{t-1} , the Momentum Threshold Autoregressive (MTAR) model. The Heaviside indicator of Equation (3) then becomes

$$I_t = \begin{cases} 1 & \text{if } \Delta \varepsilon_{t-1} \geq 0 \\ 0 & \text{if } \Delta \varepsilon_{t-1} < 0 \end{cases}$$

or

$$I_t = \begin{cases} 1 & \text{if } \Delta \varepsilon_{t-1} \geq \tau \\ 0 & \text{if } \Delta \varepsilon_{t-1} < \tau \end{cases} \quad (4)$$

The MTAR model implies that the adjustment mechanism of ε_t is dynamic, since the momentum of the series is greater in one direction than in the other.

In this research, we employ the method of Chan (1993) to find a consistent estimate of the threshold used by Enders and Siklos (2001). The consistent threshold estimate can be made by ordering the $\{\varepsilon_t\}$ sequence in ascending order such that $\varepsilon_1 < \varepsilon_2 < \dots < \varepsilon_T$, where T is the number of usable observations. There is truncating the upper and lower 15 per cent, leaves 70 per cent. Substituting this 70 per cent into the model, the estimated threshold yielding the lowest residual sum squares is the consistent estimate of the

threshold. The same method can also be applied to the MTAR model.

The threshold cointegration results further suggest that the underlying adjustment dynamics of x_{1t} in response to the changes in x_{2t} can be captured by a TECM. The TECM can be expressed as follows (Enders and Granger, 1998; Enders and Siklos, 2001):

$$\Delta x_{it} = \alpha + \gamma_1 Z_{t-1}^+ + \gamma_2 Z_{t-1}^- + \sum_{i=1}^{k_1} \delta_i \Delta x_{1t-i} + \sum_{i=1}^{k_2} \theta_i \Delta x_{2t-i} + v_{it} \quad (5)$$

where $(x_1, x_2) = (\text{Spot Futures})$, $Z_{t-1}^+ = I_t \hat{u}_{t-1}$, $Z_{t-1}^- = (1 - I_t) \hat{u}_{t-1}$ such that $I_t = 1$ if $u_{t-1} \geq \tau$, $I_t = 0$ if $u_{t-1} \leq \tau$ and v_{it} is a white noise disturbance. The long-run adjustment of x_{it} is determined by the parameters γ_1 and γ_2 . The short-run adjustment of $x_{1t}(x_{2t})$, which is governed by the parameters θ_i and δ_i , may come either from its own history of lagged dynamics or from the lagged effects of $x_{2t}(x_{1t})$. *A priori*, we expect the coefficients of Z^+ and Z^- to be negative for the spot market and positive for the futures market. Because when the shocks are positive Z^+ then this means that the spot prices are overvalued, the investors will engage in reverse cash and carry arbitrage, and then the spot prices will reverse to their fundamental value and the futures prices rise. Thus, the Z^+ is negatively correlated with the spot prices, but positively correlated with the futures prices. The Granger causality tests are examined by testing whether all the coefficients of Δx_{1t-i} or Δx_{2t-i} are jointly statistically different from 0 based on an F -test, and/or whether the γ_j coefficients of the error-correction are also significant. Since the Granger causality tests are very sensitive to the selection of the lag length, we used the Akaike's information criterion (AIC) to determine the

appropriate lag lengths and found both lag lengths of $k_1 = k_2 = 2$.

COMPARISON OF SYMMETRIC AND THRESHOLD COINTEGRATION TESTS

Pippenger and Goering (1993), Balke and Fomby (1997), Enders and Granger (1998) and Enders and Siklos (2001) argue that classical cointegration tests are weak in detecting the presence of asymmetric adjustment in practice. Before testing the asymmetric cointegration, we present the symmetric or classical cointegration test in Table 3. We follow Enders and Siklos (2001) and employ two asymmetric models, namely, TAR and MTAR, in the analysis. Table 4 reports the results of the threshold cointegration test under the constraints of τ equals 0 and it is different than 0.

We use Chan's (1993) methodology to find the consistent estimates of the threshold. As displayed in Figures 3 and 4, they are -0.00957 and -0.00179 , respectively. Both the null of no cointegration ($\rho_1 = \rho_2 = 0$) and the symmetric adjustment ($\rho_1 = \rho_2$) are rejected for the TAR and MTAR models at 99 per cent significance, implying the strong existence of a threshold co-integration between the spot and the futures

Table 3: Classical cointegration test

Rank	Trace statistic	Max-Eigen statistic
$r = 0$	63.4647***	62.0607***
$r = 1$	1.4039	1.4039

Note: *** denote rejection of the hypothesis at the 1 per cent level.

The model is VAR(3) based on AIC and Schwarz's Bayesian Criterion (SBC).

