The profitability of an Index Arbitrage and dynamic relation between mispricing, volume, volatility and open interest in the ISE-30 Equity and Future Indices

by

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This is to certify that I have examined this copy of a master's thesis by

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and have found that it is complete and satisfactory in all respects,

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To People Whom I have never met.

ABSTRACT

This study searches for the profitability of index arbitrage in ISE-30 index futures market with using daily data series and the dynamic relationship between mispricing, volume, volatility, open interest of index future contract, volume and volatility of cash index and credit default swap is examined with applying vector auto regression (VAR) framework for Turkey market. I find that ISE-30 future index is mostly underpriced and there are many chances to exploit index arbitrage considering with different transaction cost levels in the market but the magnitude and the number of mispricing series tend to decrease over the years. Regarding to the cost of carry model, dividend payment has not much effect on mispricing and the pricing error is increasing with time to maturity. Moreover, the price tick-size change effect on mispricing is also analyzed by comparing pre and post price tick change period and the impact is insignificant. Finally, the variance decomposition and impulse response function are used to identify the dynamic interaction between variables and found that an increase in open interest results in decrease in mispricing which can be used as a good proxy for the arbitrageurs.

Keywords: Mispricing, Index Arbitrage, Cash and Carry Model, VAR, impulse response function

ÖZET

Bu çalışma Vadeli Opsiyon Borsasında (VOB) işlem görmekte olan İMKB-30 endeksine dayalı vadeli işlem sözleşmesinin fiyat dengesizliği sonucunda oluşan arbitraj imkanını günlük bazda incelemektedir. Buna ilave olarak, fiyat dengesizliğinin VOB İMKB-30 kontratlarının günlük hacmi, oynaklığı ve açık pozisyon değişimi, spot piyasadaki IMKB-30 endeksinin hacmi, oynaklığı ile Kredi temerrüt takası değişkenlerinin birbirleriyle olan ilişkileri de Vektör Otomatik Regresyon(VAR) kullanılarak araştırılmıştır. Yaptığım analiz sonuçlarının gösterdiği üzere, vadeli fiyatların teorik fiyatlardan çoğunlukla düşük olduğu ve farklı eşik değerlerine gore incelendiğinde piyasada çok fazla sayıda endeks fiyat dengesizliğine bağlı arbitraj imkanının bulunduğu fakat yıllar geçtikçe fiyat dengesizliğinin sayısı ve gücünün azaldığı görülmüştür. Taşıma Maliyeti modeli düşünüldüğünde, temettü veriminin fiyat dengesizliği hesaplamalarında çok da fazla bir etki yaratmadığı bunun yanında fiyat dengesizliğinin kontratların süresi vadeden uzaklaştıkça arttığı gözlemlenmiştir. Diğer taraftan, fiyat adım değişikliğinin fiyat dengesizliği üzerinde etkisi olup olmadığı, değişiklikten önceki dönem ile sonraki dönem kıyaslanarak incelenmiş ancak fiyat dengesizliği üzerindeki etkisi önemsiz bulunmuştur. Son olarak, varyans dekompozisyonu ve etki-tepki fonksiyonları uygulanarak değişkenler arası dinamik ilişki çözümlenmiş ve İMKB-30 vadeli sözleşmelerinin açık pozisyon sayısı arttığında fiyat dengesizliğinin azaldığı ortaya çıkarılmıştır ve bu sonuç piyasada arbitrajörler tarafından kullanması için iyi bir göstergedir.

Anahtar Kelimeler: Fiyat Dengesizliği, Taşıma Maliyeti Modeli, Vektör Oto Regresyon(VAR), Etki- Tepki Fonksiyonu

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1. Introduction

Index arbitrage has drawn strong attention to investors, hedge funds and arbitrageurs especially in the newly developing future markets such as Turkey, China and India. In terms of trading volume, the Turkish stock index future market is one of the fastest growing derivative markets in Europe. Arbitrageurs, seek to take the profit from pricing inefficiencies between future index price and cash index price which cannot sustain longer in the market. In the study, we empirically investigate the existence of mispricing and dynamic relationship between mispricing, volume, volatility of index futures and their cash index with macro indicator of credit default swap.

Since the introduction of stock index futures contracts, there have been wide range of research which have been focused on the relationship between futures index market and stock index market. A large number of them focus on the possible index arbitrage opportunities. Arbitrage opportunities appear when the futures price deviates from its theoretical value which is determined by the cost of carry model proposed by Cornell and French (1983). According to model, future price and spot price would normally stay in a bound which arbitrageurs cannot exploit arbitrage profits due to the transaction costs but when future price is out of the bound in both ways, mispricing occurs and arbitrageurs apply cash-and-carry or reverse cash-and carry arbitrage for bring to balance.

Wide range of studies have been investigated mispricing series in the stock index futures market which a number have sought to identify whether the observed mispricing is large enough to be profitably in different market by using daily and high frequency data. On the whole, the existing literature finds that arbitrage profit exist but are small and have decreased over the years. In the US, Cornell and French(1983), Modest and Sundaresan(1983), Figlewski (1984) worked on daily data and find significant arbitrage opportunities but the strength of mispricing will disappear close to maturity. In addition to that, Mackinlay Ramaswamy(1988), Harris(1987) analyzed mispricing with different minute interval and showed that many deviations occurs between observed future price and theoretical price of index which arbitrageurs can significantly benefit from mispricing. To behind using high frequency data, researchers can apply different techniques to avoid non-synchronous problems and still these models confirm the existence of profitable arbitrage opportunities (Stoll and Whaley (1990), Harris (1987)). There are also many other studies from different

markets indicate the existence of arbitrage. Yadav and Pope(1990), Garret Taylor(2001) for the FTSE 100 in the UK; Fassas(2010) for FTSE/ATHEX-20 in Greece; Bialkowski and Jakubowski(2006) for WIG 20 in Poland; Bühler and Kempf(1995) for DAX in Germany; Vipul(2008) for single stocks futures in India; Zhou and Wang(2012) for CSI300 in China; Cummings and Frino (2008) in Australia; Brenner et al (1989) for the Nikkei in Japan. Adversely, Klemkosky and Lee (1991), Butterworth and Holmes (2000) and Lai and Marshall (2002) could not find any evidence of mispricing series. Additionally, Figlewski(1994), Yadav and Pope(1990), Brailsford and Hodgson(1997) Fassas (2010) found that mispricing has been mostly on negative territory and the mispricing series are mean reverting process with underpriced in future contract also future contract (reverse cash and carry arbitrage).

In the literature researchers have been trying to explain the reason of mispricing in a number of papers. Cornell and French (1983) find that tax-timing has an effect on reducing the predicted future prices result in mispricing. Peters (1985) show that mispricing is caused by the dividend uncertainty oppositely, Yadav and Pope (1990) and Figlewski (1984) defined as dividend risk is not important factor on mispricing. MacKinlay and Ramaswamy (1988), Yadav and Pope (1990) suggest that mispricing level tend to be higher for longer time to future contract maturity. The mispricing is also result of other factors for instance lack of information about the market behavior indicated by Figlewski(1984), unequal lending and borrowing rate in Gould(1988) and short selling restriction affect on mispricing in McMillan(2009)and Kempf(1998). It is hard to define the significance level of each variable that are supposed to affect on mispricing (see Modest & Sundresan, 1983).

There are also a few researchers seek for the dynamic relationship and causality between volatility, open interest, trading volume and index future mispricing with applying vector autoregressive (VAR) approach. Ferris et al (2002) showed that there is a strong dynamic interaction among these variables in S&P futures which is similar to findings of Chen et al (1995) and Chan and Chung (1993). They found that increase in mispricing leads to decrease in volatility and vice versa. Theobald and Yallup (1996) searched for the UK stock index futures and found mispricing has a negative relation with the volatility but positive effect on the trading volume. Brailsford and Hodgson (1997) conclude that mispricing has been affected by both futures trading volume and volatility in Australia future market. Contrarily, Merrick(1987) , Hemler and Longstaff(1987) and Vipul(2008) found volatility does not have any significant effect on mispricing but Vipul(2008) interestingly showed that mispricing has a positive auto-correlation with open interest up to four day lags for India Future Market.

The overall finding, in brief, show that profit arbitrage opportunities in ISE-30 index futures exist although their frequency and size appear to have decreased over the years as the future has matured. Furthermore, mispricing have strongly related to time to maturity on future contracts and dividend uncertainties on underlying of shares have been found. In addition, using a Vector auto regression(VAR) framework, I question whether mispricing, future volume, future volatility, future open interest, cash volume, cash volatility and credit default swap has a particular relationship with the observed data on these variables. In the literature, there has not been sufficient research done for Turkey future market after the introduction to financial markets, my main motivation on my thesis is to bridge this gap.

The rest of the study is organized as follows. In the next section the characteristics of the future market in Turkey is explained. Section 3 explains the index arbitrage. Section 4 presents data descriptions and methodology while section 5 provides empirical results from cost and carry and VAR model in the stock index futures markets. Finally, section 6 presents conclusion.

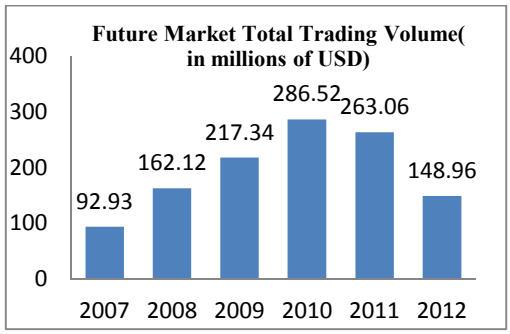
2. Futures Market in Turkey

TurkDex is the acronym for the Turkish Derivative Exchange where futures and option contracts are traded. TurkDex was registered as a business in 2001 and started derivative operations in February 2005. Ever since that time futures market has been growing rapidly in its trading volume and TurkDex has been awarded as the third world's fastest growing Derivative Exchange according to FIA in 2009. At present TurkDex is the 28th biggest future market in the world. In addition, TurkDex has drawn extra attention to local and foreign investors due to easy tax policy which are tax free for institutional foreign investors and for local investors not to pay any withholding tax for equity future contracts and pay 10% withholding tax for other instruments.

TurkDex currently has products of equity index (ISE-30, ISE-100 and ISE 30-100 spread), foreign currency (USD/TRY and EUR/TRY), commodity (cotton and wheat) and precious metal (Gold) future contracts and plans to implement options on these contracts in the near future. Future contracts are continuously traded between 9:15 am and 17:45 pm. (Cash trading session starts at 9:50 am to 17:40 with a break from 12:30 pm to 14:20 pm) the average daily volume of trading in futures is around US$ 1.3 billion. TurkDex also reached a total trading volume of over US$ 263 billion in 2011 and till end of July 2012 it is around US$ 132 billion. In fact ISE-30 equity index futures contracts is the most liquid financial instrument within the

financial system in Turkey and possesses more than 90 percent of the total turnover value of the future market with exceeding US$ 1 billion. The ISE-30 index futures represent an equity index consisting of 30 most highly capitalized and actively traded stocks in the Istanbul Stock Exchange. ISE-30 index futures value calculated based on the companies regarding to ISE National-30 stock price index by using the index's calculation method. The contract size in ISE-30 index future is around 4500$ with 10% margin requirement which enable even for the small investors to participate in the market. Future contracts are traded in a range of two month periods so that there are six maturities (February, April, June, August, October, and December) expired per year and contracts with three different expiry months nearest to the current month traded concurrently.

