"The causal relationship between foreign currency futures and spot market: evidence from Turkey"

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Abstract

The purpose of this study is to investigate the interaction between spot Turkish Lira-US Dollar exchange rate and Turkish Lira-US Dollar futures contracts traded in Turkish Derivatives Exchanges. Cointegration test are used and an error correction model is developed in order to examine the causal relationship. The results indicated that there is a long run stable relationship between foreign currency spot and futures market. Moreover, there is a two-way causality between them both in the short run and the long run.

Keywords: causality, Turkish Derivatives Exchanges, price discovery.
JEL Classification: G12, G14, G15.

Introduction

One of the economic functions of futures contracts is price discovery and hedging. Price discovery refers to use of futures prices for pricing spot market transactions and its significance depends upon the above mentioned, close relationship between the prices of futures contracts and the underlying assets. The essence of the price discovery function of futures markets hinges on whether new information is reflected first in changes of futures prices or in changes of spot prices. In other words, price discovery means whether price changes in futures markets lead price changes in spot markets more often than the reverse. If that is the case, there exists a lead-lag relationship between the two markets. Therefore, the futures prices may serve as the market's expectation of a subsequent delivery period spot price. The share of price discovery originating in the futures markets has important implications for hedgers and arbitrageurs who use these markets (Kenourgios, 2004, p. 3).

In an emerging market such as Turkey, foreign exchange rate risk is very important, especially under the current free floating exchange regime. Exchange rate risk is a very important for investors who traded with foreign currency. Investors may use exchange rate futures contracts to hedge themselves exposed to exchange rate risk. Also, exchange rate futures contracts can be used for speculative purposes. However there must be a significant long run and short-run relationship between spot and futures exchange rates, in order that futures contracts can be used for hedging. The purpose of this study is to investigate long-run and short-run causal relationship between spot TRY-US Dollar exchange rate and TRY-US Dollar futures contracts traded in Turkish Derivatives Exchanges. The findings from this study will be useful to hedging decisions especially for exchange rate risk because this study determines that there is a long-run relationship between spot and futures TRY-US Dollar exchange rates and there is a long-run relationship, it is determined which market lead to other market.

The rest of the paper is organized as follows. Section 1 describes literature review. Section 2 shows data and methodology. Section 3 presents our empirical findings. The final section concludes.

1. Literature review

Under the assumption of efficient and frictionless capital market, the changes in a spot market and futures price of underlying asset should be perfectly contemporaneously correlated and not cross-autocorrelated (Tse, 1995, p. 553). Many studies have examined relationship between spot and futures markets (Stolland, and Whaley, 1990; Kawaller, Kochand Koch, 1987; Chan, 1992; Wahaband and Lashgari, 1993). A majority of related studies indicated that futures markets lead to spot markets, though some studies have suggested different evidence.

Kavussanos and Nomikos (2003) investigated the causal relationship between futures and spot prices in the freight futures market. They found that price discovery first takes position in the futures market and then it is transmitted to underlying cash market. Their findings indicate that futures prices tend to discover new information more rapidly than spot prices. They also reported that the information incorporated in futures prices, when formulated as a VECM, produces more accurate forecasts of spot prices than the VAR, ARIMA and random-walk models.

Kenourgios (2004) investigated relationship between price movements of FTSE/ASE three-month futures index and the underlying spot market in Athens Stock Exchange over the period of August 1999 until June 2002 by using daily data. This study's results show the presence of a bi-directional causality between stock index spot and futures markets, there is an informational linkage between two markets and the existence of such an informational linkage implies that investors using these markets can explore significant arbitrage profits and hedging opportunities.

Zhong, Darrat and Otero (2004) investigated the hypotheses that Mexican stock index futures market effectively serves the price discovery function, and that the introduction of futures trading has provoked volatility in the underlying spot market. They test both hypotheses simultaneously with daily data from Mexico in the context of a modified EGARCH model that also incorporates possible cointegration between the futures and spot markets. Their findings showed that Mexican stock index futures market plays a part of price discovery function of its spot market.

So and Tse (2004) investigated the price estimation power of futures transactions on spot prices, using the Hasbrouck and Gonzalo and Granger common-factor models and the multivariate generalized autoregressive conditional heteroskedasticity (M-GARCH) model. They found that index futures lead spot index in the price discovery process. Also the Tracker Fund does not contribute to the price discovery.

