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TESTING INTRADAY VOLATILITY SPILLOVERS IN TURKISH CAPITAL MARKETS: EVIDENCE FROM ISE

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ABSTRACT

The aim of this article is to examine the presence of volatility transmission between futures index and underlying stock index by using intraday data in Turkey. We first examined the sudden changes in the variance of futures index return and the underlying spot index return. Then we employed the causality in the variance tests proposed by Hong (2001) and Hafner and Herwartz (2006). According to the empirical results, the spot market was found to be Granger cause of futures market and this result suggests that the spot market plays a more dominant role in the price discovery process in Turkey.

JEL: G10, G12, G15.

Keywords: *Spot and Futures Markets, Structural Breaks in Variance, Volatility Spillovers, Intraday Data, Causality in Variance.*

1. Introduction

Deep and strong financial markets are crucial because of the need for market-based and diversified channels of intermediation between borrowers and investors. Therefore, many emerging countries have introduced futures contracts in order to deepen and stabilize their financial markets, and accordingly futures contracts have become one of the fastest growing

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financial products over the last 20 years in the world. According to the Bank for International Settlements (BIS) statistics, the trading value of futures products rose by 894% from $1.540 billion at the end of 1990 to $1.380 trillion at the end of 2010 and the total number of the contracts exceeded $6.346 million at the end of 2010 in the world. Although, the global financial crisis that started in the US hit the developed and developing economies and led to a decrease in the global financial markets, the trading value of future contracts increased by 10% between the periods of 2007 and 2010.

As one of the fastest-growing financial products in the world, futures markets have received attention of the investors and academicians and, for that reason, the benefits of futures markets have been widely argued in the finance literature. For instance, Min and Najand (1999) indicated that the price discovery ability between futures and spot market can provide great benefits for investors because this argument suggests that the information is transmitted from informed traders to uninformed traders. Second, the empirical literature that is especially based on developed economies implies that futures market helps to improve market depth and efficiency and, therefore, decreases volatility in the spot market. At this point, the policymakers, regulators and investors in these economies are concerned about the impact of futures trading on the underlying spot market (Avramov et al., 2006). Especially, volatility transmission between futures and spot markets become a widely discussed topic in finance literature.

Regulators, investors and academicians can be interested in the causal link in the variance between futures price and the underlying spot price, because volatility spillovers effects between futures and spot market can be used to explain volatility transmitting and to decide hedging and budget planning by the investors in the market. Therefore, volatility transmission has been widely examined in the finance literature and there is a substantial body of studies that especially focuses on the developed countries. These studies mainly claim that an increase or decrease in the volatility of futures market affects the volatility of the underlying spot market (Arshanapalli and Doukas 1994; Chan et al. 1991; Chan and Chung 1995; Abhyankar 1995; Iihara et al. 1996; Grunbichler et al. 1994; Koutmos and Tucker 1996; Zhong et al. 2004; Kavussanos et al. 2008). On the contrary, Shyy et al. (1996) detected a causal relationship running from the spot price to the future price in France. They indicated that market is with asynchronous trading, and differences in trading mechanisms used in cash or futures markets can help to find the reverse relation. Similarly, Booth and So (2003) examined the volatility spillovers among futures price, options price and underlying spot price in Germany by using intraday data. They evidenced that the futures, options and spot markets are integrated in Germany. They also found out the presence of information spillover running from the spot market to the futures markets. Liu et al. (2008) investigated the information transmission between the Chinese copper futures and the underlying spot market. Their result showed that there are significant two-ways spillovers between the markets. However, they concluded that the spillover from the futures market to the spot market is stronger. Bohl et al. (2009) investigated the direction of information flows between the futures price and the underlying spot price in Poland by using daily data. Their empirical results suggested that the introduction of index futures trading does not destabilize the spot market. Yang et al. (2011) investigated intraday price discovery and volatility transmission between the stock index and the stock index futures markets in China by using asymmetric GARCH model. They showed that, even if the stock index started to decline after the stock index futures were introduced, the cash market was found to play a more dominant role in the price discovery process.

Turkish Derivatives Exchange (TURKDEX) is a new established futures market and hence there is a limited number of studies analyzing the relationship between the futures and the spot market in Turkey. For instance, Baklaci and Tutek (2006) examined the impact of the futures price on the underlying spot price. Therefore, they separated their sample set according to the pre- and post-futures trading periods and concluded that the degree of volatility persistence in the spot market significantly decreased after the post-futures periods. Cevik and Pekkaya (2007) employed causality in mean and variance tests of Cheung and Ng (1996) to determine the causal pattern between the futures and the spot market. Their empirical results showed that there is a causal link running from the spot price to the futures price. Kasman and Kasman (2008) analyzed the impact of the introduction of the stock index futures on the volatility of the underlying spot market by means of asymmetric GARCH model. Hence, they constructed a dummy variable with respect to the pre- and post-futures trading periods and concluded that starting of the futures trading significantly decreases volatility in the stock market. Furthermore, they examined the causal relation between the level of futures and spot price series and found a causal link running from the spot price to futures price by using the error-correction model.