Figure 1



*2012 includes data until August 2012

Figure 2

*2012 includes data until August 2012

3. Index Arbitrage

Index arbitrage is a type of investment instrument that generates profit from the differences between projected future price of a stock index and the actual price of that same index. This involves with selling stock index future while buying the stocks of basket or buying the stock index future while selling the stocks of basket in the same index simultaneously. As with any attempt to generate this type of profit, the idea is to minimize the degree of risk involved as much as possible. Similar to all arbitrage opportunities, index arbitrage opportunities vanishes immediately once the mispricing is in the range of exploitable level and many arbitrageurs act quickly on it in the market.

The arbitrageurs must improve an accurate assessment of the projected price of the stock index futures in order to exploit the profitable index arbitrage. The main idea is the to analyze the various factors that are highly impact on index futures including dividend yield, time to maturity and cost of carrying of stocks considering interest rate benchmark. Since the idea is

to reduce the risk as close to zero as possible, pricing the future index futures is very important for the index arbitrage.

In the market, the only arbitrageurs executing index arbitrage are the proprietary traders and hedge fund managers as the small investors cannot compete with the large money managers. Because commission charge for small investors are higher than the proprietary traders and small investors pays more for borrowing cost of stocks by short selling the basket. Also it is hard to find to borrow 30 securities in the ISE-30 index composite for small local players from The Securities Lending and Borrowing Market which is operated by the ISE Settlement and Custody Bank (Takasbank). Therefore, the highness of transaction cost band for the small investors and inability to compete with the corporate investors make impossible to take part in the index arbitrage profit in the market so proprietary traders and hedge fund managers dominates the market with using low cost advantage.

Some complications confront the arbitrageurs while applying index arbitrage with stock of basket and ISE-30 futures which make it difficult. First, index arbitrage requires the acquiring a basket of stocks that fully replicates the index and simultaneous execution of the future contract. Thus, the coordinating the future contract execution with the stock of basket is a key point to set up the process. Moreover, the potential for mismatched basket completion versus execution of future contract is risky so the basket of stock perfectly must match up with the ISE-30 index composite. These structural characteristics present formidable challenges for arbitrageurs.

4. Methodology

4.1 Pricing the fair value and measuring the mispricing

The theoretical price of an index is approximately equal to the current value of the underlying shares of index plus an amount reffered as the cost of carry. The cost of carry basically is the cost of holding the underlying shares with interest on a loan over the life of the future contract, minus the amount that shareholders would receive in dividends if they keep those shares until dividend payment days. The theoretical price for the index futures with expired date T at time t, $F^*_{(t,T)}$ is calculated as;

$$F^*_{(t,T)} = \left(S_t - D_{t,T}\right) e^{\, r_{t,T}(T-t)} \qquad (1)$$

Where S_t shows the price of spot index (ISE-30) at time t, $D_{t,T}$ is the present value of the dividends paid between time t and T in index point basis, $r_{t,T}$ is the risk-free interest rate attained with linear interpolation of the labor rates regarding to time to maturity.

Equation (1) is the fair value of spot index and based on the presumption that markets are perfect, there are no taxes and transaction cost and all arbitrageurs have non-stochastic interest rates. According to Vipul (2008) this model has more decent understanding and capturing the real market movements than the alternative model with constant dividend yield assumption. In practice, dividend amounts are difficult to know the exact rate and investors face up with uncertainties into cost of carry calculation but in recent years the projection of dividends prove to be quite accurate in ISE-30.

Consistent with Yadav and Pope (1990) and Butterworth and Holmes (2000), I analyzed for the presence of mispricing by identifying deviations from the theoretical fair price estimate derived in Equation 1. The mispricing series (M_t) are constituted with taking the differences between the actual observed future price ($F_{(t,T)}$) and fair value of future price divided by the value of ISE-30 spot index:

$$M_t = \frac{F_{t,T} - F^*_{t,T}}{S_t} \qquad (2)$$

In my empirical analysis $F_{(t,T)}$ is the settlement price of future index contract which is the weighted average price of all the transactions performed within the last 10 minutes before the closing of the trading session and $S_{t,T}$ is the closing price of underlying spot index. To reason behind dividing the deviation from fair value with $S_{t,T}$ is to normalize the mispricing series so that the transaction costs that arbitrageurs are exposed and are expressed as a percentage of points of spot index.

Market mispricing allows immediate riskless profits to be realized. When the mispricing is positive that means future index is overpriced and exceeds its fair value. In that time an opportunity arises for arbitrageurs to capture the profit by applying cash and carry model (Short future arbitrage). This requires the arbitrageurs to sell the future index contract and buy the basket of stocks at the same time. Note that you borrow the money with risk-free interest rate and buy the underlying asset and locked in the futures with open the short position. The net cost of buying stock with borrowing rate is a key factor to define the transaction cost

band. Adversely, when the mispricing is negative future index price is counted as underpriced, than arbitrageurs can engage in reverse cash and carry transactions (long future arbitrage). This requires arbitrageurs to borrow stocks to sell in the open market (short selling) and buy stock index futures simultaneously. Taking the consideration, the money which is collected from selling the stocks in the arbitrage, will be lent with a risk free rate therefore the lending rate is an also indicator of transaction cost band. In the study, lending rate and borrowing rate is assumed to be equal to define the transaction band for simplification.

In reality an arbitrage window is determined by the transaction costs (lending rate, borrow rate and commission charge) and if the cash-future basis is large enough to cover the transaction costs ($|M_t| > C$) associated with trading both in stocks and future contracts, then arbitrage can be exploited actively. In the model it is assumed that the arbitrage positions are held until the expiration of contract to search for the profitability of arbitrage in Turkey market.

4.2 Vector Auto Regression (VAR) measurement

In the second part, I search for the dynamic relation between mispricing and six other variables such as daily level of open interest in future contract, volatility of future prices, volume of the future contracts, stock index of turnover, index spot price volatility and credit default swap ratios. Following similar methods with Vipul (2008) and Ferris et al (2002), VAR (vector auto regression) estimation process is used for the identifying the strength of relation among these seven variables with a lag of five days is examined.

For the presenting model the following notations are provided from the TurkDex official web page for the future contract and Bloomberg and ISE official website for the stocks.

Where:

1. Daily highest (F_{ht}) and lowest (F_{lt}) prices of future contracts on day t.
2. Open interest($FTOP_t$) of future contact as a number of contracts at the end of day t
3. Daily trading volume of the Future index contract($FTVOL_t$) number of contract basis on day t
4. Daily highest (CS_{ht}) and lowest (CS_{lt}) price of cash index on day t.
5. Daily turnover of the cash index($CSVOL_t$) on day t
6. Daily prices of Credit Default Swap((CDS_t) at the end of day t (Turkey 5 year)

The variables of regression analysis are constructed as follows; FTOP, is the difference in natural logarithms of the daily open interest $\left\{\ln\left(\frac{FTOP_t}{FTOP_{t-1}}\right)\right\}$. FTVOL is the difference in natural

logarithms of the future index contract daily volume $\left\{\ln\left(\frac{FTVOL_t}{FTVOL_{t-1}}\right)\right\}$. CSVOL, is continuously compounded rate of change in cash price $\left\{\ln\left(\frac{CSVOL_t}{CSVOL_{t-1}}\right)\right\}$.CDS, is the difference in natural logarithms of the Credit Default Swap 5-year Turkey $\left\{\ln\left(\frac{CDS_t}{CDS_{t-1}}\right)\right\}$. To derive for the volatility of futures index contract prices ($FTVLT_t$) and volatility of stock index price($CSVLT_t$), Parkinson's Formula is used.

Parkinson formula is widely accepted and utilized for estimating the historical volatility of an underlying based on high and low prices during certain periods. Before Parkinson's Formula, the diffusion constant which characterizes the random walk, was traditionally estimated using only closing prices but Parkinson (1980) proposes a volatility measure assuming an underlying Geometric Brownian motion with no drift for the prices and shows that with using high and low prices the estimation is much more efficient comparing to the closing price estimation. Also following Parkinson's methodology Floros (2009) analyzed for the US stock and future price which found that daily prices can be characterized by the Parkinson's methodology.

Parkinson range based method is formulated as:

$$\sigma^2 = \frac{1}{4\ln 2}\frac{1}{n}\sum_{i=1}^{n}(\mathrm{l_i})^2$$

$$\sigma^2 = \frac{0{,}3607}{n}\sum_{i=1}^{n}(l_i)^2$$

$l_i = \ln(CS_{hi}) - \ln(CS_{li})$ is the logarithmic difference of the highest and lowest price for the i'th day. For my sample I apply for the single day's highest and lowest price both for the stock index price and future index price (i.e. n=1). The simplified formula given below is used to calculate the spot index price and future index price volatility.

$$\sigma_{FTVLT} = 0{,}601\ln\left(\frac{\mathrm{FT_{ht}}}{\mathrm{FT_{lt}}}\right) \qquad \sigma_{CSVLT} = 0{,}601\ln\left(\frac{\mathrm{CS_{ht}}}{\mathrm{CS_{lt}}}\right)$$

Ordinary Least Squares (OLS) is used for the regression analysis to determine the dynamic relationship between seven time series variables. Each OLS regression shown below has the same number of lagged endogenous variables which generates identical results.

