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Relation between ISE 30 index and ISE 30 index futures markets: Evidence from recursive and rolling cointegration

Aysegul Ates [a*]

[a] Akdeniz University, Department of Economics, Antalya, Turkey.
*Corresponding author's email address: aates@akdeniz.edu.tr

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ABSTRACT

Turkey is one of the most dynamic emerging markets in the world and its futures market has developed significantly since the introduction of futures contracts by Turkish Derivatives Exchange in 2005. Istanbul Stock Index 30 (ISE 30) futures was one of the first contracts introduced and its trading increased rapidly over time. This study specifically focuses on the evolution and stability of cointegration relationship between the futures and spot prices of ISE 30 index during the sample period from February 4, 2005 through October 19, 2012. We test whether changing market conditions have an impact on the long-run relationship between spot index and index futures markets by employing recursive and rolling cointegration techniques. The findings reveal that the cointegration relationship weakens significantly during the global financial crisis and eurozone debt crisis periods but holds mostly over the estimation period.

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1.0 Introduction

Turkey is one of the most dynamic emerging markets in the world and its futures market has developed significantly since 2005.[1] The development of the organized derivatives market in Turkey was a result of the growth of Turkish capital markets and economy in general. Turkish Derivatives Exchange (TurkDEX) was established in 2003 and formal trading of futures contracts started in February 2005. ISE 30 index futures contract was one of the first contracts introduced in 2005 and its trading volume has experienced tremendous growth since its introduction and it is currently the most liquid futures contract in Turkey.

Futures market has two important functions: Risk transfer and price discovery. The first of these functions pertains to hedging. Successful trading in equity index futures contracts would provide risk management solutions for hedgers and fund managers by shifting the price risk to others. Besides the traditional role of risk sharing, futures markets play an important role in the aggregation of information (Subrahmanyam 1991). Specifically, price discovery is defined as the search of equilibrium price by Harris et al. (1995) and as the dynamic process by which market impounds new information and market participants' expectations into asset prices by Hasbrouck (1995). Due to liquidity, relatively low transaction costs and low margin requirements new information about

[1] In 2006 TurkDEX was ranked the world's fastest growing derivatives exchange with a 273 percent increase to 6,848,087 contracts and in 2012 its trading volume reached to 62,474,464 contracts. (FIA, 2007, 2012).

asset prices are generally reflected in futures markets first. In sum, futures markets meet an important economic need by facilitating risk management and enabling price discovery.

The extent to which futures markets perform risk transfer and price discovery functions depends on a close relationship between cash and futures prices (Garbade and Silber, 1983). In other words, market linkage is essential for successful futures market. Theoretically prices in futures and cash markets are linked by an arbitrage relationship (cost-of-carry model) in the long run and the possibility of arbitrage prevents spot and futures prices of same asset from drifting apart over time. According to the cost-of-carry model theoretical price of index futures should be equal to underlying index price adjusted for the cost-of-carry. Specifically, arbitrage should ensure the difference between the current asset price and the futures price, which is the cost of carrying the asset, which involves transaction costs, dividend yields, interest rates and other factors (Stoll and Whaley 1990). The cost-of-carry formula can be presented as;

$$F_{t,T} = S_t e^{(r_t - d_t)(T-t)} \qquad (1)$$

where S_t is the index price at time t, $F_{t,T}$ is the index futures price at time t with maturity T, r_t is the risk free interest rate, d_t is the dividend yields and (T-t) is the time to maturity of the futures contracts. The literature which examines this arbitrage relationship uses error correction models (ECM) where error correction coefficient indicates the relative magnitude of adjustments in each market toward long run equilibrium price.[2] Market efficiency is related to no arbitrage and rapid elimination of arbitrage opportunities suggests that the market operates efficiently. The existence of the long run relationship indicates that the markets are efficient in the long run.[3] Another strand of this literature explains the relation between spot and futures markets in the context of price discovery hypothesis. This literature indicates that futures market and underlying spot market should share a common stochastic trend since both markets trading same underlying asset (Hasbrouck, 1995). Thus, spot and futures prices form a cointegration system. The cointegration system will have one cointegrating vector and one common stochastic trend. Hasbrouck (1995) employs the common trends representation of a set of variables to measure each market's contribution to the efficient price innovation. Futures and cash markets contribute to the discovery of a unique and common unobservable price that is the efficient price. In conclusion, the theoretical literature suggests that spot and futures price dynamics are based on a cointegrated system and this market linkage is essential to a successful futures market.

