

INTRADAY LEAD-LAG RELATIONSHIP BETWEEN WARRANTS AND
FUTURES CONTRACTS: A CASE OF ISE-30 STOCK INDEX

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VARANT VE FUTURES SÖZLEŞMELERİ ARASINDAKİ GÜNiÇİ
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Anahtar Kelimeler (Türkçe)

- 1) Varant
- 2) Vadeli İşlem
- 3) Gün içi Öncül-Ardıl
- 4) Vektör Otoregresif
- 5) Çapraz Korelasyon

Anahtar Kelimeler (İngilizce)

- 1) Warrant
- 2) Futures
- 3) Lead-Lag
- 4) Vector Autoregression
- 5) Cross Correlation

ABSTRACT

The aim of this thesis is to investigate empirically the intraday lead-lag relationship between warrants and futures market as applied to those traded at the Istanbul Stock Exchange (ISE) and Turkish Derivatives Exchange (Turkdex). Focus is used an intuitive method to examine the intraday lead-lag relation, if any, in the high frequency intraday data of warrants and futures which have same underlying stocks index using parametric and nonparametric methods at 5-minutes regular time interval.

The data set for the study consists of the 5 minutes time interval closing values of the ISE 30 index futures traded at the Turkdex and ISE 30 index put and call warrants traded at ISE and issued by Deutsche Bank, which are considered from January 6, 2012 to February 29, 2012 period; from May 8, 2012 to June 29, 2012 period and from July 2, 2012 to August 31, 2012 for near month futures contracts, near month and mostly heavily traded put and call warrants.

As parametric methods, cross correlation functions and Granger causality model are used to investigate whether a short term relationship among the time exists or not and vector autoregressive model is used to examine the short-term relationship between future contracts and warrants. Impulse-response functions and variance decomposition methods are also used as complementary methods to show the effects of the change in the error terms of the variables in the study on the other variables. Counting method is used as non-parametric method and statistically significance of its results is tested by chi-square method.

We find that both parametric method's and non-parametric counting method's results shows that there is an evidence that futures contract market lead the

warrant markets in Turkey. On the contrary, warrants do not lead futures market. This result is statistically significant.

ÖZET

Bu çalışmanın amacı, dayanak varlığı İMKB-30 hisse senedi endeksi olan, İMKB’de işlem gören varant ve VOB’da işlem gören futures sözleşmeleri arasındaki gün içi öncül-ardıl ilişkisini araştırmaktır. Çalışmada, aynı dayanak varlığa sahip varant ve vadeli işlem sözleşmeleri arasındaki öncül-ardıl ilişkisinin 5’er dakikalık zaman aralıklarıyla temin edilen kotasyon verileri ile incelenmesine odaklanılmıştır.

Çalışmada, 06.01.2012-29.02.2012, 08.05.2012 ve 02.07.2012-31.08.2012 tarihleri için İMKB-30 endeksine dayalı vadeli işlem sözleşmeleri ile alım satım varantlarının kapanış fiyatları kullanılmış, en çok işlem gören varantlar ile varantların vadesine yakın vade sonu olan futures sözleşmeler seçilmiştir.

Parametrik yöntemler kapsamında, çapraz korelasyon ve Granger Nedensellik Testleri ile Vektör Otoregresyon Modeli ile varantlar ve futures sözleşmeler arasındaki kısa dönemli ilişki analiz edilmiştir. Etki tepki fonksiyonları ile varyans ayrıştırma metotları uygulanmış ve hata terimindeki değişimler analiz edilmiştir. Parametrik olmayan sayma metodu uygulanmış, istatistiksel anlamlılığı Ki-Kare Testi ile ölçülmüştür.

Gerek parametrik gerekse parametrik olmayan yöntemlerin sonuçları, Türkiye’de futures sözleşmelerin işlem gördüğü piyasaların varant piyasasına öncülük ettiği yönünde bulgular sunmuştur. Diğer yandan, varant piyasasına öncülük ettiği yönünde bir kanıt rastlanmamıştır. Elde edilen sonuçlar istatistiksel olarak anlamlı bulunmuştur.

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1.INTRODUCTION

A warrant is a right to purchase or sell, within a specified period, a share of common stock at a specified price. The definition is so similar to that of the call options. The economic function of warrants is no different from options. These derivatives are leveraged securities that give investors the exposure to the underlying assets at a fraction of the cost, and the opportunity to enjoy geared returns when the market moves in favour, or to limit and hedge the risk of an existing portfolio in a falling market.

Despite their similarities, there are some important differences between call options and warrants. First, while the call option is issued by an individual, the warrant is issued by the firms. If a warrant is exercised, it increases the number of outstanding shares of the firm and thus dilutes the equity of the company while call options don't increase share numbers when call options are exercised more elaborately. Second, while call options expire within several months, warrants typically have maturities of at least several years.

This thesis tries to give some information about development process of Turkish Warrant Market and address the question concerning the lead-lag relation between the index warrant and index futures which have same underlying asset. The objective of this study is to address the question of whether there is any lead-lag relationship between stock index warrants and stock index futures in Turkey or not.

This thesis contributes to the literature in three aspects. First, we analyze short term dynamics between future contracts and warrants via parametric methods. In this way, lead-lag relationship is investigated by cross correlation, granger causality method and vector autoregressive model with complementary analysis of it. Second, we represent a counting method

to study the lead-lag relation between warrants and the underlying security's futures in Turkey. This method is efficacious in examining the lead-lag relation at the high frequency with a time resolution of 5 minutes. It is non-parametric and the assumptions critical to the regression approaches are not needed.