$$M_t = a_1 + \sum_{1}^{5} b_{1k} M_{t-k} + \sum_{1}^{5} c_{1k} FTVOL_{t-k} + \sum_{1}^{5} d_{1k} FTVLT_{t-k} + \sum_{1}^{5} e_{1k} FTOP_{t-k} + \sum_{1}^{5} f_{1k} CSVOL_{t-k} + \sum_{1}^{5} g_{1k} CSVLT_{t-k} + + \sum_{1}^{5} h_{1k} CDS_{t-k} + \varepsilon_{1t}$$

$$FTVOL_t = a_2 + \sum_{1}^{5} b_{2k} M_{t-k} + \sum_{1}^{5} c_{2k} FTVOL_{t-k} + \sum_{1}^{5} d_{2k} FTVLT_{t-k} + \sum_{1}^{5} e_{2k} FTOP_{t-k} + \sum_{1}^{5} f_{2k} CSVOL_{t-k} + \sum_{1}^{5} g_{2k} CSVLT_{t-k} + \sum_{1}^{5} h_{2k} CDS_{t-k} + \varepsilon_{2t}$$

$$FTVLT_t = a_3 + \sum_{1}^{5} b_{3k} M_{t-k} + \sum_{1}^{5} c_{3k} FTVOL_{t-k} + \sum_{1}^{5} d_{3k} FTVLT_{t-k} + \sum_{1}^{5} e_{3k} FTOP_{t-k} + \sum_{1}^{5} f_{3k} CSVOL_{t-k} + \sum_{1}^{5} g_{3k} CSVLT_{t-k} + \sum_{1}^{5} h_{3k} CDS_{t-k} + \varepsilon_{3t}$$

$$FTOP_t = a_4 + \sum_{1}^{5} b_{4k} M_{t-k} + \sum_{1}^{5} c_{4k} FTVOL_{t-k} + \sum_{1}^{5} d_{4k} FTVLT_{t-k} + \sum_{1}^{5} e_{4k} FTOP_{t-k} + \sum_{1}^{5} f_{4k} CSVOL_{t-k} + \sum_{1}^{5} g_{4k} CSVLT_{t-k} + \sum_{1}^{5} h_{4k} CDS_{t-k} + \varepsilon_{4t}$$

$$CSVOL_t = a_5 + \sum_{1}^{5} b_{5k} M_{t-k} + \sum_{1}^{5} c_{5k} FTVOL_{t-k} + \sum_{1}^{5} d_{5k} FTVLT_{t-k} + \sum_{1}^{5} e_{5k} FTOP_{t-k} + \sum_{1}^{5} f_{5k} CSVOL_{t-k} + \sum_{1}^{5} g_{5k} CSVLT_{t-k} + \sum_{1}^{5} h_{5k} CDS_{t-k} + \varepsilon_{5t}$$

$$CSVLT_t = a_6 + \sum_{1}^{5} b_{6k} M_{t-k} + \sum_{1}^{5} c_{6k} FTVOL_{t-k} + \sum_{1}^{5} d_{6k} FTVLT_{t-k} + \sum_{1}^{5} e_{6k} FTOP_{t-k} + \sum_{1}^{5} f_{6k} CSVOL_{t-k} + \sum_{1}^{5} g_{6k} CSVLT_{t-k} + \sum_{1}^{5} h_{6k} CDS_{t-k} + \varepsilon_{6t}$$

$$CDS_t = a_7 + \sum_{1}^{5} b_{7k} M_{t-k} + \sum_{1}^{5} c_{7k} FTVOL_{t-k} + \sum_{1}^{5} d_{7k} FTVLT_{t-k} + \sum_{1}^{5} e_{7k} FTOP_{t-k} + \sum_{1}^{5} f_{7k} CSVOL_{t-k} + \sum_{1}^{5} g_{7k} CSVLT_{t-k} + \sum_{1}^{5} h_{7k} CDS_{t-k} + \varepsilon_{7t}$$

Where a_1 through a_6 are intercepts terms; ε_{1t} through ε_{7t} are random errors and b_{11} through h_{75} are the regression coefficients of the OLS estimation. To avoid the high contemporaneous correlations between variables, following the Vipul (2008), I used only for the lagged values of explanatory variables and exclude the same time period (t) of the variables because a certain change in the market at time t might have an impact on more than two variables simultaneously and also putting these variables on the right hand side as an independent variable might mislead the VAR estimation and might fail to find the correct dynamic interaction and causal relation between variables in the regression system. Moreover, Augmented Dickey-Fuller unit root tests are carried out to show that all seven variables have stationary characteristics with different time lags. The partial auto-correlation function defines the maximum number of time lags for each variable. Tests are applied with using an intercept, an intercept plus a time trend and neither an intercept nor a time trend. Results of the tests justify that all variables are stationary time series regardless of lag numbers. The lags are chosen with respect to Schwarz Criteria are indicated at Appendix 1. Finally, the strength and the direction of impact on the variables are analyzed with Granger Causality/Block Exogenity Wald tests, Variance Decomposition and Impulse Response function.

For the regression analysis in the study, I omitted the expiry day data of each future contracts from the dataset because open interest of future contract on expiry day is zero this will vitiate the estimation and in order to achieve the rate of change of open interest for the first day, I would rather to use near future contract which has also high volume. Absolute mispricing (absolute value of M_t) is also used for the calculation of regression analysis but the results do not change. Therefore I did not put the regression result for the brevity.

5. Empirical Results

5.1Behaviour of the mispricing series

Financial Institutions or Brokerage house can benefit from arbitrage opportunities in the market if mispricing exceeds transaction costs. Transaction cost is the key factor of defining the arbitrage window. Transaction costs involved in index arbitrage include: round trip commission of cash market with buying and selling the stocks, round trip commission of future market to open long or short position and to close the same position and borrowing the money at risk-free rate or lock-in the money without risk-free interest rate payment. In Turkey transaction cost differs to financial institutions, members of ISE and TurkDex. The foreign traders pay more for commission charge than proprietary traders for local brokerage houses. Investors also tend to pay more for stock market executions than future market. Mostly, researchers assume one way commission charge for future market execution in their studies but investors have to pay commission charge even they keep their position till at the end of expiry date in Turkey. Therefore, I assume 0.15 per cent brokerage round trip commission for cash market, 0.10 per cent for round trip commission charge for future market, 0.20 percent for loss of opportunity cost of risk-free interest rate and totally 0.45 per cent transaction costs which investors or financial institutions are at least faced by. Consequently, in the analysis which follows, I define the total round-trip costs for arbitrageurs as 0.45, 0.90 and 1,35 transaction bands so whenever mispricing exceeds 0.45 percent level there would be chance to take arbitrage profit.

Figure 3: The ISE-30 cash-future mispricing series period between 2007 and 2012

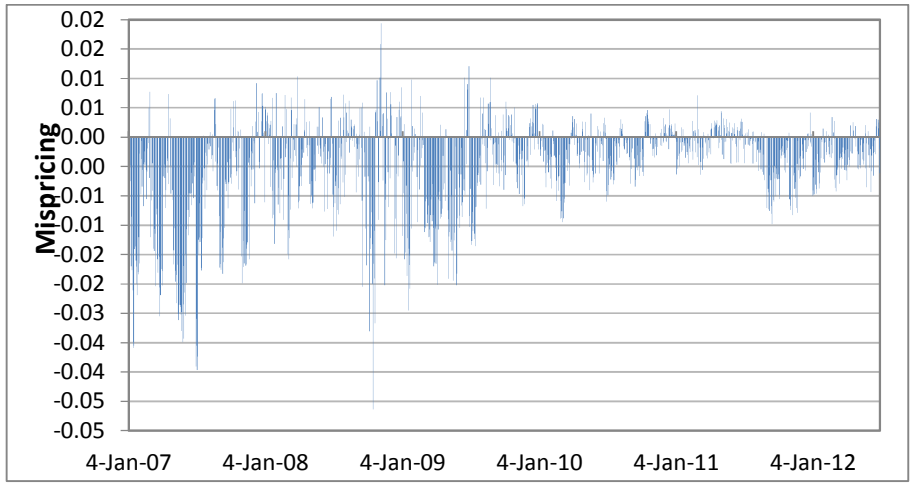


Table 1: Summary statistic relating to the mispricing series of ISE-30 contract

Contract	Obs	Mt >0	Mt <0	Median	Mean	t-statistic	S.D	Max.	Min.	Ave Abs	M>C C= 0.0045	M>C C= 0.0090	M>C C= 0.0135
February-07	40	1	39	-0.01115	-0.01333	-2.94536	0.01070	0.00505	-0.03588	0.01358	32*	22	18
April-07	42	3	39	-0.01209	-0.01279	-2.82716	0.00980	0.00776	-0.03048	0.01367	36*	27	19
June-07	44	0	44	-0.02171	-0.01959	-4.32757	0.00944	-0.00005	-0.03489	0.01959	42*	38	30
August-07	44	9	35	-0.00498	-0.00938	-2.07332	0.01223	0.00663	-0.03968	0.01039	27*	16	12
October-07	41	7	34	-0.00723	-0.00803	-1.77321	0.00838	0.00623	-0.02326	0.00910	29*	14	10
December-07	41	14	27	-0.00432	-0.00711	-1.57184	0.01019	0.00919	-0.02486	0.00927	24	16	13
February-08	43	16	27	-0.00354	-0.00343	-0.75780	0.00685	0.00753	-0.01818	0.00621	25*	9	4
April-08	42	12	30	-0.00290	-0.00398	-0.87972	0.00708	0.01037	-0.02081	0.00606	20	11	4
June-08	42	9	33	-0.00360	-0.00389	-0.85881	0.00495	0.00688	-0.01265	0.00511	22	7	0
August-08	44	18	26	-0.00119	-0.00308	-0.67946	0.00635	0.00722	-0.01694	0.00534	19	10	2
October-08	41	11	30	-0.00670	-0.00923	-2.04051	0.01240	0.00966	-0.04635	0.01123	29*	18	14
December-08	39	21	18	0.00064	-0.00155	-0.34210	0.00983	0.01939	-0.02524	0.00759	23	11	7
February-09	41	8	33	-0.00488	-0.00763	-1.68680	0.00953	0.00978	-0.02951	0.00896	24	15	12
April-09	43	3	40	-0.01330	-0.01281	-2.83040	0.00622	0.00208	-0.02516	0.01298	38*	35	21
June-09	41	8	33	-0.01010	-0.00929	-2.05307	0.00942	0.01210	-0.02525	0.01137	35*	27	15
August-09	44	12	32	-0.00508	-0.00523	-1.15655	0.00800	0.01017	-0.01854	0.00758	28*	15	8
October-09	41	17	24	-0.00087	-0.00112	-0.24767	0.00396	0.00606	-0.00895	0.00329	13	0	0
December-09	42	15	27	-0.00223	-0.00217	-0.47889	0.00498	0.00575	-0.01175	0.00448	18	5	0
February-10	40	3	37	-0.00327	-0.00385	-0.85042	0.00306	0.00226	-0.01088	0.00412	15	2	0
April-10	44	13	31	-0.00266	-0.00375	-0.82813	0.00523	0.00357	-0.01447	0.00474	16	8	4
June-10	42	14	28	-0.00128	-0.00221	-0.48744	0.00368	0.00402	-0.01132	0.00321	11	2	0
August-10	43	7	36	-0.00210	-0.00295	-0.65158	0.00345	0.00304	-0.01097	0.00342	14	3	0
October-10	40	12	28	-0.00280	-0.00223	-0.49383	0.00389	0.00460	-0.00842	0.00389	15	0	0
December-10	41	23	18	0.00034	0.00014	0.03086	0.00181	0.00473	-0.00345	0.00146	1	0	0
February-11	41	8	33	-0.00142	-0.00167	-0.36994	0.00210	0.00278	-0.00638	0.00213	4	0	0
April-11	44	20	24	-0.00016	-0.00030	-0.06711	0.00259	0.00715	-0.00640	0.00197	4	0	0
June-11	43	28	15	0.00074	0.00040	0.08939	0.00228	0.00447	-0.00456	0.00183	1	0	0
August-11	42	11	31	-0.00128	-0.00181	-0.39885	0.00230	0.00132	-0.00732	0.00214	7	0	0
October-11	42	1	41	-0.00616	-0.00633	-1.39846	0.00399	0.00078	-0.01483	0.00637	26*	12	1
December-11	41	4	37	-0.00368	-0.00484	-1.06945	0.00441	0.00418	-0.01326	0.00513	20	8	0
February-12	43	9	34	-0.00304	-0.00349	-0.77065	0.00377	0.00342	-0.00999	0.00397	13	5	0
April-12	42	5	37	-0.00364	-0.00369	-0.81572	0.00279	0.00257	-0.00921	0.00406	18	1	0
June-12	43	8	35	-0.00251	-0.00246	-0.54391	0.00300	0.00308	-0.00931	0.00318	13	1	0
2007-2012	**1386**	**350**	**1036**	**-0.00335**	**-0.00524**	**-1.15864**	**0.00807**	**0.01939**	**-0.04635**	**0.00659**	**662**	**338**	**194**

* refers to the mispricing occurrence in specified contract which exceeds the significance level according to the 0.66 percentile (24.78) over the sample.