Table 4: The threshold cointegration test

Items	TAR		MTAR	
Threshold value	0	−0.00957	0	−0.00179
<i>F</i>	128.7355***	106.8246***	107.0473***	109.7015***
<i>T</i>	−1.9173*	−3.0225***	−3.0803***	−3.7007***
AIC	−1952.4184	−1957.8540	−1958.2043	−1962.3650 ^a
SBC	−1938.4598	−1943.8954	−1944.2457	−1948.4064 ^a

^aindicates minimum value based on AIC or SBC.

Notes: * and *** denote rejection of the hypothesis at the 10 per cent and 1 per cent levels, respectively.

Critical values are from Enders and Siklos (2001).

F and *T* are the sample *F*-statistics, respectively, for the null hypothesis of $\rho_1 = \rho_2 = 0$, that is, there is no cointegration; and for the null hypothesis of $\rho_1 = \rho_2$, that is, the adjustment is symmetric.

Figure 3: Threshold estimation in TAR.

Figure 4: Threshold estimation in MTAR.

in Turkish foreign exchange rates markets. In addition, both the AIC and the Schwarz's bayesian criterion (SBC) suggest that the most preferable

model for our adjustment mechanism is the MTAR model with the threshold value of τ equals -0.00179 .

RESULTS OF THE GRANGER CAUSALITY TESTS BASED ON ECM AND TECM

In Table 5, we present the results of asymmetric and symmetric ECM by focusing on the error-correction term ($\gamma = 0$ or $\gamma_1 = \gamma_2 = 0$) in both models. The findings that there exists a significant long-run equilibrium relationship between the spot and futures markets for the symmetric error-correction model (ECM) and the TECM. The *F*-statistic shows that the null hypothesis of $\gamma_1 = \gamma_2$ (the coefficients of Z^+ and Z^- are equal) is rejected in the futures market, but accepted in the spot market. We also determine that asymmetric long-run equilibrium adjustment terms between the spot and futures markets show different price adjustment patterns.

In this research, by using empirical findings, we argue that the TECM for the

Table 5: Asymmetric and symmetric ECMs

Items	Symmetric ECMs				Asymmetric ECMs			
	Spot		Futures		Spot		Futures	
Variable	Coefficient	Standard error	Coefficient	Standard error	Coefficient	Standard error	Coefficient	Standard error
Panel A: Estimates of the ECMs								
α	−0.0057	0.0186	−0.0151	0.0343	−0.0105	0.0203	0.0240	0.0372
δ_1	−0.0481**	0.0214	−0.0043	0.0395	−22.3336***	3.2489	−1.6431	5.9737
δ_2	0.4754***	0.0327	−0.0222	0.0605	−24.5432***	3.6497	16.6110**	6.7107
θ_1	0.3764***	0.0308	0.0760	0.0568	−0.2989***	0.0324	−0.0729	0.0595
θ_2	−23.2261***	2.8636	5.7302	5.2877	−0.0487**	0.0214	0.0006	0.0394
γ	−0.2983***	0.0323	−0.0780	0.0597	—	—	—	—
$Z_{t-1}^+(\gamma_1)$	—	—	—	—	0.4713***	0.0335	0.0115	0.0616
$Z_{t-1}^-(\gamma_2)$	—	—	—	—	0.3760***	0.0308	0.0796*	0.0566
Panel B: Asymmetric test								
H_0 : $\gamma_1 = \gamma_2 = 0$	—		—		33.0333***		4.0162**	
H_0 : $\gamma_1 = \gamma_2$	—		—		0.3393		6.8491***	
Panel C: Granger causal relationship								
H_0 : $\theta_1 = \theta_2 = \theta_3 = 0$	125.04866***		—		120.35448***		—	
H_0 : $\delta_1 = \delta_2 = \delta_3 = 0$	—		0.85501		—		0.75622	
Panel D: Diagnostic								
Q(4)	1.5820		1.3100		1.4250		1.8570	
Q(8)	5.1460		4.8460		5.1000		4.1090	
Q(12)	7.3950		7.0140		7.2660		6.4870	
Log Likelihood	−582.8579		−1057.5422		−582.6868		−1054.1017	
AIC	4129.5156		5078.8841		4131.1733		5074.0031	
SBC	4157.4251		5106.7936		4163.7343		5106.5641	

Notes: *, ** and *** denote significance at the 1 per cent, 5 per cent and 10 per cent levels, respectively.

Asymmetric ECMs: $\Delta x_{it} = \alpha + \gamma_1 Z_{t-1}^+ + \gamma_2 Z_{t-1}^- + \sum_{i=1}^{k_1} \delta_i \Delta x_{1t-i} + \sum_{i=1}^{k_2} \theta_i \Delta x_{2t-i} + v_{it}$.

Symmetric ECMs: $\Delta x_{it} = \alpha + \gamma Z_{t-1} + \sum_{i=1}^{k_1} \delta_i \Delta x_{1t-i} + \sum_{i=1}^{k_2} \theta_i \Delta x_{2t-i} + v_{it}$.

futures contracts and the symmetric ECM for the spot prices are more powerful for prediction purposes by using AIC and SBC. The point estimates of the adjustment coefficients show that the speed of the long-run adjustment in the spot price is approximately 0.3760 for restoring to the equilibrium level when the error-correction is below 0. On the other hand, 0.4713 of the deviation can be restored to the equilibrium level in the spot prices when the error-correction is above 0.