The aim of this paper is to examine volatility transmission between the futures price and the underlying spot price in Turkey. Therefore, we employed causality in the variance test of Hong (2001) and Hafner and Herwartz (2006). We also investigated the existence of sudden changes in the variance of both series. Our empirical results showed that the structural breaks in the variance of the return series lead overestimated GARCH parameters. Although causality in variance test results indicated mixed results for the causal relation between futures and the underlying spot price, the spot market was found to play a more dominant role in the price discovery process in Turkey.

The paper contributes to this literature in several aspects. First of all, to our knowledge, no-one has yet examined the relation between the futures price and the underlying spot price by using intraday data in Turkey. However, Silvapulle and Moosa (1999) indicated that intraday financial data is important to determine the financial market dynamics and market microstructure. Secondly, although a large number of studies have employed the Granger causality test to investigate the causal link between the futures price and the underlying spot price, the test procedure is very sensitive to the choice of lag length. Moreover, the Granger causality test relies on distributional assumptions (e.g. normality, homocedasticity, etc.) and it is well known that most of the stock return series exhibit non-normality and ARCH effect. Therefore, in this study a new causality in variance test which does not rely on distributional assumptions was employed. Also, causality in variance test is important for financial return series because it indicates a general pattern to volatility transmission. In this context, Li et al. (2008) indicated that this information would enhance volatility forecasting in foreign markets by academics and practitioners. Thirdly, different from the other studies that focused on the futures market in Turkey, we examined the existence of sudden changes in the variance of the futures return and the spot return**.** This is very important to determine the causal link between financial markets because the effects of the structural break on the GARCH model have been widely examined, and these studies have showed that the GARCH model tends to overestimate the persistence of volatility in the series when there are structural breaks in the variance of the series.

The remainder of this article is organized as follows. In the following section, we briefly present the theoretical background of the research and especially focus on the approach of causality in variance test. Our empirical findings are presented in Section 3. Finally, Section 4 briefly discusses the empirical findings of the research and gives the conclusion.

2. Methodology of the Research

Causality relation between financial markets has been widely examined in the literature where a large number of studies generally use traditional Granger causality test. However, Mantalos and Shukur (2010) determined that the Wald test based on VAR model over-rejects the null hypothesis of noncausality when there are volatility spillover effects and the over-rejection is more severe in larger samples when Monte Carlo simulations are used.

Furthermore, the traditional Granger causality test focuses only on changes in the mean of two variables and causality in variance is as important as causality in mean for the financial variables because it implies a general pattern to volatility transmission between financial markets. Moreover, Cheung and Ng (1996) indicated that changes in variance are said to reflect the arrival of information and the extent to which the market evaluates and assimilates the new information. In addition, the causation pattern in variance provides an insight concerning the characteristics and dynamics of economic and financial prices, and such information can be used to construct better econometric models describing the temporal dynamics of the time series. In this context, we focused on and examined the presence of volatility spillover (or in other words, causality in variance) between spot and futures return series in this study.

The two approaches have been widely used in the literature for testing causality in variance. One of them is a two step methodology of Cheung and Ng (1996) that is based on the cross correlation function (CCF) of squared residuals obtained from univariate GARCH model. The other approach depends on a dynamic specification of multivariate GARCH (MGARCH) model and causality in variance can be represented in terms of specific parameter restrictions. On the other hand, Hafner and Herwartz (2006) indicated that likelihood based tests within multivariate dynamic models typically suffer from a curse of dimensionality. In addition, the multivariate GARCH models that require large number of imposition of parameter constraints to ensure covariance stationary in the estimation procedure are widely criticized in the literature. Furthermore, Caporale et al. (2006), Pardo and Torro (2007), and Qadan and Yagil (2012) empirically showed that the two step methodology of Cheung and Ng (1996) and Hong (2001) still have a powerful fit when the data is large and leptokurtic and also residuals are non-correlated. Therefore, we employed causality in variance test based on the estimation of univariate GARCH models.

Causality in variance between two variables can be described as follows:

$$E\left\{\left(X_{t+1}-\mu_{x,t+1}\right)^2 \middle| I_t\right\} \neq E\left\{\left(X_{t+1}-\mu_{x,t+1}\right)^2 \middle| J_t\right\} \tag{1}$$

where X_t and Y_t are two stationary and ergodic time series, I_t and J_t are two information sets defined by $I_t = \left\{X_{t-j}; j \geq 0\right\}$ and $J_t = \left\{X_{t-j}, Y_{t-j}; j \geq 0\right\}$. In the Equation (1), Y_t can be said to cause X_{t+1} in variance.