Mispricing is calculated by applying Equation 2 to sample from January 2007 to June 2012. The daily mispricing series are shown in figure 3 and summarized in Table 1. As figure 3 illustrates that in the first three years period (2007-2009) has higher magnitude of mispricing than the last three years period (2009-2012). ISE-30 future contracts seem to be fairly priced and mispricing has been steadily in the negative territories. Table 1 contains summary statistics of ex post mispricing series related to ISE-30 index cash and future price for thirty-three contracts. The direction of mispricing is found to be mostly underpriced on 1036 (74.7 %) out of 1386 daily observation, on the other hand 350 of sample is found to be overpriced (25.3%). It is also found that future prices have high deviations from theoretical price range between %2 to % -5 while the mean is -0.542% and the median is -0.335% for the sample. This confirms that future contracts are priced at significant discount to theoretical price over the period. The gap between minimum and maximum value of mispricing, the standard deviation and the absolute value of average mispricing series have noticeably decreased since start from February 2007 to June 2012 contracts. It is also found to be statistically significant at 1% and 5% level in the first four contracts in 2007 then the significance occasionally appeared in the remaining part of the period. This result verifies that there has been considerable improvement in pricing efficiency for future contract as reasons explained later.

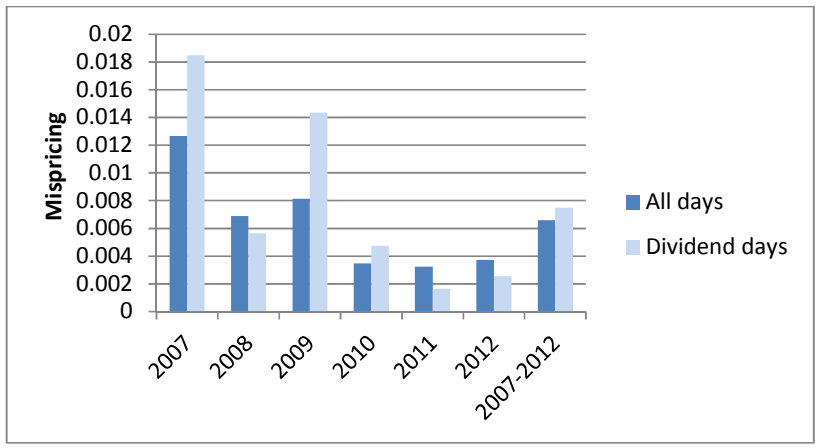
Lastly, the transaction cost violations for mispricing series related to ISE-30 at 0.45%, 0.90% and 1.35% is shown in the last three columns in Table 1. The empirical study denotes that the violations of mispricing in ISE-30 contracts at 0.45% level can be seen 662 days (47%), at 0.90% level mispricing violations in ISE-30 is associated with 338 days (24%), Interestingly, mispricing violations in ISE-30 contracts at highest level of 1.35% is also observed with 194(14%) days in the 1386 daily observations. Even substantially declining appeared since the beginning of February 2007 contract for the average value of mispricing, there has been many chances to exploit index arbitrage mostly with short cash-long futures process (reverse cash-and-carry) but also the other way process (cash-and-carry) can still be applicable in a few times during the periods in Turkey market. By comparison, using similar approach, Butterworth and Holmes (2000) found that mispricing violations faced by arbitrageurs with transaction costs of 0.5% level is violated 5% days for FTSE-100 contracts and 14% for MID-250 contracts in the 634 daily periods, At 1% level mispricing violations have been observed less than % 1 of days for MID-250 and only 1 day for FTSE-100 while they could not find mispricing violations for both contract in UK at 1.5% level. This results show that the absolute average value of mispricing for ISE-30 tends to continue with different transaction cost constraint windows so that arbitrageurs can take the actions of index arbitrage profit

more frequently than for the FTSE-100 and MID-250 indexes which are shown in the Butterworth and Holmes (2000) study for UK market.

5.2 Mispricing relation to dividend payment

ISE-30 index is constituted of 30 companies with highest level of free float market capitalization selected among the stocks of companies listed on National Market in Turkey. Dividend yield is really key factor of defining the index price. Around 15 of 30 companies distribute cash dividends with annually basis in a year and the companies pay roughly 2% dividend yield mostly in the first half of the year. The complexity in the pricing of Index futures is the fact that the dividend amount D, used to calculate the Index price at time t = 0, is based on analyst consensus and historical data. So Investors and arbitrageurs have to estimate perfectly for how much and when companies will distribute the dividend yields in order to calculate the index price correctly. Therefore I compare the mispricing series on dividend payment days with the all sample whether to see dividend payment days have any effect on mispricing and how effectively Index future is priced on payment days.

Figure: 4 Comparison of mispricing on dividend payment days over the sample



According to figure 4 presents, the mispricing on dividend ex-dates is especially higher than the average sample in the first years of future market (60 basis points in 2007 and 2009) but this difference has been started to disappear since the start of 2010. Surprisingly, mispricing on dividend payments is less than the average in 2011 and 2012. There are two main reasons behind this inequality. First, the dividend estimation was not sufficiently good enough in the first years so the forecast amount dividend differ between institutions caused the miscalculation of the fair value, lead to the risk of exposing arbitrage. Secondly, the market

was not efficient at first. The yearly total trading volume of ISE-30 index has gradually increased during the period 2007-2012 but the trading volume significantly accelerated in 2009 and was peaked in 2011(286,521 millions of USD) so the future market depth and liquidity possesses its own solid stability in 2009.

Figure 5: Dividend Measurement between 2007 and 2012 on ISE-30 spot index

	No. of Companies paid dividends	Dividend Yield(%)
2007	13	2,17
2008	15	4,43
2009	17	3,81
2010	19	1,96
2011	18	3,14
2012	22	2,94

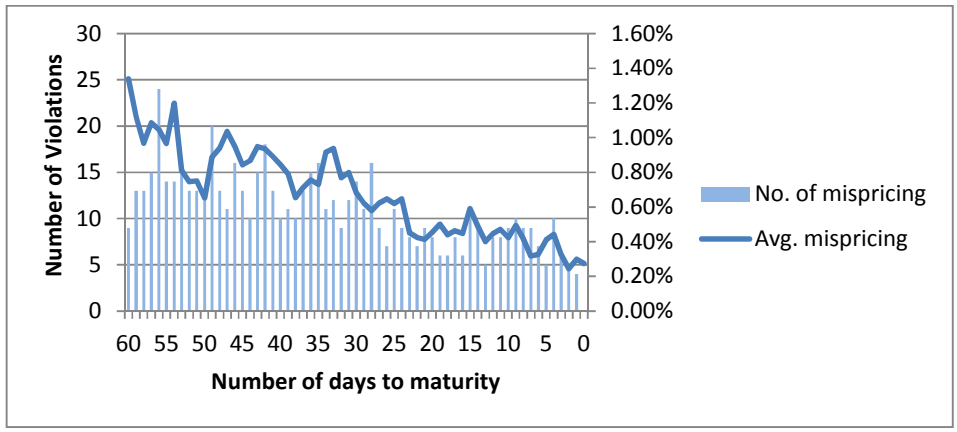
As figure 5 indicates that the number of companies which have paid dividend to stockholders has increased during the period between 2007 and 2012 for ISE-30 index. Also more companies in ISE-30 index distribute dividend compared to the past. In the second column in figure 5 is stated the dividend yields distributed by companies for ISE-30 index for each year. There is no trend for the dividend yield and varies from 2007 to 2012. According to cost of carry model, the dividend subtract from the underlying shares of index price while calculating the fair value of future price. As considering the mispricing series in our sample which is underpriced most of the period, higher dividend yield normally should decrease the mispricing. On the other hand, the dividend yield has its highest amount in 2008 and 2009 which has the biggest magnitude of the mispricing. As a result, dividend yield has not much impact on calculation of mispricing.

5.3 Time to maturity effect on mispricing

The cost-carry model assumes that time to maturity of the future contract should be positively correlated with the power of mispricing because as soon as the contract approaches to the expiration date, the impact of other factors such as dividend uncertainty, market to market flows and risk in tracking the stock index reduces. Figure 6 depicts the average mispricing ratio for different days to expiration. It is seen that the highest level of mispricing is occurred at the beginning period of contracts which suggest that if arbitrageurs start to exploit at this time, they will take the profit mostly. Besides, it shows that the closer to the expiration day, the less mispricing ratio appears and the average mispricing ratio is below the transaction cost level in the last 13 days of contract. It is also seen that the highest number of violations

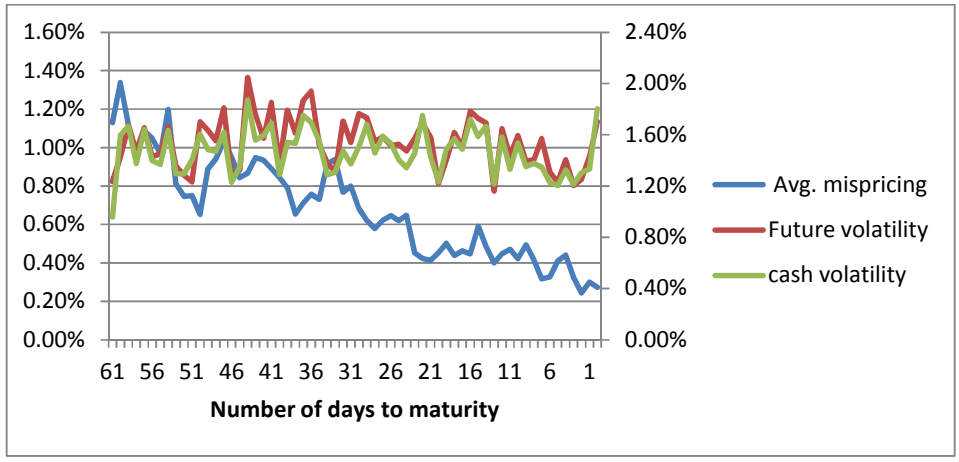
according to 0.0045 levels is happened mostly at the start of contracts and the number of violation decrease gradually with the time to maturity.