The rest of the thesis is organized as follows. In Chapter One, we present an introduction. Chapter Two provides a literature review. In Chapter Three, we give some information about characteristics and background of the warrants and warrants market in Turkey. In Chapter Four, we present theoretical background about parametric methods: cross-correlation and vector autoregressive model and non-parametric counting method, and documents the data we use in our empirical study. Chapter Five provides an analysis of the lead-lag relation between index futures and index warrants on same underlying stock index - ISE 30 - in Turkey.

2.LITERATURE REVIEW

Several studies have provided theoretical models for the pricing of warrants. These include the works of Black and Scholes in 1973, and Galai and Schneller in 1978 and Lauterbach and Schultz in 1990.

Santoso (2000) has mentioned that Black and Scholes claimed that in many cases their model could be used as an approximation to estimate the warrant value. Black-Scholes (1973) first introduced pricing model of options. Kremer (1992) had claimed that the option pricing work of Black-Scholes is known to be motivated by prior research on warrant pricing. Merton (1973) used dividend adjustment to Black-Scholes formula and proposed that when the dividend is paid, stock price decreases. The pricing theories by Black and Scholes (1973) and Merton (1973) indicated that, the price of an option is dependent on its underlying security. Only after the stock price is known can the option price be determined. However, if material information is discovered earlier in the equity option market as a result of the trades by informed traders who want to take advantage of the leverage that options provide, then the option price may lead the underlying stock price. Lauterbach and Schultz (1990) had reached a conclusion that Black and Scholes warned early in 1973 that given the relatively long life of a warrant, the volatility of the underlying stock may be expected to change substantially.

Galai and Schneller (1978) proposed the concept of dilution effect of warrants on the value of firm. The empirical results showed that number of warrants issued would not effect the wealth of shareholders even if issuance of warrants may increase future cash flows, since they would be offset by dilution of number of shares increased as warrants were exercised. Shortly, they regarded a warrant as a diluted option of an identical firm without warrants outstanding. Both studies suggested that any call option-

pricing model with some minor modifications could be used to price warrants.

Other empirical studies on warrant pricing include the works of Lauterbach and Schultz (1990), Leonard and Solt (1990), and Hauser and Lauterbach (1997) on U.S. warrants and Schulz and Trautmann (1994) on German warrants. Leonard and Solt (1990) concluded that the Black-Scholes model performs as well as more complicated adjusted Black-Scholes models for warrant pricing. They suggested that for dividend paying firms the dividend-adjusted Black-Scholes model is more accurate than the diluted adjusted one, when warrants are in-the-money or have a long maturity. Schulz and Trautmann, helped to justify option-like warrant valuation ignoring dilution effect. They have argued that dilution adjustment created double counting effects, because stock price has already incorporated dilution effects during the warrant's life. On the other hand, Lauterbach and Schultz (1990), followed by Hauser and Lauterbach, presented evidence that suggests that the Black-Scholes model be outperformed by a model that assumes a constant elasticity of variance diffusion process for stock price. They constructed the model substituting the equity value into the stock price and adjusting the effect of dilution presented by Galai and Schneller (1978). Schwartz (1977) generalized the Black-Scholes formulation by employing a closed form solution to the differential equation subject to the appropriate boundary conditions that governs the value of a warrant.

Option pricing models that incorporate adjustments to the effect of potential dilution and changing volatility are might be more appropriate for valuing warrants. Santoso (2000) had claimed that several theoretical studies have provided such models, and several empirical researches have tested them based on warrants traded at developed markets, such as U.S. and Europe, as well as at the emerging markets.

In addition to possible dilution, Chan and Pinder (2000) had stated there are other reasons for the difference in prices between warrants

and options. They proposed that difference resulted from the credit risk of the issuer of the warrant, since warrants were usually issued by a third party, generally a financial institution. Additionally, they showed that warrant prices reflect the different levels of credit risk associated with warrant issuers in their studies.

Santoso (2000) investigates empirically the relative performance of pricing models commonly used for warrants traded at the Jakarta Stock Exchange. He focuses that warrant pricing models incorporating adjustment for dilution and changing volatility. His finding suggests that dilution adjustment improves the pricing performance of Black-Scholes-Merton model. It is also indicated that models that allow an inverse relation between stock price and volatility might promise superior pricing performance.

Santoso (2000) has mentioned that empirical research on warrants traded at emerging markets includes the work of Shastri and Sirodom (1995) and Kwok (1994). Shastri and Sirodom (1995) concluded that a constant elasticity of variance model outperformed Black-Scholes model in a study about the pricing of Thailand warrants. On the other hand, he had mentioned that Kwok (1994) confirmed the practical efficiency of Hong Kong traded warrant market using Black-Scholes model.

Many analysts, including Mayhew (1995), Easley et al. (1998), have examined the option and stock price behaviors under information asymmetry. They find that informed traders do trade actively in the option market and so, this finding is that, if more informed traders leverage on options to generate a return higher than the return from trading stocks, then the option price will move ahead of the stock price in impounding the information from the informed traders.