There is a large body of work dedicated to investigating the long-run relationship between spot index and index futures prices (i.e. market linkage), explicitly whether spot and futures prices are cointegrated has been tested extensively in literature (See Ghosh, 1993, Wang and Yau, 1994, Harris et al. 1995, Pizzi et al. 1998, Brooks et al., 2001, Lien et al.,2003, Pattarin and Ferretti, 2004, Floras and Vougas, 2008 etc.). Most of the literature in this area focuses on index futures market in developed countries. For example, Wahap and Lashgari (1993) examine the linkages between S&P 500 and FTSE 100 index spot and futures markets using daily data and find that futures and spot prices are cointegrated and conclude that the results are consistent with market efficiency. Arshanapalli and Doukas (1997) examine the S&P 500 spot and futures market linkages during the October 1987 market crash and using error correction model and find a cointegration relationship between these markets before and after the market crash with the exception of October 16 and 19 by using intraday data. More recently, Pattarin and Ferretti (2004) examine Mib30 index and index futures relationship in Italian derivatives market employing daily data from 1994 to 2002 and find that there is a long-run relationship between these markets and Italian stock index futures plays an vital role in price discovery process. On the other hand, the literature on equity index futures in emerging market setting is limited. This limited literature mostly focuses on the spot index and index futures relationship in the framework of price discovery hypothesis. Among them Lin et al. (2002), Zhong et al. (2004), Hou and Li (2013) can be counted. These studies focus on testing the long-run relationship between spot index and index futures market and find there is cointegration between these markets. However, time varying characteristics of cointegration are largely neglected in the literature.

Investigating the relationship between futures and spot index prices and the nature of the cointegration relationship is important in interrelated markets and time varying characteristics of cointegration between futures and cash prices should have implications for market efficiency, price discovery and hedging. A vital shortcoming of limited empirical research on Turkish index futures markets is that they do not examine time variation in data generating process linking these two markets. This paper addresses and examines the time variation in long-run relationship between ISE 30 index and index futures markets in Turkey. Recursive and rolling cointegration techniques allow us to examine how cointegration relationship changes over time due to new

[2] See Brenner and Kroner (1995) for an analysis of the link between arbitrage and cointegration.

[3] This is no-arbitrage definition of efficiency which is characterized by the absence of arbitrage opportunities in the market. Note that this definition is different from Fama's (1970) definition of efficient market in which prices always fully reflect available information.

information. It is relevant to focus on the Turkish index futures market developments during the recent crises (2008 global financial crisis and eurozone debt crisis) since market turmoil in the financial markets might affect the underlying data generating process. Previous studies that examine cointegration between Turkish index and futures markets conclude that there is a long run relationship between ISE 30 index and index futures markets. Kasman and Kasman (2008) test cointegration relationship between ISE 30 index and index futures using both Engle Granger two-step procedure and Johansen cointegration test and conclude that two markets are related in long-run for the period February 2005 to October 2007. Cagli and Mandaci (2013) also find spot and futures prices of underlying ISE 30 index are cointegrated by employing weekly data from February 2005 to October 2012 after accounting structural breaks. However, all of these analyses are static in nature. Neither of these studies explicitly accounts for time variation in long run relationship between index and index futures due to new information in Turkish derivatives market.[4] In order to examine how the process evolves over time techniques such as recursive and rolling methods that allow for the investigation of gradual change in the data generating process should be employed.