The most common approach in the literature is *S* statistic of Cheung and Ng (1996) to examine causality in variance. On the other hand, the criticism of the *S* test statistic is that it may not be fully efficient when a large *M* is used because it gives equal weighting to each of the *M* sample cross-correlations. However, the empirical studies exhibit that the cross-correlation between financial assets decays to zero when lag order *l* is increased. In this context, Hong (2001) modified *S* statistic by using the non-uniform kernels weighting function. He indicates that his test statistics, in which the null hypothesis shows that there is no causality, outperforms in the Monte Carlo simulation studies. The Hong's (2001) test statistic is defined as:

$$Q_1 = \frac{T\sum_{l=1}^{T-1} k^2\left(\frac{l}{M}\right)\hat{\rho}^2_{\xi_i\xi_j}(l) - C_{1T}(k)}{\sqrt{2D_{1T}(k)}} \tag{2}$$

where $\hat{\rho}^2_{\xi_i\xi_j}(l) = \left\{\hat{C}_{\xi_i\xi_i}(0)\hat{C}_{\xi_j\xi_j}(0)\right\}^{-1/2}\hat{C}_{\xi_i\xi_j}(l)$, $\hat{C}_{\xi_i\xi_i}(0) = T^{-1}\sum_{t=1}^{T}\hat{\xi}^2_{i,t}$, $\hat{C}_{\xi_j\xi_j}(0) = T^{-1}\sum_{t=1}^{T}\hat{\xi}^2_{j,t}$ and $\hat{\xi}_{i,t}$ and $\hat{\xi}_{j,t}$ are standardized residuals derived from GARCH model. In Equation (2), $k(l/M)$ is a weight function, for which we use the Barlett kernel[1]

$$k(l/M) = \begin{cases} 1-\left|l/(M+1)\right| & if\ \ k/(M+1) \leq 1 \\ 0 & otherwise \end{cases} \tag{3}$$

where $C_{1T}(k) = \sum_{l=1}^{T-1}\left(1-|l|/T\right)k^2\left(l/M\right)$ and $D_{1T}(k) = \sum_{l=1}^{T-1}\left(1-|l|/T\right)\left\{1-\left(|l|+1\right)/T\right\}k^4\left(l/M\right)$.

[1] In this study, we used Barlett kernel because Hong (2001) shows that several non-uniform kernels are performed similar results.

Q_1 test statistics is a one-sided test and upper tailed normal distribution critical values should be used. For example, the asymptotic critical value at the 5% level is 1.645. The test procedure summarized by Hong (2001) is given as:

1- Estimate univariate GARCH (p, q) models for time series and save the standardized residuals.

2- Compute the sample cross-correlation function $\hat{\rho}_{\xi_i \xi_j}(l)$ between the centered standardized residuals.

3- Choose an integer M and compute $C_{1T}(k)$ and $D_{1T}(k)$.

Then compute the test statistic Q_1 by using Equation (2) and compare it to the upper-tailed critical value of normal distribution at an appropriate level. If Q_1 is larger than the critical value, there is no causality and accordingly the null hypothesis is rejected.

Hafner and Herwartz (2006) determined that in case of small and medium sample sizes S statistic appears to suffer from significant oversizing if the innovations underlying a conditionally heteroskedastic process are leptokurtic by means of Monte Carlo simulations. Therefore, they proposed a new test statistic that is based on Lagrange Multiplier (LM) principle to test for noncausality in variance and showed that their test statistic outperforms than S statistic. LM test statistic in which null hypothesis is noncausality in variance can be formulated as follows:

$$\lambda_{LM} = \frac{1}{4T}\left(\sum_{t=1}^{T}\left(\xi_{it}^2 - 1\right) z'_{jt}\right) V\left(\theta_i\right)^{-1} \left(\sum_{t=1}^{T}\left(\xi_{it}^2 - 1\right) z_{jt}\right) \xrightarrow{d} \chi^2(2) \tag{4}$$

where ξ_{it} is standardized residuals, $V\left(\theta_i\right) = \frac{\kappa}{4T}\left[\sum_{t=1}^{T} z_{jt} z'_{jt} - \sum_{t=1}^{T} z_{jt} x'_{it} \left(\sum_{t=1}^{T} x_{it} x'_{it}\right)^{-1} \sum_{t=1}^{T} x_{jt} z'_{jt}\right]$ and

$\kappa = \frac{1}{T}\sum_{t=1}^{T}\left(\xi_{it}^2 - 1\right)^2$. Also $z_{jt} = \left(\varepsilon_{jt-1}^2, \sigma_{jt-1}^2\right)'$, $\sigma_{it}^2 = \omega_i + \alpha_i \varepsilon_{i,t-1}^2 + \beta_i \sigma_{i,t-1}^2$, $x_{it} = \sigma_{it}^{-2}\left(\partial \sigma_{it}^2 / \partial \theta_i\right)$ and

$\theta_i = \left(\omega_i, \alpha_i, \beta_i\right)'$.

Hafner and Herwartz (2006) summarized the test procedure as follows:

1. Estimate a GARCH(1,1) model for ε_{it} and ε_{jt} and obtain standardized residuals ξ_{it}, derivatives x_{it} and the volatility process σ_{jt}^2 entering z_{jt}.

2. Regress $\xi_{it}^2 - 1$ on x_{it}' and the misspecification indicators in z_{jt}'.

3. λ_{LM} is equal to T times the degree of explanation (R^2) of the latter regression.