Stephan and Whaley (1990) investigated the intraday price change and trading volume relationship between stocks and options by using causality tests causality tests of observed and implied stock prices and found that price changes in the stock market lead the option market by

fifteen minutes. However, Manaster and Rendleman (1982) and Anthony (1988) had found a reverse relationship. Manaster and Rendleman (1982) had used daily closing data in their study and found that option market is leading stock prices for 1 day. Anthony (1988) had used daily data to examine by using causality tests to determine timing and direction of information flow. He argued that call options led underlying shares and underlying shares were taken 1 day to adjust price changes in the option. Chan et al. (1993) used a nonlinear multivariate model to compute implied stock prices, rather than an option pricing model and argued that stock price, rather than the transaction price, led the bid-ask midpoint. They have found that neither market led.

Kui (2007) suggests an intuitive method to examine the lead-lag relation, if any, in the tick-by-tick data of covered warrants and their underlying stocks or underlying index futures. Kui find that the electronically traded warrants do not lead stocks or index futures; the movements in the warrants' quotes provide little information about the quotes of the underlying stocks or index futures. Kui also shows that the stocks and index futures lead the warrants.

There are various studies that have analyzed the lead/lag relation between derivatives and the spot market. However, empirical studies examining the intraday patterns on warrant market is relatively scarce in Turkey, the absence of data in these markets may possibly be a reason for it. Abuk (2011) had claimed that the general consensus reveals that futures market is the leader of both options and and spot markets with little or no feedback. But, there is no consensus for the relation between options and spot markets. Finnerty & Park (1987) and Kawaller et al. (1987) are the first that investigate the temporal relation between index futures and the cash index markets. Both reach to the conclusion that futures market leads the spot market. Kawaller et al. (1987) found that index futures prices lead cash index prices up to 40 minutes although cash index of only one minute is observed at times. In these studies, the price discovery role of futures

market mostly had been explained by low transaction costs and high degree of leverage.

Stephan and Whaley (1990) investigated intraday lead-lag relationship between S&P 500 and money market index futures by using data broken into 5 minute intervals. They showed that futures market leads spot market about 5 and 10 minutes but there was no unidirectional effect between them. They also suggested that there was evidence that spot market led the futures market even though it was not a very strong effect respectively.

Frank De Jonga and Monique W.M. Donders (1996) had proposed that investigation of intraday lead-lag relationships between futures, options and underlying index with high frequency data and observations on the three series which are probably unequally spaced in time. They have showed that futures market led both options and the underlying asset's spot market by using a regressive model which is modified according to covariances and correlations. They have mentioned that choosing a long unit time interval minimizing the number of missing observations and imputing zero returns for intervals in which no trading took place were the two ways to deal with that problem of unequally spaced observations. However, they also mentioned that these methods had 2 shortcomings. First, when a long unit time interval is chosen, trading cannot be very frequent, in which a lot of information is thrown away. Second, there is a risk in imputing zero returns for intervals in which no trading took place that it can create an error in the variables problem that will bias the covariance and correlation estimates toward zero. They have mentioned that in perfectly efficient market, all price movements were expected to be simultaneous and lead-lag relationship existed. They have interpreted the results of their study that quotes of cash index were due to infrequent trading. Moreover, they have claimed that futures market had leverage effect twice as large as in the option market and transaction costs are lower in futures market relative to the option market and the spot market.

The relationship between spot and derivatives markets is first studied by Ozen et al. (2009) in Turkey. Futures transactions from Turkish Derivatives Exchange (TURKDEX, VOB) and Istanbul Stock Exchange (ISE) national 30 spot index prices are examined with closing prices of 1.024 trading days for the period February 4, 2005 – February 27, 2009. Their study focused on the short and long run causal relationship on the basis of co-integration and then determines the direction of the relation by Granger causality applied over error correction mechanism. Long run results indicate bidirectional causality whereas a unilateral causality relationship from spot to futures market was determined.

Kapusuzoğlu and Tasdemir (2010) try to explain the impact of TURKDEX futures market on ISE national 100 index prices through market efficiency. Similar to the previous study of Ozen et al. (2009), co-integration and Granger causality are performed on the daily closing prices beginning from November 1, 2005 until June 30, 2009. Empirical study reveals that both TURKDEX derivatives and ISE spot markets are efficient in a weak form. What they find is on the contrary to the expected result of dominant futures market. The futures market price is found to be not effective on the spot market price and spot market is found to be leading futures market significantly. They have interpreted the results of their study that the derivative market in Turkey was not very efficient and increasing volume of transactions in futures contracts and development of the TurkDex would contribute positively to the efficiency.

Öztürk (2008) investigated of ISE-100 index and ISE30 index spot market returns and the returns of futures contracts' based on these indices. He found in his study that for daily returns of variables there was a one way causality relationship from spot market to futures market.

Kayalıdere (2012) et. al. has aimed to analyze the interaction between derivatives and spot markets using ISE-30, TURKDEX-TL/Dollar futures contracts. Short and long term dynamics between market prices have been researched by the VAR (Vector Autoregressive Regression) Model and

it has been concluded that there was an effect from derivatives market to spot market for the latest years while there is an interaction from spot market towards derivatives market for the early years.

3.WARRANTS

3.1. Definition of Warrant

Warrants are capital markets instruments that give the holders the right to buy or sell the underlying instrument or indicator at a predetermined price on, or before, a particular date, against a premium payment. This right is exercised by registered delivery or cash settlement and this right doesn't mean an obligation for the holder.

Warrants, which are only under the responsibility of the issuer, are securitized options which are listed on a stock exchange and traded in the relevant market segment. They are traded in the secondary market and settled in the same way like the other securities.