Thus, the first contribution of this paper is to assess the statistical significance of the cointegration relationship over time from the start of index futures trading on February 4th, 2005 to October 19th, 2012 by employing the recursive and rolling cointegration techniques in Turkish index futures markets. These procedures allow for the time-variation in the data generating process. Secondly, our data period covers an extensive range of economic conditions including, a period of robust economic growth and price stability in Turkish economy, global financial crisis, Eurozone debt crisis and increased sophistication in asset markets in general. This gives us a chance to examine whether recent global financial and Eurozone crises hampered the cointegration relationship between spot and futures markets, hence market efficiency in Turkish index futures markets. Thirdly, previous studies on stock index futures mainly examine developed markets and studies on emerging markets are relatively scarce and this paper focuses on Turkish index futures market (i.e. ISE 30 index spot and futures prices) which is one of the most dynamic emerging markets in the world. The results of this study have implications for hedgers, traders as well as regulators.

The paper is organized as follows: Section 2 introduces data and methodology Section 3 presents and discusses the empirical results and Section 4 concludes the paper.

2.0 Data and methodology

The data employed in this study comprise daily observations on ISE 30 stock index futures and underling ISE 30 index from February 4th, 2005 to October 19th, 2012.[5] Data is obtained from TurkDEX. Futures prices are the prices of nearby futures contracts. The choice of data period is motivated by the fact that data period covers extensive range of economic conditions including, a period of robust economic growth and price stability in Turkish economy, 2008 global financial crisis as well as Eurozone debt crisis of 2009-2010. Moreover, data period includes the introduction period of futures markets which is defined with low trading volumes as well as mature period where trading volumes increased noticeably. Focusing on this data period allows us to test whether the cointegration relationship changes with changing market conditions.

If the price series are individually non-stationary but there exists a linear combination of prices that is stationary then these series are cointegrated. Such cointegrated variables cannot drift far apart and they tend to move together in the long run. However, the extent of cointegration may change over time or cointegration relationship may break down as the underlying data generating process changes due to policy changes, financial crises and other exogenous factors. Therefore, appropriate examination of this relationship requires a time varying procedure such as recursive or rolling cointegration methods.

The empirical analysis is based on a vector autoregression (VAR) system. x_t denotes a vector which includes the log of futures and spot index price series and the error correction representation is:

$$\Delta x_t = \Pi x_{t-1} + \sum_{i=1}^{k-1} \Gamma_i \Delta x_{t-i} + \mu + e_t \qquad (2)$$

[4] Rangvid and Sorensen (2002) argue that econometric techniques that include structural breaks are not suitable for inspecting gradual change in the data generating process since structural changes is well defined points in time. Thus, following Rangvid and Sorensen (2002) rolling and recursive techniques employed in this paper.

[5] The underlying asset of ISE 30 index futures is ISE 30 index, which is composite index of 30 actively traded stocks listed on the Istanbul Stock Exchange (i.e. Borsa Istanbul). Contracts' months for the ISE 30 futures are February, April, June, August, October and December. Contracts with three different expiration months nearest to current period are traded.

where x_t is a price vector, μ is a (2x1) vector of constants. The parameter matrix, $\prod$, contains information about the long-run relationship between two prices Γ_i are short run parameter matrices, e_t is normally distributed error term. If the prices are non-stationary, then one can examine the cointegration relationship between these two series by determining the number of cointegrating vectors, r, as follows:

$$H(r):\ \prod = \alpha\beta' \qquad (3)$$

where α is weighting elements for the cointegration relationship, β is vector of cointegration relationship.

In order to determine the number of cointegrating vectors (r), the Johansen (1991) trace test is conducted. The null hypothesis for the trace test is that there are at most r number of cointegrating vectors. For system of two non-stationary variables (futures and spot prices) the rejection of null hypothesis of no cointegration indicates that there is a common stochastic trend driving the movements of the futures and spot prices. To examine the stability of the identified cointegration relationship over each data point, both the recursive cointegration and the rolling cointegration methods based on Hansen and Johansen (1999) and Rangvid and Sorensen (2002) are applied in this paper. This is accomplished by testing constancy of cointegration rank. This approach involves the estimation of the Johansen (1991) over various intervals of the sample period. Two different windowing strategies -recursive and rolling- are applied.