Figure 6: Average mispricing and number of mispricing according to 0.45% transaction cost band



As figure 7 plotted the relationship between mispricing, futures and cash index volatility related to time to expiration day. The volatility of futures and cash stay in 1.60%-2.00% level in the first half of the contract then they tend to decrease step by step to the 1.20%-1.60% level. Interestingly, the volatility increase in the last two days of contracts which may be due to the rolling over period to the nearest contract has an effect on the increment of volatility both on cash and future index.

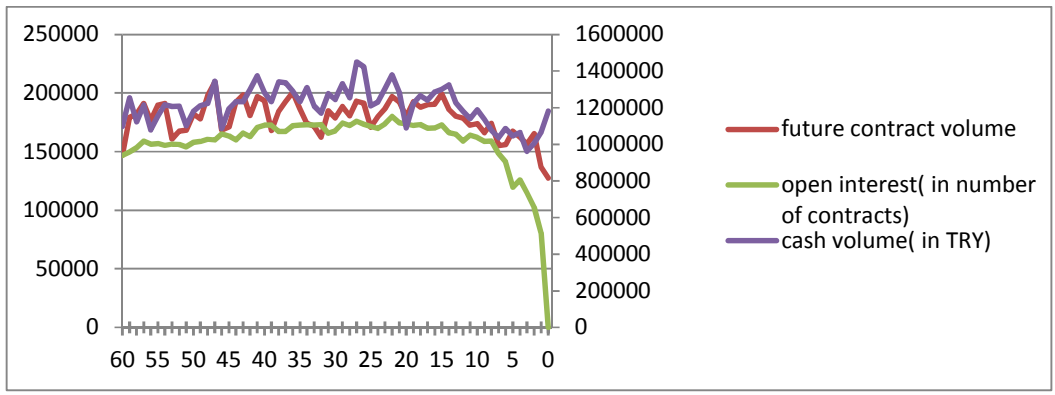
Figure 7: Relationship between average mispricing, future and cash volatility of ISE-30 Index



Supported by the existing literature see Yadav and Pope (1990), when a future contract approaches to the expiration day the trading volume decreases as trading interest shifts to the

next nearest future contract as hedgers roll over their positions and as speculators move to the increasingly liquid new nearby contract. The level of trading activity in both futures and stock follow a cyclical pattern with the highest level of activity occurring middle of the contract period. The average cash and futures trading volume with open interest of the future contract for the time of sixty days to the maturity are shown in figure 8. It is observed that both cash and future volume trading activity are inclined to decrease within the last ten days of contract period but surprisingly, cash trading volume start to increase rapidly on the last three day to expiration day. The arbitrageurs who do not want to carry out their position to the nearby contract have to execute basket orders on maturity day, may increase the trading volume of cash index.

Figure 8: Time to expiry patterns in trading activity



5.4 Price tick-size change effect on mispricing

Price efficiency in Turkey cash and future markets may be related to two reasons. Firstly, ISE reduced the minimum price variation (tick size) in half for the stock price on 1 November 2010 as shown in table 2. Intuitively, the trading volume is negatively related to trading cost. Since extensive tick size in stocks makes trading unnecessarily expensive by artificial inflating the spread, it forces investors to trade less than they otherwise would so reducing the tick size in half is likely to increase trading volume. The impact of reducing the minimum tick size is accompanied by both lower bid-ask spreads and lower the market depths especially on the most actively stocks generate liquidity increase. There are numerous papers like Ball. et. Al (1985) and Harris (1994) regarding the consequences of the changing the tick size and found that there is a considerable effect on the market depth and trading volume. For ISE-30 Index, before the reduction in tick size the bid-ask spread is around 600 basis points but after the adjustment on price tick size the bid-ask spread is down to 260 basis points. Interestingly,

the number of mispricing which is observed in period 2007-2012 tends to decrease after the adjustment in price tick size. Hence, the bid-ask spread reduction may have an effect on the decrease of the spread between future and cash index. As a result, I divided the dataset into two parts as pre-tick size and post-tick size to investigate for the price tick size change on mispricing with applying vector auto regression (VAR). First dataset includes the information without any change in price tick size (pre-tick size) on the other hand second dataset represent the information after the price tick-size adjustment by ISE on share prices. The comparison results are shown in the following section after the VAR estimation introduced.

Table 2: Price Tick Size change on ISE

Before 1 November 2010			**After 1 November 2010**	
Share of price range	**Price Tick**		**Share of price range**	**Price Tick**
0.01-2.50	0.01		**0.01-5.00**	0.01
2.52-5.00	0.02		**5.02-10.00**	0.02
5.05-10.00	0.05		**10.05-25.00**	0.05
10.10-25.00	0.10		**25.10-50.00**	0.10
25.25-50.50	0.25		**50.25-100.00**	0.25
50.50-100.00	0.50		**100.50-250.00**	0.50
101.00-250.00	1.00		**251.00-500.00**	1.00
252.50-500.00	2.50		**502.50-1000.00**	2.50
505.00 and upper	5.00		**1005.00 and upper**	5.00

5.5 Vector Auto Regression framework on Mispricing

I construct VAR system with seven endogenous variables to find the short run dynamic relation between arbitrage opportunities and six other variables in the ISE 30 index futures market. I choose the lag number of 5 for the system with following the Ferris et al (2002) and Vipul (2008) because of looking for the week days affect on variables. But I also test whether lag five is accurate for the VAR estimation with the lag length criteria based on seven-variable VAR system and the maximum lag number of 7, is reported in Table 3.

Table 3: VAR Lag Order Selection Criteria
Endogenous variables: MS, FTVOL, FTVLT, FTOP, CSVOL, CSVLT,CDS

Lag	LogL	LR	FPE	AIC	SC	HQ
0	18501.74	NA	2.74e-21	-27.48104	-27.45398	-27.47090
1	19537.99	2060.186	6.32e-22	-28.94799	-28.73144	-28.86688
2	19798.64	515.4736	4.61e-22	-29.26246	-28.85643*	-29.11038
3	19952.14	301.9814	3.95e-22	-29.41773	-28.82223	-29.19468*
4	20030.77	153.8803	3.78e-22	-29.46177	-28.67678	-29.16775
5	20102.49	139.6125	3.66e-22	-29.49553	-28.52107	-29.13054
6	20154.03	99.78550	3.64e-22*	-29.49931*	-28.33536	-29.06334
7	20197.61	83.91005*	3.67e-22	-29.49124	-28.13782	-28.98431

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

The lag order chosen by the LR test, the FPE, the AIC criterion and SC criterion are different except FPE and AIC. In the literature AIC is the most widely accepted criterion for the VAR analysis. But choosing the lag number of 5 which is close to the AIC criteria level will not vitiate the estimation process.

Short run effect on mispricing with using explanatory variables (future volume, future volatility, future open interest, spot volume, spot volatility and cds) is captured by using lag order five Vector auto regression (unrestricted VAR with strictly stationary variable) according to sub periods of the pre-tick size and post- tick size period and all sample which are reported in Table 4.

Table: 4 Explanatory Power of Variables on mispricing with VAR estimation

	Pre-Tick Size change	Post-Tick Size change	All sample
	MS	MS	MS
MS(-1)	[12.4127]**	[4.61498]**	[14.7813]**
MS(-2)	[4.88630]**	[4.74422]**	[6.20218]**
MS(-3)	[5.42980]**	[3.19394]**	[6.32895]**
MS(-4)		[2.11765]*	
MS(-5)		[2.14795]*	
FTVOL(-4)		[2.97155]**	
FTVLT(-4)		[-2.60132]*	
FTOP(-2)	[2.40645]*	[3.85775]**	[3.44473]**
FTOP(-3)	[3.96707]**	[2.73740]*	[4.46804]**
FTOP(-5)	[2.49757]*	[3.78218]**	[3.27253]**
CSVOL(-1)	[-2.11652]*		
CSVLT(-4)		[2.81277]*	
CDS(-4)		[-2.79574]*	
R-squared	0.562801	0.572968	0.580916
Adj. R-squared	0.545799	0.532682	0.569736

* significant at 5% level (2-tailed) ** significant at 1% level (2-tailed), MS is mispricing; FTVOL is the daily rate of change in the future price volume; FVLT is the daily rate of change in future price volatility; FTOP is the daily rate of change in the open interest of futures; CSVOL is the daily rate of change in spot price volume; CSVLT is the rate of change in the spot price volatility; CDS is the daily rate of change in the credit default swap.

VAR result indicates that mispricing is affected significantly by their previous lagged values and lagged values of open interest in both sub periods and all sample. During the Pre-Tick size change period, the mispricing is affected significant at 5% level by the first lagged value of cash volume while fourth lagged of future volume, fourth lagged of future volatility, fourth lagged of cash volatility and fourth lagged of credit default swap are significant for the Post-Tick size change period. There are some differences between pre and post periods and the number of variables effect on mispricing seem more in Post-Tick size period as compared to the Pre-Tick change period but mispricing couldn't be explained longer than one lagged variables except its own and open interest. That gives us open interest is strong indicator of understanding the mispricing movements. On the other hand R-squared results are 56% for pre-tick size change period, 57% for the post-tick size change period and 58% for the all sample which illustrate that there is not essential improvement on explaining the mispricing and the power of explanatory variables does not change significantly during the sub periods. To be more precise for the effect of price tick-size change on mispricing, I analyze the sub

periods (Pre and Post tick size change) with using joint hypothesis of zero coefficients on all five lags of each variable.