Rosenberg and Traub (2006) compared price discovery in the foreign exchange futures and spot markets. They developed a foreign exchange futures order flow measure that is a proxy for the order flow observed by Chicago Mercantile Exchange pit traders. They find that futures market has the major contribution to price discovery than the spot market.

Gupta and Belwinder (2006) examined the price discovery mechanism in the NSE spot and future market. The study used the daily closing values of index future Sand PCNX Nifty, from June 2002 to February 2005. By using the techniques like Johansen and VECM. It was found that there exists stronger casual relation from Nifty futures to Nifty index.

Frino et al. (2006) explored the source of price discovery in the Australian dollar currency market. The study is estimated time-varying relationship between changes in quotes posted by spot market dealers and changes in currency futures quotes. They showed that price discovery originates in the spot market in any trading period. It also found that local desks can provide significant price discovery in the Australian dollar currency market during Australian daytime.

Lien and Zhang (2008) summarized theoretical and empirical research on the roles and functions of emerging derivatives markets and the resulting implications on policy and regulations. They found that empirical results from a few emerging countries suggest a price discovery function of emerging futures markets. The findings on the price stabilization function of emerging derivatives markets are mixed. Their finding suggested that the constructive development of derivatives markets in emerging market economies is that it needs to be supported by sound macroeconomic fundamentals and updated financial policies and regulations.

Floros (2009) examined the price discovery between futures and spot markets in South Africa over the period from 2002 to 2006. FTSE/JSE Top 40 stock index futures and spot markets were cointegrated and he found that futures and spot play a strong price discovery role, that was, FTSE/JSE Top 40 futures prices led to spot prices and vice versa.

Pradhan and Bhat (2009) investigated the causal relationship between spot and futures prices in Nifty futures markets, using Vector Error Correction Model (VECM). Their study is compared the forecasting ability of futures prices on spot prices with three major forecasting techniques namely ARIMA, VAR and VECM model. The findings indicated the importance of taking into account the long-run relationship between the futures and the spot prices in forecasting future spot prices.

Ozen et al. (2009) examined that the short-term and long-term causality between futures market and spot market for the period from February 2005 to February 2009. They used the analysis, unit root test, co-integration test and causality analysis depending on Vector Error Correction Model (VECM). Their findings indicated that the series derived from the futures prices and cash market prices were as stationary, as each other and co-integrated. It was also found that futures market leads spot market in the long term on the other handspot market is the cause of futures market in the short term.

2. Data and methodology

This study examined relationship between spot TRY-US Dollar Exchange rate and TurkDEX-TRY US Dollar futures contract. The data cover the period from January 2007-December 2011. Daily closing values of spot TRY-US Dollar Exchange rate and TurkDEX-TRY US Dollar futures contract are used. TurkDEX-TRY US Dollar futures contract data are taken from the official web site of TurkDEXand spot TRY-US Dollar Exchange rate data are taken from The Central Bank of the Republic of Turkey Electronic Data Delivery System. For the futures prices series, the nearest futures contracts are used. The logarithms of the price series is used in the analysis.

In this study Engle-Granger (1987) methodology is used. Engle and Granger (1987) stated that two time series are nonstationary in levels but a linear combination of these series may be stationary. If a linear combination of these two series is stationary, these series are cointegrated, that is, there is a long-run stable relationship between them. In the Engle-Granger methodology, if two series is nonstationary in the levels, but their first differences and the deviations from long-run equilibrium relationship between two series are stationary, two series are co-integrated of order *CI* (1,1).

The steps of the Engle-Granger testing procedure can be expressed as fallows (Enders, 1995, pp. 373-377). In the Engle-Granger methodology, order of integration of the variables is determined in the first step. Augmented Dickey-Fuller (ADF) unit root test can be used to determine the order of integration of series. To test for the presence of unit root is used in the following ADF regression:

$$\Delta s_t = \mu + \delta s_{t-1} + \sum_{i=1}^{n} \delta_i \Delta s_{t-i} + e_t. \qquad (1)$$

The ADF test examine $H_0 : \delta = 0$, the null hypothesis of unit root process against $H_1 : \delta < 0$. The rejection of null hypothesis states that the series s_t are stationary.