Warrants are known as structured products which are not issued for financing purposes. They derive their value from another underlying instrument. Some warrants give holders the right to buy, or to sell the underlying instrument to the warrant issuer for a particular price according to the terms of issue. Alternatively, some of them such as index warrants provide holders with a cash payment relating to the value of the underlying instrument at a particular time.

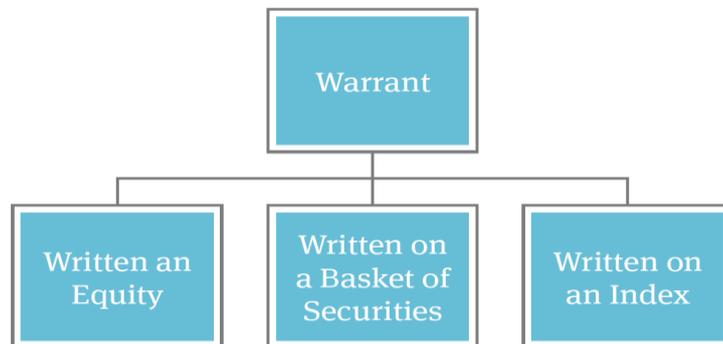
3.2. Features of Warrants

Some key warrant features are described below. Warrants do not have standardized terms, since some of them appear in all warrant types and some do not.

3.2.1. Underlying Instruments of Warrants

Warrants can be issued over securities such as shares, a basket of different securities, a share price index, debt, currencies and commodities. Some warrants have higher risk/return profiles than others

that offer lower risk features such as capital guarantees. (<http://www.macquarie.com.au>).



Source: imkb.org.tr

Figure 1. Popular underlying financial products for writing warrants

As shown in the Figure 1 above, the underlying asset may be a single equity or a basket of equities. (For example, call warrant issued by Z bank, entitling the holder to buy the shares of ABC Incorp. at TL 6.00 on 20.12.2014.) If the underlying instrument of a warrant is a single equity or a basket of equities, “underlying asset” term is used, whereas in the case of warrants written on an index, the term “underlying indicator” is used. (For example, a put warrant issued by Z bank, which entitles the holder to sell the ISE-100 Index at 80,500 points on 20.12.2014)

Warrants over a basket of securities give exposure to the performance of a group of securities or a particular industry. The underlying instrument may be adjusted. if there is a corporate action or similar event and the disclosure document would explain when this may occur.

3.2.2. Types of Warrants

Investors use trading warrants to gain significant leveraged exposure to a variety of underlying assets in a rising or falling market. (<http://www.asx.com.au/products/about-asx-warrants.htm>). Some types of warrants can also be used to protect the value of an existing portfolio or

shareholding and they are called as investment warrants. Warrants can be classified as either call warrants or put warrants. Call warrants benefit from an upwards price movement in the underlying instrument whereas put warrants benefit from a downward price movement. Warrants that give the right to buy have the advantage of being at profit in the bull markets, whereas warrants that give the right to sell have the advantage to gain in the bear markets.

3.2.2.1. Call Warrants

A call warrant gives the right to buy the underlying asset from the issuer at a specified price, on or before a particular date. The buyer of a call warrant usually believes the value of the underlying asset will rise during the life of the warrant.

3.2.2.2. Put Warrants

A put warrant gives the right to sell the underlying asset to the issuer at a specified price, on or before a particular date. The buyer of a put warrant usually believes the value of the underlying asset will fall during the life of the warrant.

3.2.3. Exercise Price of Warrants

The amount of money which must be paid by the holder for a call warrant or by the warrant issuer for put warrant for the transfer of each of the underlying instrument(s) (not including any brokerage or other transfer costs) is known as exercise price. The exercise price is determined by the issuer prior to the issue of the warrant.

For call warrants; when the exercise price/level is below the spot price/level of the underlying instrument, the warrant is “in-the-money”, whereas it is above the spot price/ level of the underlying instrument, the warrant is “out-of-the-money”. When the exercise price/ level is equal to the spot price/level of the underlying instrument, the warrant is “at-the-money”.

For put warrants, these relationship is vice versa and it is negatively related with underlying asset's price.

3.2.4. Expiry Date and Exercise Style of Warrants

The expiry date refers to the last date on which the right arising from the warrant can be exercised. Warrants can be either American style or European style exercise. European style means the warrant is exercised only on the expiry date of the warrant, while in the case of American style warrants, the warrant can be exercised at any time on or before the expiry date.

3.2.5. Conversion of Warrants

Conversion means the exercising of a warrant, in other words, using of a right arising from a warrant. Conversion may be realized by registered delivery or cash settlement and this is determined by the issuer. For call warrants written on equities and settled by registered delivery, the warrant holders have to pay to the issuer the amount calculated over the price specified in the prospectus, while he receives the equities by registered delivery. In the case of put warrants written on equities and settled by registered delivery, the warrant holder is obligated to sell the underlying equities to the issuer, while he receives the amount calculated on the basis of exercise price. (<http://www.imkb.gov.tr>)

The conversion ratio, which is determined by the issuer prior to the issue of the warrant, means the number of underlying equities that one warrant gives the holder to buy or sell or the number of warrants that must be exercised for the buy or sell one unit of the underlying equity. It stands for the number of warrants required to buy or sell 1 stock unit. For example, a conversion ratio of 4:1 means that 4 warrants entitle the holder to buy or sell 1 equity. The conversion ratio of a warrant may be affected following a corporate action by the underlying company, as a result of a bonus issue or capital reconstruction (www.macquarie.com.au). The conversion ratio

affects the price of the warrant on a per share basis, but not the leverage. A higher conversion ratio means a lower warrant price. While trading prices are quoted on a per warrant basis, the exercise price is quoted on a per underlying instrument (or share) basis. Because of these, being aware of the conversion ratio of a warrant series before investing is important.