Table: 5 The effect of lagged variables on mispricing

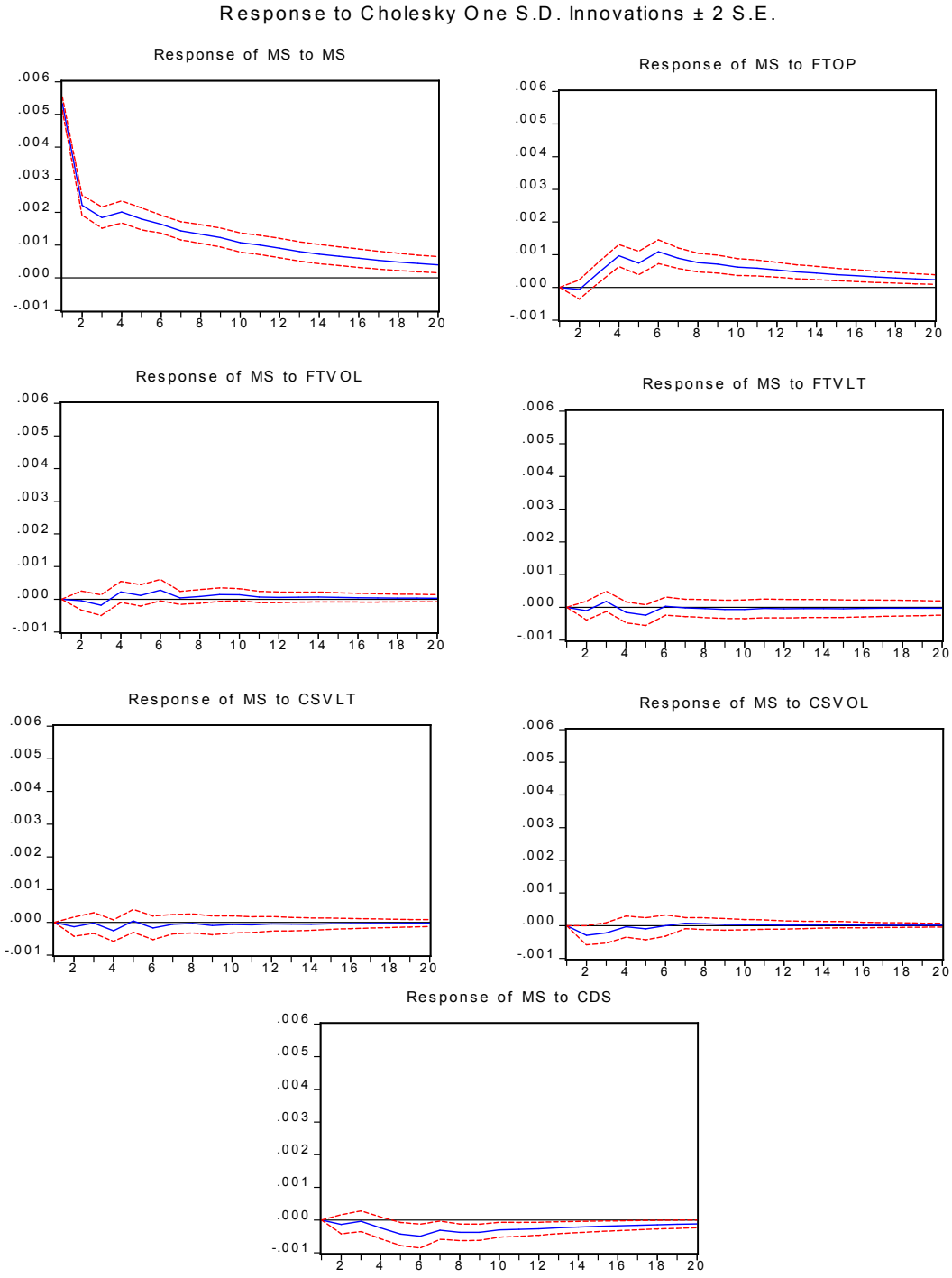
Dependent variable: MS			
	Pre-Tick Size	Post-Tick Size	All Sample
Explanatory Variables	**P. Value**	**P. Value**	**P. Value**
FTVOL	0.2606	0.0552	0.0583
FTVLT	0.4394	0.1474	0.2343
FTOP	0.0000	0.0000	0.0000
CSVOL	0.3227	0.3305	0.3082
CSVLT	0.7650	0.1055	0.4301
CDS	0.4244	0.0934	0.2101
All	0.0001	0.0000	0.0000

MS is mispricing; FTVOL is the daily rate of change in the future price volume; FVLT is the daily rate of change in future price volatility; FTOP is the daily rate of change in the open interest of futures; CSVOL is the daily rate of change in spot price volume; CSVLT is the rate of change in the spot price volatility; CDS is the daily rate of change in the credit default swap.

As shown in table 5, the only significant at 5 % level variable with joint five lagged of each variable is open interest in both Pre-Tick size and Post-Tick size periods and there is no other variable significantly explain mispricing. The impulse response functions for pre and post periods are also shown in Appendices, once again the response of each variable according to the shocks have no major differences. To sum up, considering the R-squared results in Table 4 and the explanatory power of joint five lagged of each variable in Table 5 follow the similar path on predicting mispricing therefore the tick size change of underlying shares in ISE does not have any impact on reducing the mispricing.

In order to measure how mispricing is affected by variables in the VAR system, I conduct impulse response function over the period. Figure 9 illustrates Cholesky asymptotic impulse response graphs of mispricing. It includes seven small graphs which are denoted the dynamic response of mispricing to a one standard deviation shock on itself and other variables (mispricing(ms), future volume (ftvol), future volatility (ftvlt), future open interest (ftop), cash volume (csvol), cash volatility (csvlt) and credit default swap (cds)). In each small graph, the horizontal axis shows twenty days following the shock and the vertical axis measures the daily impact of the shock on each endogenous variable. The two standard error confidence intervals are presented by short dashed lines.

Figure 9: Impulse response of mispricing with shock to all variables for the total period (2007-2012)



The first graph of figure 9 presents the short run positive effect of mispricing (ms) to their own shock (ms). Under its own shock, mispricing significantly increases in the following day but after second day the effect gradually decrease which becomes insignificant in 2-3 weeks period. An impulse originating in open interest results with an increase in mispricing and the effect is perceived but vanishes in six days period. On the other hand, future index is mostly underpriced in the period and mispricing series for ISE 30 index are in negative territory. Therefore, a shock in open interest actually reduces the pricing error. Open interest refers to the number of active trades at any point in time in the market and open interest is not same as the volume because with volume both entries and exists cause volume to increase but with open interest, entries cause open interest to increase while exist cause open interest to decrease. As a result increasing open interest means that the rate of new trades is increasing and more players take part in the market which reduces the mispricing and brings more efficiently priced index future.

Looking at also to other graphs on figure 9, it is shown that future volume, future volatility, cash volume, cash volatility and credit default swap are statistically insignificant in its effect on mispricing.

In summary, excluding its own variable (mispricing), the open interest is the only variable can significantly explain mispricing and open interest plays critical role for predicting mispricing in ISE-30 future index.

5.6 Dynamic Relationship between variables with VAR

In order to find the causality between those seven time series, I applied the Granger causality/Blok exogenity Wald (GCBEW) test. Because Figlewski (1981) advices to use Granger test in analyzing causality in future market due to the possibility of reverse causation. So this test reveals whether the lags or one variable can Granger-cause any other variables in the VAR system. Therefore, I continue to the next step of testing the causality relationship which is reported in Table 6, includes seven columns. The first column reports the results of testing whether we can exclude each variable out the equation of mispricing. Similarly, the next columns indicate the results of the testing for the equation of FTVOL, FTVLT, FTOP, CSVOL, CSVLT and CDS. In each column there is a list of variables which will be excluded from the equation and P-value. The last row in each column of Table 6 reports the joint statistics of the seven variables excluded from the equation.

Table: 6 VAR Granger Causality/Block Exogeneity Wald Tests

VAR Granger Causality/Block Exogeneity Wald Tests with five lags												
Dependent variables	MS		FTVOL		FTVLT		FTOP		CSVOL		CSVLT		CDS	
Explanatory variables	p. Value		p. Value		p. Value		p. Value		p. Value		p. Value		p. Value	
	FTVOL	0.0583	MS	0.1589	MS	0.7312	MS	0.0001	MS	0.5717	MS	0.1283	MS	0.0147
	FTVLT	0.2343	FTVLT	0.0163	FTVOL	0.0578	FTVOL	0.0182	FTVOL	0.1375	FTVOL	0.6768	FTVOL	0.4979
	FTOP	0.0000	FTOP	0.0538	FTOP	0.3292	FTVLT	0.8512	FTVLT	0.1081	FTVLT	0.000	FTVLT	0.1478
	CSVOL	0.3082	CSVOL	0.0299	CSVOL	0.6460	CSVOL	0.1036	FTOP	0.0003	FTOP	0.3448	FTOP	0.3712
	CSVLT	0.4301	CSVLT	0.0000	CSVLT	0.0269	CSVLT	0.9440	CSVLT	0.0015	CSVOL	0.8189	CSVOL	0.6970
	CDS	0.2101	CDS	0.0336	CDS	0.0000	CDS	0.1796	CDS	0.0027	CDS	0.000	CSVLT	0.0116
	All	0.0000	All	0.0000	All	0.0000	All	0.0001	All	0.0000	All	0.0000	All	0.0207

MS is mispricing; FTVOL is the daily rate of change in the future price volume; FVLT is the daily rate of change in future price volatility; FTOP is the daily rate of change in the open interest of futures; CSVOL is the daily rate of change in spot price volume; CSVLT is the rate of change in the spot price volatility; CDS is the daily rate of change in the credit default swap.

The GCBEW tests suggest that the variables are not exogenous because the P- values of the joint test for each equation are significant at 0.01 levels. This test provides some reason that there are bidirectional causalities between mispricing and future open interest with 0.01 significance level, cash volatility and future volatility, credit default swap and cash volatility, future open interest and future volume, future volatility and future volume with significant 0.05 levels. There are also unidirectional causalities in VAR system which are mispricing on credit default swap (cds), cash volatility on future volume, cds on future volume at 0.05 level cds on future volatility and future open interest on cash volume, cash volatility on cash volume with 0.01 levels. These results are required to combine with those from the impulse response function and the variance decomposition.

GCBEW test does not give sufficient information for the direction of the impact and the relative significance between variables that affect contemporaneously to each other. For example, this test indicates the causality of future volatility on future volume and also cash volatility on future volume. Based on this test I do not explain on whether or not future volatility and cash volatility have positive impact on future volume. To find the answer of the question, I analyze the variance decomposition and the impulse response function.

Table 7 reports the variance decomposition of the endogenous variables. The values in each row are the percentages of the variance of the forecaster variable considered for by alteration in the explanatory variables of the system. The estimates are generated with five lag VAR system for each variable. The sum of the entries in each row is 100. The variance decompositions are also sensitive to the ordering of the variables so I change the ordering of the variables until I obtain the variance decompositions that are closest to the estimated results from GCBEW test (Sims 1980).

Looking at Table 7, the fluctuation of MS is explained by its own (86.64%) and FTOP (10.20%) in the long run while innovation in FTOP accounts for (6.38%) of the variance in MS. The evidence suggests that there is a dynamic relation between MS and FTOP. The variance in FTVLT and FTVOL are partially by the change of CDS. Interestingly, the variance in CSVLT is mostly explained by the change of FTVLT (19.33%) and FTVOL (50.473%, In addition to that FTVOL accounts for 45.85% in the variance of CSVOL. This result support that there is a strong dynamic relation between cash market and future market and future market has a good indicator of forecasting the cash market changes, the reason behind is that arbitrageurs or hedge funds prefer to take their position in future market in the first place because futures market gives an opportunity to take large position with low margin requirement.