The asymptotic distribution of λ_{LM} will depend on the number of the misspecification indicators in z_{jt}. In our case λ_{LM} test statistic follows χ^2 distribution.

However, extensive literature that focused on estimating of GARCH models argued that the presence of structural breaks in the unconditional variance of series leads us to overestimate GARCH parameters. For instance, Hillebrand (2005) showed that parameter regime changes in GARCH models that are not accounted for in global estimations cause the sum of estimated GARCH parameters to converge to one via Monte Carlo simulations, and he referred to this effect as “spurious almost-integration”. These findings are very important for testing causality in variance because the test statistic that is considered in this study relies on estimating of univariate GARCH models. Therefore, biased GARCH model results can generate misleading causality results. In this context, Van Dijk et al. (2005) and Rodrigues and Rubia (2007) determined that causality in variance test suffers from severe size distortions when there are structural breaks in the variance of series. Accordingly, we examined the presence of structural breaks in the unconditional variance of both returns series before testing causality in variance.

Inclan and Tiao (1994) proposed a test procedure that is based on ICSS (Iterative Cumulative Sum of Squares) to detect structural breaks in the unconditional variance of a stochastic process. In order to test the null hypothesis of constant unconditional variance against the alternative hypothesis of a break in the unconditional variance, Inclan and Tiao (1994) proposed using the statistic given by:

$$IT = \sqrt{T/2}D_k \tag{5}$$

where $D_k = (C_k / C_T) - (k/T)$ and $C_k = \sum_{t=1}^{k} r_t^2$ be the cumulative sum of squares of a series of uncorrelated random variables with mean 0 and variance σ_t^2, $\text{t} = 1, 2, ..., \text{T}$. The value of k $(\text{k} = 1,\ldots, \text{T})$ that maximizes $\left|\sqrt{T/2}D_k\right|$ is the estimate of the structural break date. Under the variance homogeneity IT statistic behaves like a Brownian bridge asymptotically. At the 5% significance level, the critical value computed by Inclan and Tiao (1994) is $C_{0.05} = 1.358$.

The most serious drawback of the *IT* test statistic is that it is designed for independently and identically distributed random variables. However, Andreuo and Ghysels (2002) and Sanso et al. (2004) determined that the test statistic generates oversized results when the dependent variable exhibits a conditional heteroskedasticity process. In this context, Fernandez (2006) determined that *IT* test statistic fails to find the effect of the terrorist attacks on September 11 on the volatility of the world stock markets. Sanso et al. (2004) modified the *IT* test statistic for GARCH process in the dependent variable and they showed that the modified test statistic outperforms than *IT* test statistic by means of Monte Carlo simulation. In this study modified *IT* test statistic was used to detect break points in the variance of spot and futures return series as in Arago-Manzana and Fernandez-Izquierdo (2007), Rapach and Strauss (2008) and Ewing and Malik (2010). The modified *IT* test statistic given by

$$\kappa = \sup_k \left|T^{-1/2}G_k\right| \tag{6}$$

where $G_k = \hat{\omega}_4^{-1/2}\left(C_k - \frac{k}{T}C_T\right)$ and $\hat{\omega}_4$ is a consistent estimator of ω_4. Non-parametric estimator of ω_4,

$$\hat{\omega}_4 = \frac{1}{T}\sum_{t=1}^{T}\left(r_t^2 - \hat{\sigma}^2\right)^2 + \frac{2}{T}\sum_{l=1}^{m}\omega(l,m)\sum_{t=l+1}^{T}\left(r_t^2 - \hat{\sigma}^2\right)\left(r_{t-1}^2 - \hat{\sigma}^2\right) \tag{7}$$

where $\omega(l,m)$ is a lag window, such as the Barlett, defined as $\omega(l,m) = 1 - l/(m+1)$, or the quadratic spectral.

In the test procedure, if we were looking for only the possibility of a single point change, then the G_k function would provide a satisfactory procedure. But when we are interested in finding multiple change points on an observed series, the usefulness of the G_k function becomes questionable because of the masking effect. A solution is an iterative scheme based on successive application of G_k to pieces of the series, dividing consecutively after a possible change point is found (see Inclan and Tiao (1994) for ICSS procedure details).

3. Data and Empirical Results

3.1. Turkish Derivative Exchange Market

The TURKDEX was established in 2002 to launch the derivatives exchange in Turkey and formal trading in futures contracts started in February 2005. The TURKDEX has a fully electronic exchange system with a remote access and all trading activities for derivates contracts listed at the Exchange are carried out by the TURKDEX Exchange Operations System (TEOS). There is a single trading session that starts at 9:15 a.m. and finishes at 5.35 p.m. Although the only futures contracts are listed in the TURKDEX, an application has been made to the Capital Markets Board of Turkey (CMBT) for options contracts by the TURKDEX. The futures contracts include index futures (ISE-30 and ISE-100), currency futures (US Dollar/TRY, Euro/TRY), interest rate futures (for 91-day T-bill, 365-day T-bill and T-benchmark), commodity futures (cotton, wheat, and etc.) and precious metal futures (gold and others).