3.3. Value Term in Warrant Features

The price of a warrant can be considered in two parts: the time value and the intrinsic value. For reaching a breakeven point for the investment in warrant, it is expected that for every day the underlying asset is moving in the right direction as the expiration date is getting closer.

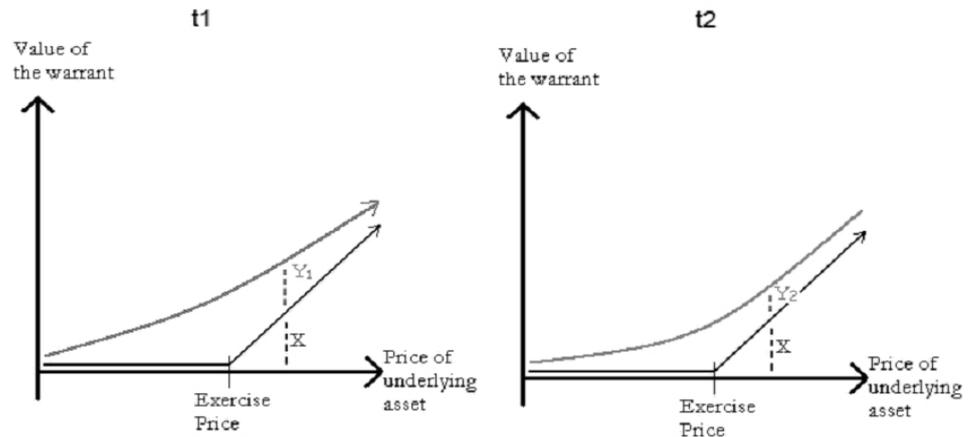
For call warrants, the intrinsic value is the financial gain that is received if the warrant is exercised. For all time when the price of the underlying asset is below the exercise price (when the warrant is out-of-the-money), the intrinsic value will be zero. The intrinsic value rises linearly when the price of the underlying asset increases, no matter how long time it is to expiration. At the date of maturity the warrant's value will consist of one hundred percent intrinsic value and zero percent time value (Eitman et al., 2004). The second part of the value is the time value. This value only exists if the price of the underlying asset has a potential to move closer to or further into the money. The time value is supposed to gain or lose the same value if the underlying asset is moving in either direction from the exercise price. This is only a proof of that the warrant price is calculated from models with principal based on an expected distribution of possible outcomes around the exercise price. The time value is by far the most discussed and debated one among investors (Gustafsson, 2005).

The intrinsic value is the sum of money the investor would receive if he converts his warrants today instead of on the expiration date

(this is except for European warrants). Resulting in the following formula for call warrants;

$$\text{Intrinsic value} = (\text{Underlying Price} - \text{Exercise Price}) / \text{Parity}$$

$$\text{Time value} = \text{Price of the warrant} - \text{Intrinsic Value}$$



Source: Gustafsson, 2005

Figure 2. Time value and intrinsic value of a call warrant

The graph on the right shows what has happened to the time value and intrinsic values after some time passed after the graph on the left side, if all else are kept constant. This is called the convexity, or more general “the ice hockey stick”. The curved line is the total value of the warrant. Its shape is so because as time passes to maturity, there is a smaller chance that spot price will increase. The straight line that is straight until the exercise price and then rises linearly, is the intrinsic value line and it equals to zero up to exercise price (Gustafsson, 2005).

3.4. General Overview of Models Used for Valuation of Warrants

3.4.1. Black-Scholes-Merton European Call Option Model

The original Black-Scholes call option model that is adjusted for dividend by Merton is the simplest method used for pricing of warrants (Boonchuaymetta, 2007). The Black-Scholes pricing formula is adjusted for dividend by Merton, which is as follows:

$$W = Se^{-d\tau} N(d_1) - Xe^{-d\tau} N(d_2)$$

where

W	: Warrant price
S	: Underlying Price (in generally stock or stock index)
d	: Dividend yield
τ	: Time to warrant expiration
X	: Exercise price
r	: Risk-free interest rate
N(x)	: Cumulative standard normal distribution evaluated at x
σ	: Volatility (yearly) of Underlying Price

$$d_1 = \frac{\ln\left(\frac{Se^{-d\tau}}{X}\right) + \left(r + \frac{\sigma^2}{2}\right)\tau}{\sigma\sqrt{\tau}}$$

$$d_2 = d_1 - \sigma\sqrt{\tau}$$

The resulting Black-Scholes model assumes that the dividend yield is certain and will not rise above the risk-free interest rate to induce early exercise. Black-Scholes model also assumes that volatility, defined as the instantaneous standard deviation of stock return, as well as risk-free interest rate, is constant over the life of the warrant (Santoso, 2000). Black-

Sholes pricing formula assumes that the financial product does not pay a dividend or interest, the option is European style, risk-free interest rate is fixed during the life of the option and yields of financial products are normally distributed (<http://www.imkb.gov.tr>).