The standard errors for Z_{t-1}^- and Z_{t-1}^+ show that the spot prices respond strongly to positive shocks. In other words, when the difference between spot price and futures price is higher than 0, the investors sell spot and buy the futures contract. In addition, the non-significant coefficient of Z_{t-1}^+ in the futures creates constraints on the short-selling. Therefore, arbitrage cannot engage in reverse cash-and-carry arbitrage, that is, sell the index futures contract and buy the spot index. The empirical results show that the price transmissions are asymmetric in the futures markets and symmetric in the spot markets.

The results of the Granger causality test summarized in Table 5 Panel C show that, for the symmetric model, futures prices have Granger causality on spot prices. Therefore, we conclude that the spot prices of USD/TRY exchange rates are cointegrated and affected by the futures contracts using asymmetric ECM. On the other hand, when we use the symmetric model, it is empirically proven that the spot prices have effects on futures prices. We state that using the asymmetric model in Turkish markets has more explanatory power as it is an emerging market containing asymmetric information flow.

CONCLUSION AND SUGGESTIONS FOR TRADING STRATEGIES IN EMERGING MARKETS

In this research article, we examine the informational dependency between spot and futures foreign exchange markets in Turkey. The empirical tests are based on TECM in order to detect any asymmetric causality between spot and futures prices.

The empirical tests for asymmetric cointegration between USD/TRY spot and futures contracts employ data based on daily closing prices from 4 February 2005 to 28 March 2008.

In Turkey, the futures markets were established in February 2005. Before February 2005, there were no futures markets either for foreign exchange or equity markets. The forward transactions are the basic instruments in managing the risk in exchange rates in the financial sector. However, as the forward transactions are based on over-the-counter pricing, the determination of the forward rates is mainly based on the cost of carry model.

The empirical findings in this research based on the threshold ECM point out a feedback causality relationship between the futures and spot markets in Turkish markets. The MTAR model has higher predictive power than the TAR model. Under the asymmetric model, the empirical results show that the futures markets have statistically significant effects on the spot prices. The spot prices of USD/TRY exchange rates are cointegrated with the futures prices in asymmetric ECM. Under the model predictions, we propose that the TECM is a more appropriate methodology for prediction of the futures prices, whereas the symmetric ECM is suitable for the spot prices.

The empirical findings described above have certain practical implications in trading strategies, and provide clues on the investors' behaviors under different circumstances. The main trading strategy in the market is based on any price differences in spot and futures markets. The test results show that the standard errors for Z_{t-1}^- and Z_{t-1}^+ point out that the spot prices respond strongly to positive shocks. From trading perspective, the results underline the fact that the investors sell USD in the spot markets and take long positions in the futures markets when the difference between spot price and futures price is higher than 0.

In addition, the tests result that a non-significant coefficient of Z_{t-1}^+ in the futures creates constraints on the short-selling provides another strategy in trading in the foreign exchange futures markets. This result mainly indicates that arbitrage cannot engage in reverse cash-and-carry arbitrage. In other words, it is not profitable to sell the index futures contracts and take the long position in the spot market. The main reason behind the suggestion of that strategy, that is, not selling the futures contracts to hold the long position, is that the price transmissions are asymmetric in the futures markets and symmetric in the spot markets.

It is not possible to make a generalization for trading strategies by solely examining the price behaviors in one individual market. However, we suggest that the pricing transmission between spot and futures markets should be empirically examined with appropriate econometrics models when developing trading strategies. Though the cost of carry model provides the financial cost or benefits in holding positions in the futures markets, the asymmetric price behaviors between the spot and futures markets might include clues to setting up trading strategies, especially in

emerging economies in which the asymmetric causality between the markets is more likely due to informational inefficiency in the markets.

Finally, we argue that when trading strategies in a market are based on certain empirical models, the appropriate model for that specific market should be constructed by examining the alternative methodologies. Especially in emerging economies, the test results are sensitive to the model employed. Therefore, the appropriate model should be detected among the alternatives for specific market conditions and time periods. In our case, the symmetric model would not provide appropriate empirical findings for the futures markets.

In our research, the threshold Vector Error Correction Model is used to allow for two regimes and one threshold. The main focus in this research article is to provide initial empirical results for new emerging Turkish futures foreign exchange markets. Future research can concentrate on a wide set of models for comparison. More general model specifications, for example the STAR (or STAR ECM) model that allows for two regimes with many transitional regimes, can be employed for more flexible analysis. In addition, as the daily data are used, we can also further consider the GARCH model, at least in the two-step manner. In future research, allowing for alternative models might lead to more precise parameter estimates and thus may affect the inference.

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