In recursive approach, first λ_{trace} statistic is estimated over the chosen period t_0 to t_n. Then the initial sample is kept fixed and sample length is increased by adding an additional observation at each recursive estimation. The relevant statistics (λ_{trace} statistics) obtained from these estimations are plotted over time. This plot is called global plot by Aggarwal et al. (2004). The plotted trace test statistics are also normalized by the 5% critical value. If the normalized values are above 1, then the null hypothesis of no cointegration is rejected at 5 % significance level. An upward slope is interpreted as rising comovements. In sum, by applying this recursive approach one can see the evolution of the λ_{trace} statistics and long-run relationship over time. One advantage of recursive method is that it takes into account all historic information.

Pascual (2003) argues that this method might be misleading because the expansion of the sample size by adding observations recursively increases the path of the λ_{trace} statistics. Since recursive tests gradually add more observation into the sample, this method does not allow us to differentiate whether the calculated test statistics are due to increasing power of the tests arising from the additional observation or result of a change in the extent of cointegration relationship. In order to avoid this problem, we also calculated the λ_{trace} statistics by keeping the time interval constant as rolling over the next time interval. This method is rolling estimation approach. In this method, the tested sample size (i.e. number of observations) is maintained fixed. Therefore, the test statistic is estimated over a time interval of a constant length. In other words, the λ_{trace} statistic is estimated over an i period interval from, for example, t_0 to t_{0+i} and estimation period is then moved k data points and λ_{trace} is reestimated from t_{0+k} to t_{0+i+k}. In sum, in the rolling approach, the data are divided into a number of overlapping samples and then the Johansen (1991) methodology is applied to obtain each λ_{trace} statistics. This approach has been employed by Kutan and Zhu (2003) to examine the link between spot and forward exchange rates. The obtained λ_{trace} statistics are normalized again by the 5% critical value and plotted over time. This plot is called Local Plot (Aggarwal et al. 2004). In sum, in the rolling tests the sample size is maintained, but the sample period allowed to change. In this method when the sample period changes with each estimation the observed trace test statistics reflects the variation in the degree of cointegration due to new information.

3.0 Empirical results

In this section, we report the results of our analysis. Daily log prices of futures and spot markets are plotted in Figure 1 which shows that both series appear to move closely. Both series presents upward trend until the end of 2007. During the financial crisis period both series show a declining trend as a result of the ongoing financial crisis until the beginning of 2009. Price series started to move upwards again in mid-2009. Table 1 presents summary statistics, namely first and second moments for log price series in first differences. Mean and standard deviation are almost same for two series. However, kurtosis and skewness (absolute) measures of the cash return series are greater than that of futures return series suggesting that the cash market may be more volatile than futures market and Jarqua-Bera test rejects normality at 1 percent level. Augmented- Dickey Fuller (ADF) test results are also given in Table 1 for both in levels and in first differences. It is generally accepted in the literature that spot and futures prices are non stationary and ADF test results confirm the presence of unit root for both price series at 1 percent level. Both futures and spot prices are integrated order of one (i.e. I(1)). Preliminary analysis confirms that ISE 30 index and index futures series present the empirical characteristics of most financial returns sampled at daily intervals. Given the non-stationary nature of prices we proceed to test for cointegration relationship between spot and futures prices.