If the results of first step indicate that variables are integrated of same order $I(1)$, long-run equilibrium relationship between variables is estimated by using OLS regression at the second step. Long-run equilibrium relationship can be shown as follows:

$$s_t = \beta_0 + \beta_1 f_t + e_t, \qquad (2)$$

where s and f_t are contemporaneous spot and futures prices at time t, β_0 and β_1 are parameters, e_t is the deviations from long-run equilibrium relationship.

In order to determine if the s_t and f_t are actually cointegrated, denote the residuals sequence from long-run equilibrium regression by e_t. Thus, e_t is the series of the estimated residuals of the long-run equilibrium relationship. If these deviations from long-run equilibrium relationship are found to be stationary, s_t and f_t sequences are cointegrated of order (1,1), denoted *CI*(1,1). Augmented Dickey-Fuller unit root test can be performed on the series of the estimated residuals to determine their order of integration. To test for the presence of unit root the following ADF regression is used:

$$\Delta \hat{e}_t = a_1 \hat{e}_{t-1} + \sum_{i=1}^{n} a_{i+1} \Delta \hat{e}_{t-1} + \in_t. \qquad (3)$$

If the rejection of the null hypothesis states that residual series contains a unit root, residual series are stationary; in other words deviations from long-run equilibrium are stationary and s_t and f_t series are cointegrated of order (1, 1).

If the variables are cointegrated, an error-correction model that contains the last period equilibrium error terms and lagged value of first differences of each variable is estimated in the third step. The error correction model is expressed by the following equations:

$$\Delta s_t = \alpha_0 + \sum_{i=1}^{n} \propto_{1i} \Delta s_{t-i} + \sum_{i=1}^{n} \propto_{2i} \Delta f_{t-i} + + \lambda \hat{e}_{1t-1} + u_{1t}, \qquad (4)$$

$$\Delta f_t = \beta_0 + \sum_{i=1}^{n} \beta_{1i} \Delta f_{t-i} + \sum_{i=1}^{n} \beta_{2i} \Delta s_{t-i} + \theta \hat{e}_{1t-1} + u_{1t}. \qquad (5)$$

Equations (4) and (5) describe the short-run as well as long-run dynamics of the equilibrium relationship between s_t and f_t (Tse, 1995, p. 555). The value of the residual $\hat{e}_{1t-1}$ estimates the deviation from long-run equilibrium in period t-1. The coefficients of equilibrium errors, λ and θ are speed of adjustment coefficient. If λ is zero, the change in s_t does not at all respond to the deviation from long-run equilibrium in t-1. If λ is zero and all $\propto_{2i}$ is zero, then it can be said that (Δf_t) does not Granger cause Δs_t. It is known that one or both of these coefficients should be significantly different from zero if the variables are cointegrated. After all, if both λ and θ are zero, there is no error correction (Enders, 1995, p. 377).

3. Empirical results

First, in this study spot and futures price series are tested for stationary using ADF unit root test. Akaike information criterion is used to determine the optimal lag length. The results of ADF unit root test are given in Table 1. For the variable's level value, the null hypothesis cannot be rejected because ADF test statistics value is greater than the critical values at the 1%, 5% and 10% levels. Therefore for the variable's first differenced value, the null hypothesis can be rejected, for the reason that ADF test statistics value is smaller than the critical values at the 1%, 5% and 10% levels. Thus, both series are integrated of the first order, that is, $I(1)$.

Table 1. The results of ADF unit root test

	Level		First-order differences	
Series	Intercept	Trend and intercept	Intercept	Trend and intercept
Spot	-0.794541	-2.457458	-8.289884*	-8.359253*
Futures	-0.977519	-2.657733	-7.285604*	-7.358678*

Notes: * Indicates rejection of null hypothesis of unit root at 1% level of significance. McKinnon critical values are -3,43, -2,86, -2,57 for the model with intercept and -3.96, -3.41, -3.13 for the model with both intercept and trend, at 1%, 5% and 10% levels of significance, respectively.

To determine whether there is a long-run stable relationship between foreign currency spot and futures markets, in other words, whether spot and futures markets move together in the long run, and cointegration test is performed. First, long-run equilibrium relationship between spot and futures market is estimated by using OLS regression. The lag length is chosen to whiten the error term and tests for autocorrelation Breusch-Godfrey serial correlation, Lagrange multiplier tests (LM) for the presence of autocorrelation up to the 12^{th} order are reported in Table 2. LM test results indicate that there is not significant serial correlation in the residuals. Later, the series of the estimated residuals of the long-run equilibrium relationship (the deviations from long-run equilibrium relationship) is tested for stationarity by performing ADF unit root test. The results of the cointegration test are shown in Table 2. Since the deviations from the long-run equilibrium relationship are found to be stationary, the null hypothesis of no cointegration is rejected at the 1% level of significance for both systems. Therefore, for TRY-US Dollar exchange rate foreign currency spot and futures market are cointegrated, denoted $CI(1,1)$.