3.4.2. Dilution-Adjusted Black-Scholes-Merton Model

Galai and Schneller (1978) showed conceptually how to consider the dilution effect. Interpreting them, Lauterbach and Schultz (1990) proposed three modifications to be made to an option pricing method when applied to warrant pricing:

- Substitute underlying price S with $S + \frac{M}{N}W$
- Consider the volatility σ as the volatility of $S + \frac{M}{N}W$
- Multiply the result by $\frac{N}{N+M}$

where W is the warrant price, N is the number of outstanding shares, and M is the number of outstanding warrants. $N/(N+M)$ is known as the dilution factor. As a result, the formula tells that the warrant can be priced by adjusting the value of call option for the dilution that will occur at the time warrants are exercised (Suntraruk, 2007). Under the assumption that the firm has only one series of outstanding warrants, Galai and Schneller (1978) showed that the value of each stock warrant equals the value of an equivalent call option on the firm's equity multiplied by an adjustment for dilution and their approach considers distribution of dividend not as an obligation so dilution adjustment can be applied whatever is the underlying process of the asset price (Lim, 2002).

3.5. Factors Influencing The Warrant Price

3.5.1. Price of the Underlying Asset of Warrant

There is a positive correlation between the price of the underlying instrument of a call warrant, while this correlation is negative in the case of put warrants. As the price of the underlying asset increases, the price of call warrants increases and the price of put warrants decreases.

3.5.2. Exercise Price of Warrant

There is a negative correlation between the exercise price of a warrant and call warrants, while this correlation is positive in the case of put warrants. As the exercise price increases, the price of call warrants decreases and that of put warrants increases.

3.5.3. Days to Maturity for Warrant

There is a positive correlation between the days to maturity and both call and put warrants. As the days to maturity increase, the price of both call and put warrants increases.

3.5.4. Volatility of Underlying asset

There is a positive correlation between the volatility of the underlying asset and both call and put warrants. As the volatility of the underlying asset increases, the price of both call and put warrants increases.

3.5.5. Market Interest Rate

There is a positive correlation between the interest rate and call warrants, while this correlation is negative in the case of put warrants. As the interest rate increases, the price of call warrants increases and that of put warrants decreases.

3.5.6. Dividend of the company

There is a negative correlation between the dividend distributed by the company on whose equities the warrant is written and the price of

call warrants, while this correlation is positive in the case of put warrants. As dividends increase, the price of call warrants decreases and that of put warrants increases.

3.6. Advantages and Disadvantages of Warrants

3.6.1. Advantages

3.6.1.1. Leverage

Warrants offer high gearing with a small investment (premium) in the warrant in comparison to a direct investment in the underlying instrument. Most warrants offer some degree of leverage. This can range from negligible leverage to a high level of leverage, depending on the type of warrant. Some warrants, such as structured investment products effectively have no leverage and generally speaking, investment style warrants offer less leverage than trading style warrants. Leverage means that small percentage changes in one variable are levered up into larger percentage changes in another variable. Leverage is the ratio of spot price to the price of warrant multiplied by the parity. Also, the elasticity can be a complementary of leverage, because it shows investor the sensitivity of a warrant is to price changes in the underlying asset. The elasticity describes how many percent the warrant should change in value if the underlying asset is changing by 1% (Gustaffson, 2005). However, this advantage can change to a disadvantage where the value of the underlying instrument moves against the warrant position. This is because an adverse movement in the underlying instrument will also result in a greater percentage decrease in the value of warrant, i.e. leverage works in both ways.

3.6.1.2. Speculation

A speculator is a trader who is prepared to bear more risk in return for an expected higher return. If a speculator believes that the value of a particular asset will rise in the future they could purchase the asset now in anticipation. An alternative would be to buy a deliverable call warrant

over the same asset. The difference between these and other alternatives is the cost of investment. Purchasing a leveraged warrant costs less than purchasing the underlying asset. There is however the risk that the warrant will be worthless at the expiry date.

3.6.1.3 Investment

Some warrants are structured as longer term investment-style products, for example installments. The benefits of investing in these types of products might be capital growth, income, capital protection or a combination depending on the nature of the product.

3.6.1.4 Hedging

Equity and index put warrants allow investors to protect the value of portfolio against falls in the market or in particular shares. Put warrants allow to locking in a selling price for the underlying instrument. Protecting position in these ways are called hedging, which means a transaction which reduces or offsets the risk of a current holding.

3.6.1.5 Limitation of Loss

The risk is limited since the maximum loss is the initial premium (price of the warrant) paid. If the value of the underlying instrument is less than the exercise price of the warrant at expiry then a call warrant will expire worthless. The maximum loss is the amount paid for the warrant. While entire investment can be lost in the warrants, that loss has to be compared to the size of the exposure the warrant holding gave, and what an equivalent exposure in the underlying instrument would have cost. However, they offer potentially unlimited profits, equivalent to the difference between the predetermined price of the warrant (strike price) and the price of the underlying instrument.

3.6.2. Disadvantages

3.6.2.1. Loss even if the choosing the right underlying asset

There is a risk of loss since price of call warrant can be affected negatively by any other factors even if price of underlying asset goes up.

3.6.2.2. Leverage effect

A two-sided leverage effect can be mentioned for warrants. Even if leverage is an important advantage for warrant as a result of limitless profit opportunity and loss amount is limited, loss ratio can be higher than the change in price.

3.6.2.3. Risk that issuer will not perform his obligations

For warrants, there isn't a warranty against the probability that issuer will not perform his engagement, unlike the options that the obligation of the seller of option is guaranteed by the Exchange (Türkmen, 2012).

3.6.2.4. Limited time for maturity

Warrants are for limited time period unlike stocks and expire at the end of maturity.