Table: 7 The percentage of 20-day forecast error variance explained by each variable in the seven-variable VAR system for the period (January 2007-June 2012)

	Independent explanatory variables						
Variable explained	MS	FTVOL	FTVLT	FTOP	CSVOL	CSVLT	CDS
MS	86.644	0.373	0.227	10.207	0.242	0.236	2.071
FTVOL	0.804	93.574	0.682	0.828	1.246	2.010	0.855
FTVLT	0.708	20.089	71.732	0.769	0.131	0.852	5.719
FTOP	6.387	1.595	0.197	89.971	1.289	0.075	0.486
CSVOL	0.321	45.850	2.669	2.240	46.952	1.031	0.938
CSVLT	0.902	19.330	50.473	0.650	0.194	24.396	4.055
CDS	1.598	0.880	0.449	0.836	4.875	2.552	88.810

MS is mispricing; FTVOL is the daily rate of change in the future price volume; FVLT is the daily rate of change in future price volatility; FTOP is the daily rate of change in the open interest of futures; CSVOL is the daily rate of change in spot price volume; CSVLT is the rate of change in the spot price volatility; CDS is the daily rate of change in the credit default swap.

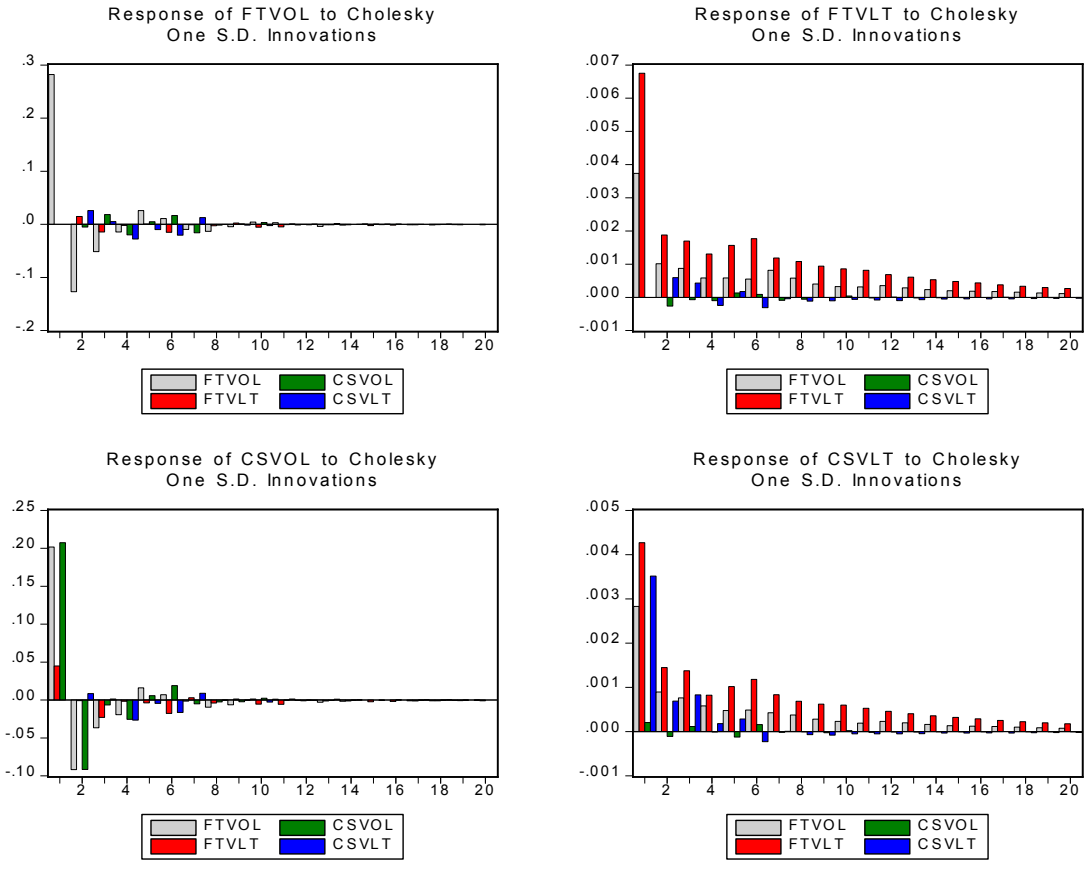
Following figure 10 represents the relationship between cash market and future market with regarding to impulse response function. Its own shock to future volume has positive effect on future volume in the following day but the effect turn out to be negative on second day while shocks to future volatility, cash volume and cash volatility have no significant effect on future volume. This gives us the idea that an increase in the future market volume result in the increment of future volume in the following day but the effect disappears and turn out to be negative on the second day. Similarly, the response of future volatility with shocks to future volume and its own are significant and both have positive effect on future volatility but shocks to cash volume and cash volatility have no impact on future volatility. On the other hand, apart from their own shocks on cash volume and cash volatility, shocks to future volume and future volatility have both significant effect on cash volume and cash volatility. Additionally, future volume and future volatility impact on cash volume have positive effect

on the first day but both effects change their direction to negative on the second day and become insignificant in one week. Interestingly, Future volatility shock on cash volume has impact more than its own shock. The effect of future volatility on cash volume vanishes in two week days and the effect of cash volume shock on cash volume disappears in five days.

It is observed that the response of all the seven variables to their own positive shock is short lived and become insignificant in 2-3 weeks time and also credit default swap shock has positive effect on future volatility and cash volatility which is found in Appendix 4.

In summary, the rate of change in future market can be explained by its own variables while the variation in cash market has mainly explained by future market. The result reveals that future market responds to the speculation or information transmission more quickly than the cash market does and leads cash market.

Figure 10: Impulse response graphs for cash and future market variables



6. Conclusion

Based on daily data of ISE-30 index futures, this study construct no-arbitrage band by cost of carry theory and empirically investigate the arbitrage opportunity in the Turkey market for 1386 days (1 January 2007 to 30 June 2012). Our results have been underscored that arbitrageurs have found many chances to exploit arbitrage possibilities range between percent 14 to %48 over the period considering with transaction cost level. It is also found that the spread between future index and spot index tend to decrease over the period due to the improvement in forecasting on dividend yield and higher liquidity in future market which indicates market is more efficient comparing to the past. Turkey future index is mostly underpriced which is exposed to reverse cash and carry application (buying future index contract and selling stocks) on the other hand small numbers of cash and carry arbitrage (selling futures and buying the underlying of shares) signals still could be seen. The absolute size of pricing error for futures indices increase significantly with time to maturity consistent with MacKinlay(1988) and Buhler and Kempf(1995) and vanishes at the maturity.

In the empirical analysis, the vector auto regression model is used to examine the dynamic interactions and causal relationships between future mispricing and the rate of changes in future price volatility, future volume, future open interest, underlying of price volatility, underlying volume and rate of change in credit default swap in Turkey. First, it is found that the price tick change has no effect on mispricing with analyzing pre and post tick size change periods. Second, this study shows that rate of change in open interest and mispricing has strong dynamic interaction according to the variance decomposition and impulse response function analysis. After one standard deviation shock in open interest response to decrease in the pricing error for up to 6 days which is opposed to the Ferris et al (2002) findings. Therefore, open interest is a good proxy for finding the mispricing in future market. The main reason behind is that open interest is an indicator of number of players involved in the market. Increase in the open interest creates more efficient market which helps to better pricing and cause decrease in the pricing error between future index and spot index. On the other part, I detect that there is no other past or current value of changes in variables could significantly explain the mispricing series. Finally, there is some evidence found that future market leads cash market. When one standard deviation shock in future volatility and future volume as the future market reacts first to the new information due to the leverage advantage to investors with low margin costs. For future studies, the results from this analysis will be beneficial to

arbitrageurs because it by highlights the existence of mispricing and explanatory variables on mispricing.

REFERENCES

Brailsford, T. and A. Hodgson (1997), 'Mispricing in Stock Index Futures: A Re-Examination Using the SPI', *Australian Journal of Management* , 22(1): 21–45.

Brenner M., Subramanyam M. And Uno J. (1989), 'The Behaviour of Prices in the Nikkei Spot and Futures Market', Journal of Financial Economics, 23, pp 363 - 384.

Butterworth, D. and **P. Holmes** (2000), 'Mispricing in Stock Index Futures Contracts: Evidence for the FTSE 100 and FTSE Mid 250 Contracts', *Applied Economics Letters* , 7(12): 795–801.

Bühler, W., & Kempf, A. (1995). DAX index futures: Mispricing and Arbitrage in German markets. *Journal of Futures Markets*, 15, 833-859.

Chan, K. and **Y.P. Chung** (1993), 'Intraday Relationships among Index Arbitrage, Spot and Futures Price Volatility, and Spot Market Volume: A Transactions Data Test', *Journal of Banking and Finance* , 17(4): 663–87.

Chen, N.F., C.I. Cuny and **R.A. Haugen** (1995), 'Stock Volatility and the Levels of the Basis and Open Interest in Futures Contracts', *Journal of Finance* , 50(1): 281–300

Christos Floros (2009), 'Modelling Volatility Using High, Low, Open and Closing Prices: Evidence from Four S&P Indices', *International Research Journal of Finance and Economic,* 28. pp. 198-206. ISSN 1450-2887

Cornell, B. and French, K. (1983) The pricing of stock index futures, *Journal of Futures Markets*, 3: 1 – 14.

Cummings J. R. And Frino A. (2008), 'Index arbitrage and the pricing relationship between Australian stock index futures and their underlying shares', 51:661-683.

Fassas A. (2010), Mispricing in stock index futures markets: The case of Greece,

Ferris, S.P., H.Y. Park and K. Park (2002), 'Volatility, Open Interest, Volume, and Arbitrage: Evidence from the S&P 500 Futures Market', *Applied Economics Letters* , 9(6): 369–72.

Figlewski, S. (1984), 'Hedging Performance and Basis Risk in Stock Index Futures', *Journal of Finance* , 39(3): 657–70.

Gould F. J. (1988),' Stock Index Futures: The Arbitrage Cycle and Portfolio Insurance', 44(1):48-62.

Harris L. (1987), The October 1987 S&P 500 stock-futures basis, *Journal of Finance* 44, 77-99.

Hemler, M. L. and F. A. Longstaff (1991), General equilibrium stock index futures prices: Theory and empirical evidence, *Journal of Financial and Quantitative Analysis*, 26, 287-308.

Jakubowski J. and Bialkowski J. (2006), 'Stock index futures arbitrage in emerging markets: Polish evidence', 17 :363-381

Kempf A. and Korn O. (1998), 'Trading System and Market Integration', Journal of Financial Intermadian, 7:220-239.