Table 2. The results of cointegration

Dependent variable	Intercept	Trend and intercept	None	LM
Spot	-35.39285*	-35.47065*	-35.40701	1.162246 (0.3055)
Futures	-35.49168*	-35.48341*	-35.50587	1.450324 (0.1368)

Note: * Indicates rejection of null hypothesis at the 1% level of significance. Numbers in parenthesis denote prob. F-statistics.

If two variables are cointegrated, there is causality among these variables at least in one direction (Engle and Granger, 1987, p. 259). Since these variables are cointegrated, the error correction models are used to determine the direction of causality. The error correction models are estimated by using the one lagged value of the deviations of long-run equilibrium relationship and lagged value of the first differences of each variable. The optimal lag length is chosen by using Breusch-Godfrey serial correlation Lagrange multiplier tests (LM) for the presence of autocorrelation up to the 12^{th} order. Number of six and seven error correction models and Wald test are used to examine short run and long run causality.

$$\Delta s_t = \alpha_0 + \sum_{i=1}^{3} \propto_{1i} \Delta s_{t-i} + \sum_{i=1}^{3} \propto_{2i} \Delta F_{t-i} + + \lambda \hat{e}_{1t-1} + u_{1t}, \tag{6}$$

$$\Delta F_t = \beta_0 + \sum_{i=1}^{3} \beta_{1i} \Delta F_{t-i} + \sum_{i=1}^{4} \beta_{2i} \Delta s_{t-i} + \theta \hat{e}_{1t-1} + u_{1t}. \tag{7}$$

Table 3 shows the test results of the restrictions imposed on the speed of adjustment coefficients (λ and θ) and the lagged variables coefficients ($\propto_{2i}$ and β_{2i}) to equations (6) and (7), using the Wald test statistic, and Chi-square distributed. The speed of adjustment coefficient (λ and θ) in equations (6) and (7) are negative and statistically significant. Thereby λ and θ are nonzero. The significant and negative speed of adjustment coefficient means that the current period change in the spot price responds to the previous period's deviation from long run equilibrium. In other words, this indicates that the long-run disequilibrium is being corrected in each short period to obtain a stable long-run relationship. The value of the speed of adjustment coefficient (θ), in the equation 7, greater than -1, that is, instead of monotonically converging to the equilibrium path directly, the error correction process fluctuates around the long run value in a dampening manner and however, once this process is complete, convergence to the equilibrium path is rapids mentioned in Narayan and Smyth's (2006) study. The Wald test is used for testing the significance of the lagged variables coefficients ($\propto_{2i}$ and β_{2i}). The results of the Wald test on coefficients $\propto_{2i}$ and β_{2i} show that the null hypothesis that the coefficients are jointly equal to zero is rejected at the 1% level of significance. Hence, it is stated that in the short-run spot market does Granger cause to futures market and futures market does Ganger cause to spot market. Consequently, that the speed of adjustment coefficient both in equations (6) and (7) is negative and statistically significant means that there is a long-run bi-directional causality between spot and futures markets. Also, F-Wald statistics, statistically significant, indicates that there is a short-run bi-directional causality between spot and futures markets. In sum, the results show the presence of bi-directional causality between foreign currency spot and futures market.

Table 3. The results of Granger causality tests

Dependent variable	Error correction term	Long run causality	F-Wald statistics	Short run causality
Spot	-0,9916* (0,0000)	Spot → Futures	592.6442* (0.0000)	Spot → Futures
Futures	-1.015719* (0,0000)	Futures → Spot	444.6813* (0,0000)	Futures → Spot

Note: * Indicates rejection of null hypothesis at the 1% level of significance. The numbers in the parentheses are p-values. The results of LM test for dependent variable spot market: F-statistics = 1.445110 (0.1390) and for dependent variable futures market: F-statistics = 1.596269 (0.0865).