Figure 1

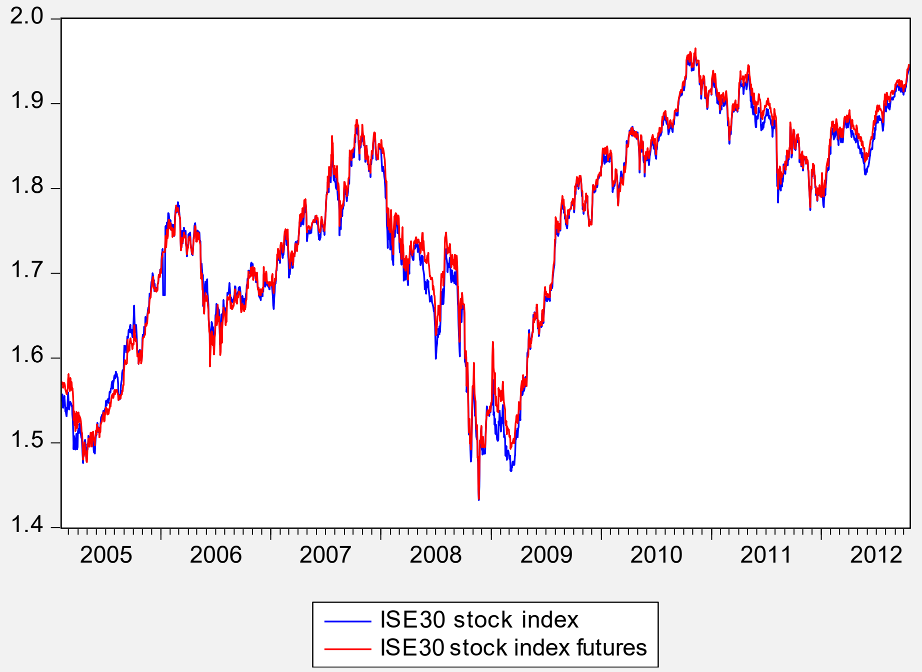


Table 1: Descriptive statistics

	(ΔP_F)	(ΔP_C)
Mean	0.0002	0.0002
Maximum	0.0494	0.0761
Minimum	-0.0436	-0.0544
Std. Dev.	0.0085	0.0086
Skewness	-0.0927	0.1485
Kurtosis	6.4048	9.1439
Normality[a]	973.74*	3168.76*
ADF Test[b] (P_t)	-1.4819	-1.5484
ADF Test[b] (ΔP_t)	-23.3201*	-21.3106*

Note: $\Delta\Pi_\Phi$ ανδ ΔP_C are changes in log price series of futures and cash markets respectively. * denotes significance at 1 % level. a. Jarqua-Bera test for normality b.H_0: Unit root. The lag orders are determined by Schwartz criterion. Only intercepts are included in the level series. Critical value for ADF test is 3.4336 (2.8629) for 1 % (5 %) significance level.

Table 2 presents Johansen trace test results for the full sample. The static examination of cointegration relationship indicates that there is one cointegration relationship between the series of ISE 30 index futures and the underlying spot index, i.e. in the long-run there is a stable relation between these two series over the full sample period. This result provides information about full sample, including both normal and crisis periods and is in line with findings of previous studies. However, studies such as Longin and Solnik (2001) suggest that market behavior is different in extreme periods such as crisis. Kledon and Whaley (1992) claim that in normal trading conditions the stock market and futures market comprise virtually one market but their results indicates that there was a delinkage during the October 1987 market crash. In order to examine whether market conditions have an impact on cointegration relationship we employ recursive and rolling cointegration techniques which allow us to observe the evolution and stability of long-run relationship over time.