3.6.2.5 Mergers and Acquisitions:

It's generally seen on corporate warrant. If there are some news about the company on the market, holder of the warrant faces with the risk of losing his warrant premium. For example, at the time of investment, price of a stock is 7\$ and exercise price is 10\$. When a merger occurs, stock price will jump up to 9 \$ and the price to be paid will be equal to this. As a result, warrant will not be used and it will be unvaluable (<http://www.imkb.gov.tr>). The performance of warrants depends on the performance of underlying asset. Because of the leverage effect, if the investor buys a warrant in a

market at which underlying asset's price is going up, then the investor will gain a profit (Reilly, 1995).

3.7. Comparison of Warrants and Options

Differences and similarities can be listed as below: (<http://www.ise.org>)

3.7.1. Similarities

Warrants offer their holders the opportunity to gain exposure to the price fluctuations of the underlying asset, without owning such asset, like options. Like options, warrants are financial instruments, which entitle their holder to buy or sell a certain amount of underlying asset or indicator, at a predetermined price, on or before the expiry date. Neither warrants nor options provide control over the underlying asset until exercised. Both of them represent a right.

3.7.2. Differences

Options are contracts, whereas warrants are securities. Options are traded according to the principles of a futures market, whereas warrants are traded according to the principles of a spot (cash) market.

Options are standardized contracts. The features of them are determined by the stock exchanges on which they are traded. Unlike options, the terms of warrants are set by the issuer and the terms are more flexible than options, for example, warrants have not a just fixed expiry.

The selling party writes the option for options. On the other hand, there is a single issuer for warrants and he is the only responsible party for the right presented by warrants. Because the issuer is entirely responsible for the product, there are no margin calls or margining associated with trading warrants unlike options.

Market quotation of warrants is done in the same way with an initial public offering. However, options are just the matching up buyer with seller (Chan et al., 2011).

Warrants generally have longer maturities than options. For a warrant and an option whose underlying asset are the same (in other words, the stock of the same corporation) on the same valuation date, if the option has longer maturity and its exercise price is less than warrants, option can be more valuable than warrant. Vice versa is also valid (Veld, 1995) The main difference between warrants and options is that value of the firm rises up with the time that warrants beginning to trade depending on the underlying asset (Koziol, 2006).

3.8. Turkish Warrant Market

3.8.1 Legal Grounds for Turkish Warrant Market

The basic principles regarding the issue, issuers, registration, and trading of warrants are regulated by the Capital Markets Board of Turkey (CMB) by its Communiqué Series: III Number: 37 “*Regarding the Registration with the Capital Markets Board of Turkey and Trading of Intermediary Institutions’ Warrants at the Stock Exchange*” according to the Communiqué Article 16., warrants are traded on the Warrant Market on ISE, under the Corporate Products Market.

Also, the procedures and principles regarding the listing and trading of warrants on the ISE are stipulated by the ISE’s Circular Number: 318, dated Jan 5, 2010. According to this, if the right attached to warrant is related to securities, it’s called as “underlying security”, if it’s related to an index, then, it’s called as “underlying index”. Underlying asset can be a security index, single securities traded on ISE 30 or a basket of the equities that are included in ISE 30 index.

According to Capital Markets Board's regulations, the registration to the CMB has to be made within 3 months starting from the date of the decision of the issuer. CMB reviews the applications according to public disclosure requirements and registers the warrants. The ISE Settlement and the Central Registry Agency of Turkey allocates ISIN codes for the warrants issued in Turkey. For warrants to be issued by the intermediary institutions established abroad, the ISIN codes allocated abroad will be notified to the ISE, Takasbank and the Central Registry Agency of Turkey, by the issuer.

3.8.2 Features of Warrants To Be Traded

Warrants that give the investor the option to buy the issuer shares of the company itself or the common shares of other listed companies trading on the ISE are named as "call warrants". If it gives the investor the option to sell, it's called as "put warrant". The first warrant started to be traded on Istanbul Stock Exchange (ISE) on August 13, 2010. The traded warrant qualifies as an "intermediary institution warrant", which is issued by banks and brokerage firms. Warrants are classified according to the way in which they can be exercised. An American-style warrant can be exercised at any time up to the expiry date. In contrast, a European option can only be exercised on the expiry date. For traders in the warrants, the difference between American and European is of little concern as the warrant issuers provide continuous bid and offer prices for their respective warrants.

In Turkey, warrants can be issued by non-resident or Turkish resident intermediary institutions which have been assigned a long-term rating grade corresponding to highest 3 level or above among investable level credit ratings assigned by credit rating agencies recognized by CMB. If the intermediary institution does not meet the rating condition, it has to guarantee its settlement obligations by an intermediary institution which fulfills the rating criterion. In this case, issuer and the guarantor institution are both responsible in the same way for meeting the obligation. If the credit

rating goes below the necessary rating, CMB prohibits the issuing of warrants and does not allow a new issue. Moreover, in this case, issued warrants continue to be traded as normal (Dumanlı, 2010). The maturity date of the warrants can vary between two months and five years. There can be more than one issuer on the same security, portfolio or ISE index. Warrants which have the same issuer, underlying asset, expiration, exercise price and type (call/put) are listed with the same ticker symbol. If there is any difference in any of the items specified, a separate ticker symbol should be created (each ISIN code requires a new ticker symbol to be created) (ISE Circular Letter Number:318, 2010).