Although the TURKDEX is a newly established market, the total trading value has sharply increased since 2005. The trading value rose by 141% from 3.029 million TRY at the end of 2005 to 431.681 million TRY at the end of 2010. In 2010, the annual trading value increased by 29% in comparison to the trading value of the year 2009. The highest trading between the futures contract in the TURKDEX is equity index contracts that constituted 88%

in the annual number of contracts traded and 97% share of the trading value (in TRY terms) in 2010.

3.2. Data

The Istanbul Stock Exchange 30 (ISE-30) index that is traded as a futures contract in the TURKDEX consists of 30 stocks which have been selected among the stocks of the companies listed on the National Market and the stocks of the real estate investment trusts and venture capital investment trusts listed on the Corporate Products Market. Because the ISE-30 index consists of large capitalization common stocks listed on the ISE, the index may reflect an overall market performance. Therefore, in this study, we examined whether there are volatility spillovers between ISE-30 futures index price and the underlying stock index price. For this aim, we considered intraday data in which 5 minute stock index and futures index prices were collected from the ISE and TURKDEX covering the period from May 01, 2006 to May 31, 2010. The logarithmic stock and futures return series were calculated by using the $r_t = ln\ (P_t/P_{t-1})$ formula.

3.3. Empirical Results

The expressions in the previous sections indicate that Turkish derivatives exchange market is new established market and hence there are limited numbers of studies that examine relationship between futures price and underlying stock price in Turkey. However, understanding of price discovery process between futures price and underlying stock prices is very important for investors and hedgers and it would provide several benefits to construct optimal portfolio. Therefore, in this study we focus on Turkish derivatives exchange market to fill the gap in the literature.

The descriptive statistics are presented in Table 1. As shown in Table 1, while the mean of both return series is quite small, the mean return is higher for the futures market than for the spot market. Additionally, the futures return series exhibit evidence of a higher volatility according to the greater volume of its standard deviation. These results are consistent with the expectations because Turkish Derivatives Exchange (TURKDEX) is still a new financial market for investors. Therefore, the trading volume in the TURKDEX is low in comparison to the trading volume in the ISE.[2] In addition to this, the presence of leverage effect in the futures market can be the cause of the increase in the volatility and hence futures returns series are found to be more risky.

Also both series show the evidence of strong skewness and excess kurtosis, which indicates that both of them are leptokurtic. Jarque-Bera normality test results show that the distributions of both returns series are not normal. Ljung-Box *Q* statistics strongly indicates the presence of a serial correlation in the returns and squared returns series. Finally, we examined the existence of the unit root in the spot and futures return series by means of the augmented Dickey-Fuller (ADF), Phillips-Perron (PP) and Kwiatkowski, Phillips, Schmidt and Shin (KPSS) unit root tests. Both unit root tests results suggest that spot and futures return series are stationary.

Table 1

Descriptive statistics for Spot and Futures Return Series for ISE30 Index

	ISE30 Index Spot Returns	**ISE30 Index Futures Returns**
n	60459	60459
Mean (x10000)	0.035	0.038
Maximum	7.830	10.566
Minimum	-8.488	-10.414
Std. Dev.	0.300	0.523
Skewness	-1.143	-0.149
Kurtosis	88.369	38.019
Jarque-Bera	18372522 [0.000]	3089610 [0.000]
ARCH (5)	16.606 [0.000]	1401.5 [0.000]
Q (20)	167.471 [0.000]	6767.89 [0.000]
Qs (20)	95.742 [0.000]	9209.75 [0.000]
ADF	-150.419***	-130.254***
PP	-250.965***	-381.087***
KPSS	0.096***	0.083***