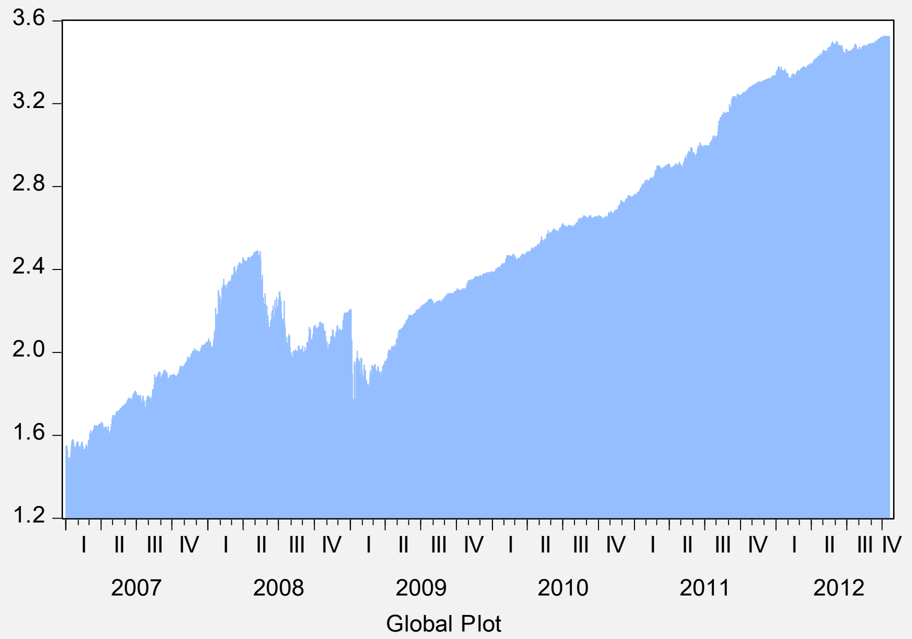
Table 2: Johansen trace test

Hypothesized Number of Cointegrating equations	Trace Statistics	5 % critical value
None	54.6217*	15.4947
At most 1	2.8001	3.8415

Note: * denotes rejection of the hypothesis at 5% level. Trace test indicates one cointegrating equation at the 5% level for the period February 4th 2005 to October 19th 2012.

In the recursive approach, the Johansen (1991) methodology is applied to an initial subset of the data. In this case, the sub-period (February 4, 2005 – December 29, 2006) is employed as the base period.[6] Then an additional data point is added to the system and λ_{trace} statistic reestimated. This process continues until we exhaust all the observations and in the final stage we perform cointegration analysis for the full sample and calculate the λ_{trace} statistic. Thus this allows us to examine evolution of λ_{trace} statistics and thereby the change in the cointegrating relationship between ISE 30 index and index futures prices over the sample period. As mentioned all statistics are normalized by the 5% critical value. The rescaled λ_{trace} statistics suggests the rejection of null hypothesis of no cointegration if it is above one. The plot of estimated λ_{trace} statistics is presented in Figure 2 which indicates a robust cointegration relationship between spot and futures markets since all the normalized trace statistics are above one. Recursive estimations suggest that although the cointegration relationship weakened starting mid 2008s, which coincides with global financial crisis period, has not broken down and overall a stable relationship prevails.

Figure 2: Recursive λ_{trace} statistics



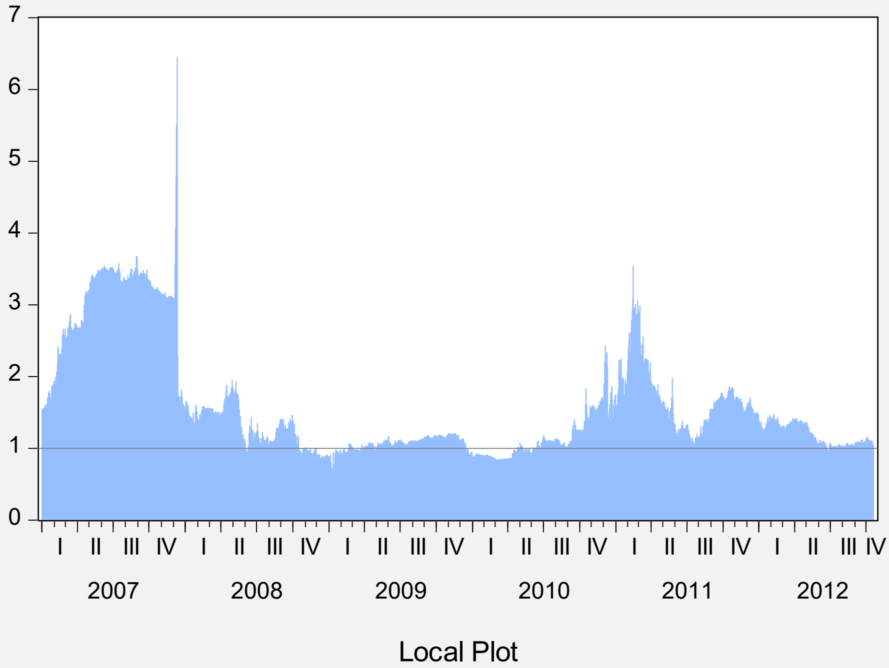
Note: This figure presents λ_{trace} statistics calculated on a recursive basis, starting February 4th, 2005 and initially ending December 31th 2006. Thereafter λ_{trace} statistics are recalculated by adding one observation each period successively. Values greater than one in the plot indicate the rejection of no cointegration at 5 percent level.