Klemkosky, R. C. And J. H. Lee (1991),'The intraday Ex Post and Ex Ante Profitability of Index arbitrage', *Journal of Futuew Markets*, 11: 291-311

MacKinlay, C.A. and K. Ramaswamy (1988), 'Index Futures Arbitrage and the Behaviour of Stock Index Futures Prices', *Review of Financial Studies* , 1(2): 137–58.

McMillan D. and Ülkü. N. (2009), 'Persistent Mispricing in a Recently Opened Emerging Index Futures Market: Arbitrageurs Invited', *Journal of Futures Markets*, (2009), 29, 218-243.

Merrick, Jr., J. J., 1987, Volume determination in stock and stock index futures market: An analysis of arbitrage and volatility effects, *Journal of Futures Market,* 7, 483-496.

Modest, D.M. and **M. Sundaresan** (1983), 'The Relationship between Spot and Futures Prices in Stock Index Futures Markets, Some Preliminary Evidence', *Journal of Futures Markets* , 3(1): 15–41

Parkinson, M. (1980), 'The Extreme Value Method for Estimating the Variance of the Rate of Return', *Journal of Business* , 53(1): 61–65.

Peters, E. (1985), 'The growing efficiency of index futures markets. Journal of Portfolio Management, II, 52-56.

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.

Theobald, M. **and P. Yallup** (1996), 'Settlement, Tax and Non-Synchronous Effects in the Basis of UK Stock Index Futures', *Journal of Banking and Finance,* 20(9): 1509–530.

Vipul (2008), 'Futures Market Mispricing, Volume, Volatility and Open Interest : Evidence from Indian', *Journal of Emerging Market Finance*, 7(3): 263-92

Yadav, P.K. and Pope, P.F. (1990), 'Stock index futures arbitrage: International evidence', *Journal of Futures Markets*, Vol. 10, No. 6, pp. 573 603.

Zhuo W. And Wang (2012), 'Study on Stock Index Futures' Mean Reversion Effect and Arbitrage in China Based on High-Frequency Data', *iBusiness*,4,78-83

APPENDICES

Appendix 1

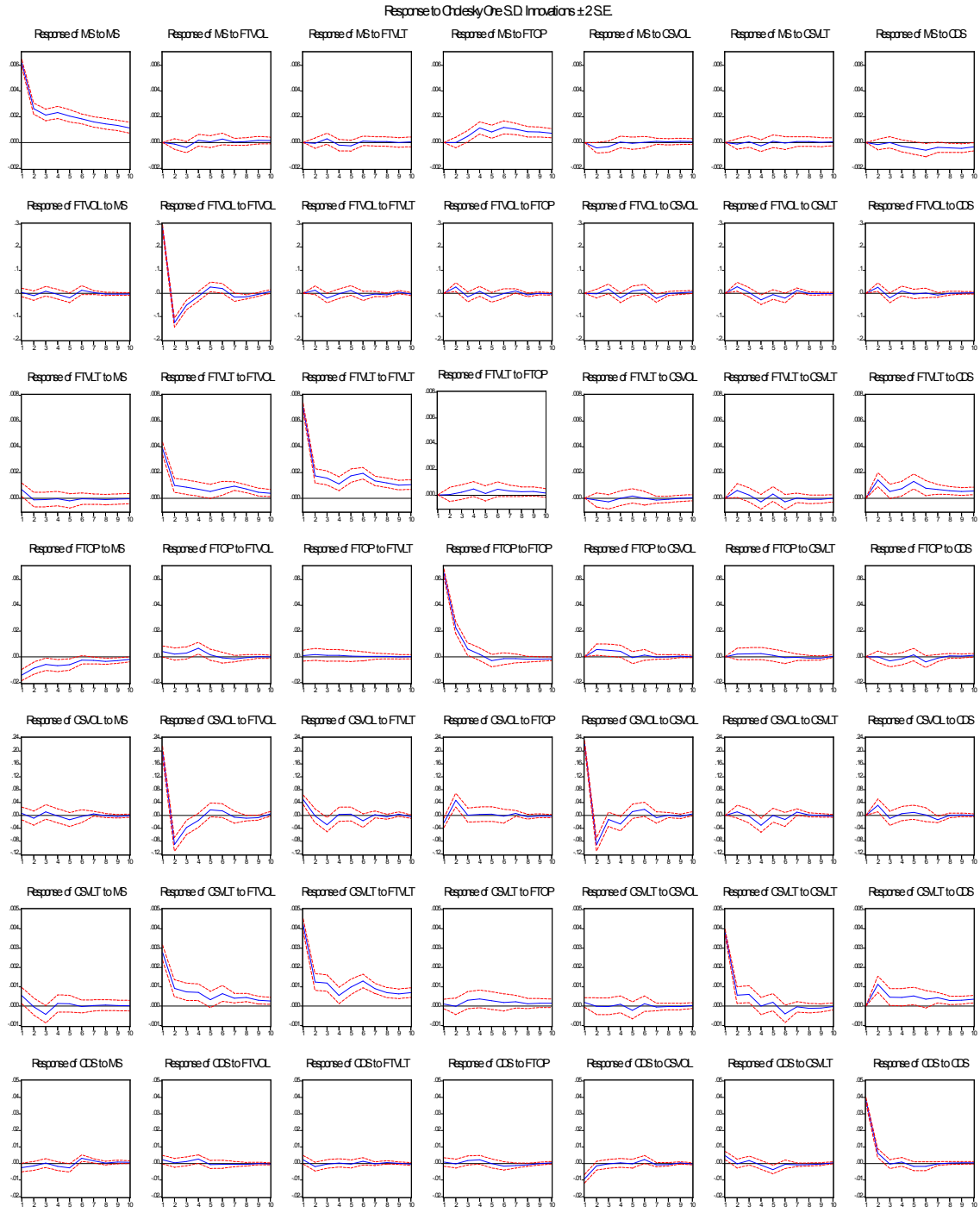
Test of Stationarity of Variables

Variable	Lags	t value	t (critical) at 0.05	Lags	AIC*	Lags	SC**
MS	5	-7.17771	-2.863471	3	-7.79197	2	-8.43877
FTVOL	5	-20.34097	-2.863471	3	-27.3958	2	-33.0549
FTVLT	5	-7.45341	-2.863471	3	-9.81398	2	-11.6711
FTOP	5	-14.39287	-2.863471	3	-24.909	2	-24.9131
CSVOL	5	-19.03026	-2.863471	3	-26.6514	2	-31.1815
CSVLT	5	-8.85988	-2.863471	3	-11.0072	2	-14.9481
CDS	5	-16.94572	-2.863471	3	-31.5145	2	-31.503

*Akaike Information Criterion ** Schwarz Criterion, MS is mispricing; FTVOL is the daily rate of change in the future price volume; FVLT is the daily rate of change in future price volatility; FTOP is the daily rate of change in the open interest of futures; CSVOL is the daily rate of change in spot price volume; CSVLT is the rate of change in the spot price volatility; CDS is the daily rate of change in the credit default swap.

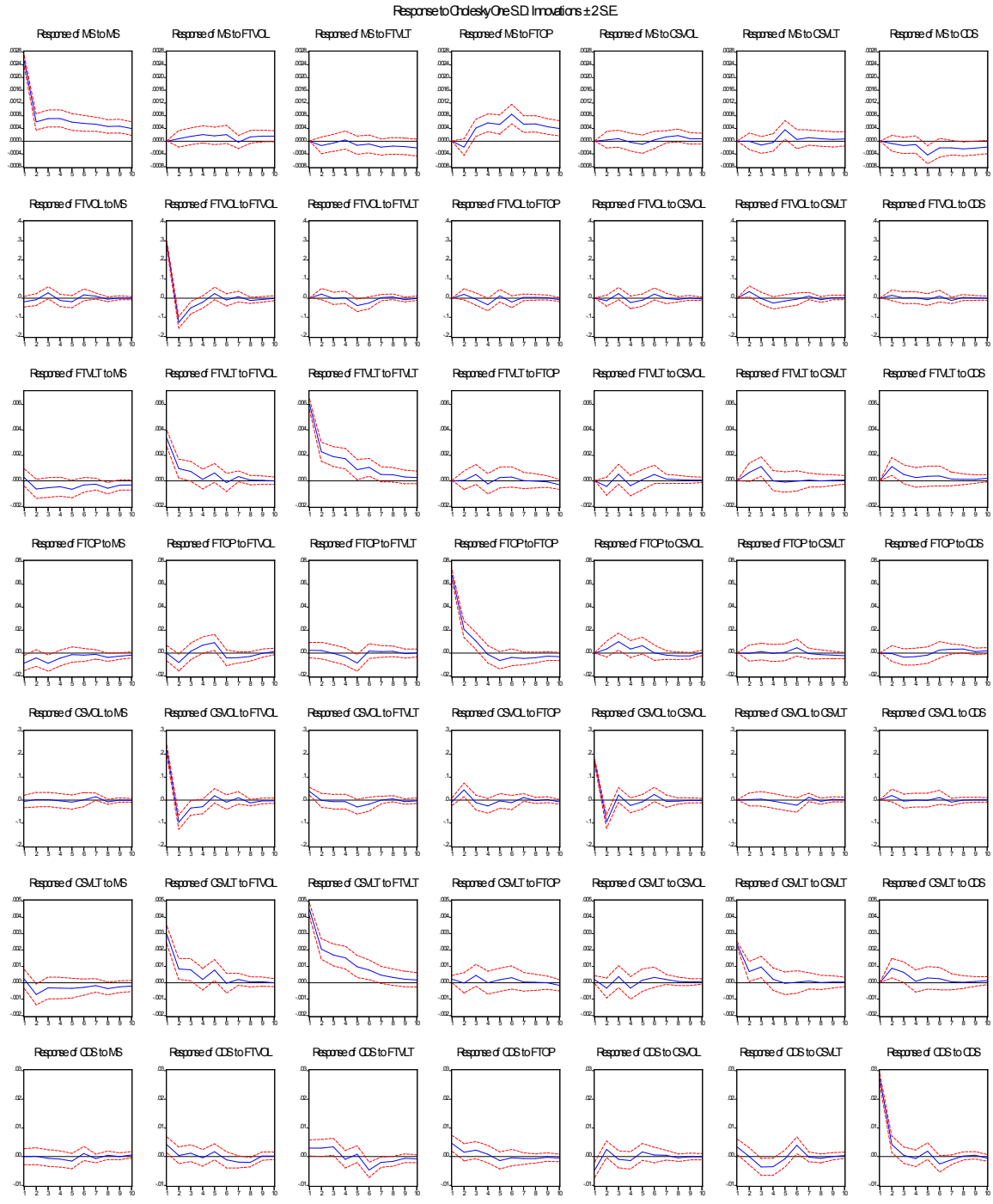
Appendix 2

Pre Tick Size Change Impulse Response functions



Appendix 3

Post Tick Size Change Impulse Response functions



Appendix 3

Impulse Response function for the total sample (1 January 2007- 30 June 2012)