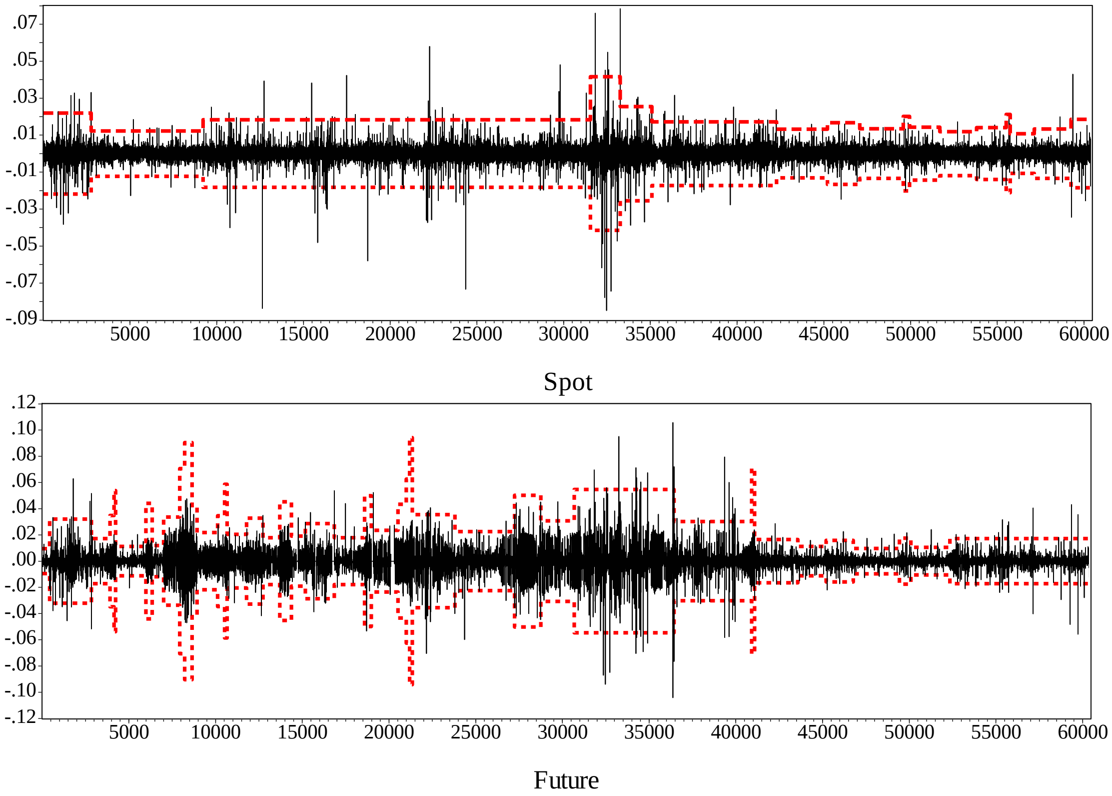
Notes: The figures in square brackets show the probability (*p*-values) of rejecting the null hypothesis. ARCH (5) indicates LM conditional variance test. $Q(20)$ and $Q_s(20)$ indicates Ljung-Box serial correlation test for return and squared return series respectively. *** indicate that the series in question is stationary at the 1% significance level.

[2] The total trading value in the ISE is 635.664 million TRY at the end of 2010.

We started our empirical analysis first by testing the presence of sudden changes in the variance of spot and futures return by means of modified *IT* statistic. Figure 1 illustrates the return for each series with the points of the sudden change and ± 6 standard deviations. In addition to this, Table 2 indicates the time periods of sudden changes in volatility, as identified by the ICSS algorithm.

Figure 1

Intraday Returns Series for ISE30 Spot and Futures



Notes: Dashed line indicates ± 6 standard deviations.

The spot return shows sixteen sudden change points, making for seventeen distant volatility regimes, whereas the futures return evidences forty sudden change points, corresponding to forty-one distinct volatility regimes. In order to eliminate the effects of the structural breaks, we constructed dummy variables regarding to the time periods of sudden changes as in Lamoureux and Lastrapes (1990), Aggarwal et al. (1999), Arago-Manzana and Fernandez-Izquierdo (2007), Wang and Thi (2007), and Ewing and Malik (2010).

Table 2

Structural breaks in the variance of ISE30 Spot and Futures Return Series

Spot Returns			Futures Returns					
Break Points	**Break period**	**Standard deviation**	**Break Points**	**Break period**	**Standard deviation**	**Break Points**	**Break period**	**Standard deviation**
1	July 19, 2006	0.0036	1	May 11, 2006	0.0016	21	September 3, 2007	0.0048
2	January 18, 2007	0.0020	2	July 21, 2006	0.0053	22	October 18, 2007	0.0030
3	September 11, 2008	0.0030	3	August 22, 2006	0.0029	23	October 26, 2007	0.0083
4	October 28, 2008	0.0069	4	August 28, 2006	0.0058	24	December 6, 2007	0.0039
5	December 17, 2008	0.0042	5	August 31, 2006	0.0090	25	December 19, 2007	0.0072
6	June 1, 2009	0.0029	6	October 17, 2006	0.0019	26	December 27, 2007	0.0104
7	July 30, 2009	0.0022	7	October 31, 2006	0.0074	27	January 2, 2008	0.0157
8	September 7, 2009	0.0028	8	November 17, 2006	0.0020	28	March 3, 2008	0.0059
9	October 27, 2009	0.0022	9	December 12, 2006	0.0056	29	May 28, 2008	0.0037
10	November 5, 2009	0.0034	10	December 20, 2006	0.0118	30	July 4, 2008	0.0084
11	December 11, 2009	0.0024	11	December 29, 2006	0.0151	31	August 21, 2008	0.0051
12	January 21, 2010	0.0020	12	January 11, 2007	0.0068	32	January 16, 2009	0.0091
13	February 23, 2010	0.0023	13	February 13, 2007	0.0036	33	April 28, 2009	0.0050
14	March 1, 2010	0.0035	14	February 23, 2007	0.0058	34	May 4, 2009	0.0118
15	March 25, 2010	0.0018	15	March 1, 2007	0.0098	35	June 29, 2009	0.0028
16	May 6, 2010	0.0022	16	April 3, 2007	0.0034	36	July 30, 2009	0.0019
			17	May 2, 2007	0.0055	37	September 1, 2009	0.0026
			18	May 30, 2007	0.0030	38	October 23, 2009	0.0016
			19	June 19, 2007	0.0075	39	November 9, 2009	0.0029
			20	July 12, 2007	0.0032	40	December 24, 2009	0.0018