However, in order to take into account of Pascual's (1993) critique, λ_{trace} statistics are recalculated by using rolling window as well. In this case, again the sub-period from February 4, 2005 to December 29, 2006 is employed as the base period.[7] Then the λ_{trace} statistics are estimated moving sample by one data point (i.e. $k = 1$) in each estimation. The plot of normalized the λ_{trace} statistics is presented in Figure 3. The overall results indicate a stable cointegration relationship between futures and spot prices with the exception of global financial crisis and Eurozone debt crisis periods. It can be seen from Figure 3 that the strength of cointegration relationship increased until mid 2007. This suggests that during the early stages of TurkDEX (started its official operation on 4 February 2005) there was a relatively weak cointegration relationship between futures and spot markets as futures markets matured (i.e. trading volume and liquidity increased in the futures market) the strength of cointegration relationship increased as well. However, there was a significant drop in the strength of the cointegration relationship between futures and spot prices starting from 2008 and weakened relationship continued until the mid-2010. There are also periods where the cointegration relationship was broken as financial crisis amplified and pricing in financial markets became seriously disturbed and series started drifting apart from each other.[8] The co-movement pattern of futures and spot prices seems to have been re-established in the mid-2010. Rolling estimation results indicate that recent global financial crisis and Eurozone debt crisis weakened and at times

[6] This subperiod can be considered as the introduction period (i.e. early stage of market development) of Turkish futures markets since the trading volume of futures contracts relatively low compared to the following periods.
[7] In this method fixed sample size (February 4, 2005 – December 29, 2006) contains 496 observations. To obtain plot of λ_{trace} statistics 1514 regression estimated.
[8] Lehman Brothers' bankruptcy on September 15, 2008 triggered the global financial crisis and the real impact of crisis in emerging markets started to be seen after November 2008. The Eurozone sovereign debt crisis started with Greek government debt crisis in late 2009 and it was intensified in early 2010. Examination of those periods where λ_{trace} statistics does fall below the 5 percent critical value reveal that our results of broken cointegration relationship between spot and futures coincide with these events. (See Figure 3)

broke the long-run relationship between cash and futures prices. In times of crisis, strained liquidity, increased transaction costs, and amplified volatility in the financial markets may hamper the cointegration relationship between futures and cash markets. An important lesson is that future studies need to take into account the potential changes in the nature of the long run relationship due to extreme market events driving the data generating process in order to obtain more reliable results when conducting research based on cointegration relationship between futures and cash markets.

Figure 3: Rolling λ_{trace} statistics



Note: This figure presents λ_{trace} statistics calculated on a rolling basis for window of 469, starting February 4th, 2005 and initially ending December 29th 2006. The sample length is maintained the same but the sample is allowed to change one observation at a time. Values greater than one in the plot indicate the rejection of no cointegration at 5 percent level.

4.0 Conclusion

This paper contributes to the literature by using two techniques namely time varying recursive and rolling cointegration tests to reexamine the dynamics of the spot index and index futures prices in Turkey. The results of cointegration tests provide evidence of a long run relationship between spot and futures markets which displays time variation in Turkish equity index market. We find that the cointegration relationship noticeably weakened and even broke down at times during the financial crisis and Eurozone crisis periods however, overall a stable relationship prevails. Our findings suggest that the weakened relationship is related to market turmoil and changing market sentiment. Since investor sentiment has a positive impact on price volatility and trading costs on both spot and futures markets this might explain the changing cointegration relationship between spot and futures prices during the recent crises. Our findings have policy implications for traders, hedgers and portfolio managers. When traders and hedgers determine their trading and hedging strategies and exchange regulators set rules to provide efficiency and liquidity in the markets, they have to take into account that economic functions of futures might be severely hampered during the distressed markets.

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