Conclusion

This paper investigates the causal relationship between foreign currency spot and futures market by using Engle and Granger (1987) methodology. The results of cointegration test provide evidence of significant long-run relationship between spot and futures market. Since two markets are cointegrated, Granger causality test based on error correction models is used to determine the direction of causality. The results of Granger causality test indicate that the futures market does not lead to spot market, andthere is two-way causality between foreign currency spot and futures market for TRY-US Dollar exchange rate both in the short run and the long-run. Therefore, there exists an informational linkage between spot and futures markets. Similarly, an informational linkage shows that spot and futures markets can be used for arbitrage profits and hedging.

References

1. Chan, K. (1992). "A further analysis of the lead-lag relationship between the cash market and stock index futures market", *The Review of Financial Studies*, Vol. 5, No. 1, pp. 123-152.
2. Enders, W. (1995). *Applied Econometric Time Series*, 1th edition, John Wiley&Sons Inc., Canada.
3. Engle, R.F. and Granger C.W.J. (1987). "Co-integration and error correction: representation, estimation and, testing, *Econometrica*, Vol. 55, No. 2, pp. 251-276.
4. Floros, C. (2009). "Price discovery in the South African stock index futures market", *International Research Journal of Finance and Economics*, Vol. 34, pp. 148-159.
5. Frino, A., E. Jarnecic, M. Stevenson and Tan, A. (2006). "Sources of price discovery in the Australian dollar currency market", *Review of Futures Markets*, 15.
6. Gupta, K. and Belwinder, S. (2006). "Price discovery and causality in spot and future markets in India", *The ICFAI Journal of Derivatives*, Vol. 3, No. 1, pp. 30-41.
7. Kawaller, I.G., Paul, D. and Koch, T.W. (1987). "The temporal price relationship between S&P 500 futures and S&P 500 index", *The Journal of Finance*, Vol. 42, No. 5, pp. 1309-1329.
8. Kavussanos, M.G. and Nomikos, N.K. (2003). "Price discovery, causality and forecasting in the freight futures market", *Review of Derivatives Research*, Vol. 6, pp. 203-230.
9. Kenourgios, D.F. (2004). "Price discovery in the Athens derivatives exchange: evidence for the ftse/ase-20 futures market", *Economic and Business Review*, Vol. 6, No. 3, pp. 229-243.
10. Lien, D., and Zhang, M. (2008). "A survey of emerging derivatives markets", *Emerging Markets Finance and Trade*, Vol. 44, No 2, pp. 39-69.
11. Narayan, P.K. and Russell, S. (2006). "What determines migration flows from low-income to high-income countries? An empirical investigation of Fiji-US migration: 1972-2001", *Contemporary Economic Policy*, Vol. 24, No. 2, pp. 332-342.
12. Ozen E., Bozdogan T. and Zugul M. (2009). "The relationship of causality between the price of futures transactions underlying stock exchange and price of cash market: the case of Turkey", *Middle Eastern Finance and Economics*, Vol. 4, pp. 28-37.
13. Pradhan, H.C. and Bhat, K.S. (2009). "An empirical analysis of price discovery, causality and forecasting in the nifty futures markets", *International Research Journal of Finance and Economics*, Vol. 26, pp. 83-92.
14. Rosenberg, J.V. and Traub, L.G. (2006). "Price discovery in the foreign currency futures and spot market", FRB of New York Staff Report No. 262.
15. So R.W. and Tse Y. (2004). "Price discovery in the Hang Seng Index Markets: index, futures and the tracker fund", *The Journal of Futures Markets*, Vol. 24, No. 9, pp. 887-907.
16. Stoll, H.R. and Whaley, R.E. (1990). "The dynamics of stock index and stock index futures returns", *Journal of Financial and Quantitative Analysis*, Vol. 25, No. 4, pp. 441-468.
17. Tse, Y.K. (1995). "Lead-lag relationship between spot index and futures prices of the Nikkei stock average", *Journal of Forecasting*, Vol. 14, pp. 553-563.
18. Wahab, M. and Lashgari, M. (1993). "Price dynamics and error correction in stock index and stock index futures markets: a cointegration approach", *Journal of Futures Markets*, Vol. 13, No. 7, pp. 711-742.
19. Zhong, M., Darrat, A.F., and Otero, R. (2004). Price discovery and volatility spillovers in index futures markets: Some evidence from Mexico, *Journal of Banking & Finance*, Vol. 28, No. 12, pp. 3037-3054.