Next, we estimated univariate GARCH model of Bollerslev (1986) with and without dummy variables for spot and futures return series and GARCH(1,1) model was found to be sufficient for an adequate model volatility for both return series.[3,4]

According to the results in Table 3, when the structural breaks in the variance of series are ignored, the sum of the *alpha* and *beta* parameters is found to be 0.777 for the spot return and 0.985 for the futures return series. On the other hand, the inclusion of dummy variables significantly reduces the sum of the parameters for both return series (0.633 for spot return and 0.799 for futures return). Especially, we spotted an overly dramatic decrease in the *beta* parameter for futures return (from 0.617 to 0.255). These findings are consistent with *IT* test statistic results because the number of the sudden changes was found to be higher for futures return than for spot return. Hence, it can be expected that the decrease in the persistence of the volatility is greater for the futures return than for the spot return.

[3] We consider the Schwarz BIC in selecting the number of autoregressive parameters in the ARMA model. We find that the AR (5) model is adequate to describe time series behavior of the data for spot and futures return series during the sample period.

[4] We also implemented EGARCH and GJR-GARCH models to determine the presence of leverage effect in the volatility of spot and future series. However, EGARCH and GJR-GARCH models do not outperform than GARCH model according to log likelihood values.

Table 3

GARCH(1,1) model results for ISE30 Spot and Futures Return Series

Spot	ω	α	β	ν	$\alpha+\beta$	Log likelihood	Q (20)	Q_s (20)
Without dummies	1.67E-06 [0.000]	0.166 [0.000]	0.611 [0.000]	0.975 [0.000]	0.777	279097.8	75.105 [0.000]	4.214 [0.997]
With dummies	3.77E-06 [0.000]	0.141 [0.000]	0.492 [0.000]	1.006 [0.000]	0.633	279590.0	59.988 [0.000]	6.479 [0.971]
Futures	ω	α	β	ν	$\alpha+\beta$	Log likelihood	Q (20)	Q_s (20)
Without dummies	1.27E-06 [0.000]	0.368 [0.000]	0.617 [0.000]	0.545 [0.000]	0.985	279165.0	689.95 [0.000]	30.296 [0.003]
With dummies	1.81E-06 [0.000]	0.544 [0.000]	0.255 [0.000]	0.555 [0.000]	0.799	280914.9	596.52 [0.000]	11.591 [0.561]

Notes: The figures in square brackets show the *p*-values. *v* is GED parameter. $Q(20)$ and $Q_s(20)$ indicates Ljung-Box serial correlation test values for the return and the squared return series respectively.

Log likelihood values in Table 3 indicate that GARCH model with dummy variables gives a better fit for both return series. In addition to this, we employed a likelihood ratio (LR) test to determine the significance of the dummy variables in the volatility process. The LR test can be calculated by using LR = $2[L(M_d)-L(M)]$ where $L(M_d)$ and L(M) are the maximum log likelihood values derived from the GARCH models with and without dummy variables respectively. The test statistic is asymptotically χ^2 distributed with degrees of freedom that is equal to the number of the restrictions (or number of the dummy variables). For spot return, LR test statistics was determined as 984.4 (*p*-value = 0.000), so the null hypothesis of no change was rejected at the %1 significance level. For futures return, LR = 3499.8 (*p*-value = 0.000) and this result suggests the rejection of the null hypothesis at the 1% level. Therefore, the LR test results strongly indicated that the existence of dummy variables in the GARCH model increases the explanatory power of the model.

Then we employed Hong's test to determine the causal relation between the spot and the futures market and the results are presented in Table 4. When we ignored structural breaks in the variance (in other words, when we used standardized residuals derived from GARCH model without the dummy variables), we determined a causal link running from the spot market to futures market. Especially, the highest cross-correlation coefficient was found at third lag in the Hong's test and this result suggests that spot market influences the futures market within 15 minutes.

On the other hand, when the structural breaks were considered (or standardized residuals obtained from GARCH model with dummy variables were used), we determined a bidirectional causality between the variance of the spot and the futures return series. These results are very interesting because if we had not eliminated the effects of structural breaks, we could not have determined the presence of the feedback effect between spot and futures market. In addition to this, these results are consistent with the findings of Van Dijk et al. (2005) and Rodrigues and Rubia (2007) because they indicated that the causality in variance tests suffered from severe size distortions if structural breaks are ignored.

Table 4

Hong's causality in variance test results for ISE30 Spot and Futures Return Series

	Causality Direction	M=1	M=2	M=3	M=4	M=5
Breaks ignored	Spot →Futures	-0.322 [0.626]	4.953*** [0.000]	400.7*** [0.000]	835.5*** [0.000]	1127.6*** [0.000]
	Futures → Spot	0.198 [0.422]	0.027 [0.489]	0.395 [0.347]	0.840 [0.200]	1.101 [0.135]
Breaks accounted for	Spot →Futures	-0.481 [0.685]	3.247*** [0.000]	396.9*** [0.000]	830.1*** [0.000]	1120.9*** [0.000]
	Futures → Spot	2.679*** [0.004]	2.445*** [0.007]	2.302** [0.011]	2.197** [0.014]	2.068** [0.019]

Notes: The figures in square brackets show the *p*-values. *, ** and *** indicates the existence of causal link at the 1%, 5% and 10% level respectively.

We also employed the LM test statistic of Hafner and Herwartz (2006) to determine whether Hong's test results are robust and the test results are given in Table 5. As in Hong's test, we computed two different test statistics by considering and by ignoring the effects of structural breaks. The test results in Table 5 strongly indicate the existence of causality relation going from spot return to futures return series. Differently from Hong's test results, the causal link running from the futures market to spot market cannot be determined at the conventionally significant levels (the null hypothesis can only be rejected at the 18% significance level). On the other hand, the test statistics significantly increases (and p-value decreases) for this causality relation when structural breaks are considered and this is consistent with Hong's test results. Therefore, it can be said that both of the causality in variance tests suffered from size distortions in the case of structural breaks in variance of the series.

Finally, as in Cheung and Ng (1996) we re-estimated GARCH model in which squared return series for futures and spot price take place in the variance estimation to determine the size of volatility transmission between the futures market and the underlying spot market. Therefore, we considered the lags of squared return series in the variance equation and determined the optimal model according to the model selection criteria (Akaike and Schwarz) and Log likelihood value.[5]

Table 5

LM Causality in variance test results for ISE30 Spot and Futures Return Series

	Causality Direction	λ_{LM}
Breaks ignored	Spot →Futures Futures → Spot	177.55* [0.000] 1.874 [0.391]
Breaks accounted for	Spot →Futures Futures → Spot	21.823* [0.000] 3.444 [0.179]

Notes: The figures in square brackets show the *p*-values. * indicate the existence of causal link at the 1% level.

Augmented GARCH model results are presented in Table 6. As seen in Table 6, squared futures return was not found to be statistically significant in the spot return model. On the other hand, squared spot return is statistically significant at the 1% level and these results are consistent with the LM test statistic of Hafner and Herwartz. Consequently, we determined that the spot market plays a more dominant role in the price discovery process in Turkey and these findings are consistent with Shyy et al. (1996), Booth and So (2003), Liu et al. (2008), Bohl et al. (2009) and Yang et al. (2011).

Table 6

Augmented GARCH model results for ISE30 Spot and Futures Return Series

Spot	ω	α	β	δ	ν	Log likelihood	Q (20)	Q_s (20)
	3.79E-06 [0.000]	0.141 [0.000]	0.491 [0.000]	0.0001 [0.490]	1.006 [0.000]	279590.1	59.992 [0.000]	6.446 [0.971]
Futures	ω	α	β	δ	ν	Log likelihood	Q (20)	Q_s (20)
	1.13E-06 [0.000]	0.427 [0.000]	0.301 [0.000]	0.019 [0.000]	0.615 [0.000]	283488.8	775.89 [0.000]	19.045 [0.212]

Notes: The figures in square brackets show the *p*-values. v is GED parameter and δ is volatility parameter of spot and futures return series. $Q(20)$ and $Q_s(20)$ indicates Ljung-Box serial correlation test for return and squared return series respectively.

[5] Initially, we start with five lags of the squared return series and also evaluate them together and separately in the variance equation. In the spot and future model estimation, optimal lag is found to be 2 for squared futures and spot return series.

4. Conclusion

In this study, we examined the presence of volatility transmission between the futures return and the underlying spot return series in the Turkish market. First, we investigated whether there are structural breaks in the variance of both returns series because a vast literature that focused on the effects of structural breaks on the GARCH parameters showed that structural break in the variance caused to overestimate the volatility persistence. Our empirical results are in line with the findings of the previous studies in the related literature. (Booth and So (2003); Shyy and Vijayraghavan (1996); Yang, Yang and Zhou (2012)) The empirical findings indicate that the sum of *alpha* and *beta* parameters for both return series declines significantly when we consider the effects of structural breaks. Causality in variance test results strongly indicated the causal link running from the spot market to futures market. Furthermore, the augmented GARCH model result verifies these findings.

Regardless of the large literature that has discussed the information transmission mechanism between the futures and spot market, little consensus has emerged. Furthermore, hardly any study has been conducted so far to investigate intraday spillover effects between stock index futures and spot market with respect to the Turkish financial markets. At this point it should also be emphasized that the intraday data set used in this study is essential as it it leads us to capture the market dynamics more accurately. This article will help investors and especially the institutional investors to prudently make up their investment strategies in Turkish financial markets, by hedging their risks more efficiently. Furthermore, as the Turkish equity market has been one of the best performing emerging markets in recent years, the findings of this study could also be a good benchmark point for the institutional investors in other emerging markets. The article will also provide foreign institutional investors with a better understanding of the Turkish Market which will generate new ways for researchers to a more comprehensive investigation of the Turkish market and will encourage the researchers for further studies.

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