3.8.3. Transaction Code of Warrants

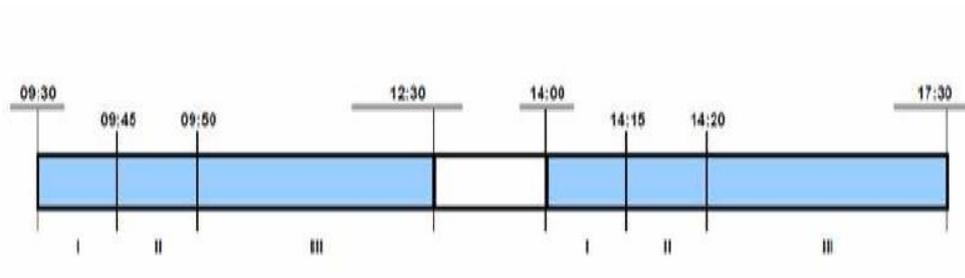
Short and long transaction codes are used in warrants. Such codes are determined and determined by the ISE. Codes of warrants show some of their characteristics. According to the ISE Circular 318 for warrants, the short code is in alphanumeric order, and consists of 5 characters. For example, a warrant whose short code is “OZDCC”, the first two letter (“OZ”) shows the underlying asset and for this warrant, it is ISE-30 index. (whereas “US” means dollar rate, “AU” means gold). The third letter, “D”, shows the issuer, Deutsche Bank. (It is “I” for Is Investment). The last two letters, “CC” shows that it is a call warrant, since the letters between “AA-OO” are for call warrants, “PP-ZZ” are for put warrants. Long code of warrants include 32 characters and shown on stock inquiry screen (Bulut, 2010).

3.8.4 Operation of Warrant Market

Since warrants are issued as a security, investors can make transactions right after signing the “risk form” contentiously just beginning from the date of issue even without asking to the issuer. Because of this principle, warrants, which have different characteristics/behaviors in terms

of pricing according to the products traded on Turkish Derivatives Exchange (Turkdex), are traded on ISE not on Turkdex.

Warrants are traded by “market making in multiple price - continuous auction system” (<http://www.imkb.gov.tr>). This system is operated by entry of buy/sell quotations by the market maker member in charge of the warrant and entry of buy/sell orders by members (including the market maker member) for such warrant. Trading hours and quotation hours in Turkey market can be seen from the figure below:



Source: http://turkborsa.net/belgeler/varant_brosur.pdf, p.3.

Figure 3. Turkish Warrant Market Session Hours

The first session is between 09:50-12:30 and the second session takes place between 14:20-17:30 hours. The time periods tagged as “I” are the opening session and time for collecting order. During these times, quotation and order entries are not done. For the time periods tagged as “II”, opening session price is determined, opening transactions are done and then quotations are entered. After 09:50 and 14:20 (in the periods tagged as “III”), orders are transmitted. Orders can be changed during the session and the market maker may also change the quotation during this time. No order entry is accepted for warrants before the market maker member enters a quotation. Orders are entered into the trading system according to price and time priority and then matched with the buy/sell orders and/or the quotations within the appropriate quotation interval (including quotation prices) (Bulut, 2010).

3.8.4 General Rules for Warrant Market Maker

In order to provide a liquid and well-regulated market, the market maker is required to give quotations continuously. A two-sided order that the market maker enters the ISE Stock Market Automated Trading System (System), which includes information about the price at which and the quantity of the warrant that he is ready to buy or sell. Currently, only covered warrants, which are issued by the financial institutions are traded on the Exchange. Warrants cannot be issued on any platform other than the exchange. According to ISE Circular Number 318, a market maker can act as the market maker of more than one warrant.

Members who are market makers in warrants have to deposit a collateral of called the Warrant Market Making Collateral (an amount of TL 500.000), in the name of the issuer whose market making they undertake (ISE Circular Letter Number:318, 2010). Market makers for warrants in Turkey have to give quotation at least minimum 250 lots and maximum 100.000 lots for every warrant of buying and selling quantities. After the first quotation, if the quantity at buy and sell party finishes completely as a result of trading, quotation price stays the same on the system, however, the quantity is seen as “zero”. At this situation, by the 3rd minutes after the time beginning from the depletion of quantity, the market maker has to complete the quantity to the minimum quotation amount. But if he does not make any change, the system automatically assigns the quantity to the minimum requirement (Türkmen, 2012). According to ISE Circular Number 318, this assignment is made using the code of the market maker representative who entered the quotation and the account number. When quotation changes are made, the market maker can raise/reduce the price of buying/selling prices and quantities in the minimum and maximum ranges. These actions can also be done together at the same time (<http://www.turkborsa.net>).

According to the rules mentioned on the Circular Number 318 announced by the ISE, the price tick is applied as “1 kurus” at each price

level in case of order and quotation entries for warrants. A price tick of 1 “kurus” is applied when an order is entered in the default, official auction and wholesale markets of warrants. The difference between the bid and ask prices given by the market maker is called the spread which is at a minimum of one price tick. There is no limit for the maximum spread in warrants, and the market maker determines the quotation spread according to the price movements in the underlying stock, market liquidity of the underlying, the availability of derivatives on that underlying, the warrant’s conversion ratio, the general market situation, the specific warrant terms, the volatility, and the issuer. The purpose of the bid/ask spread is to cover transaction costs incurred by an issuer acting as hedging its warrant books. When determining the spread, issuers take the bid/ask spread of the underlying as a guideline. For example, if a structured warrant is quoted at S\$ 0.53 / 0.54 and the conversion ratio is 10:1, the spread is equivalent to S\$ 0.01 (S\$ 0.54 minus S\$ 0.53), multiplied by ten. Seen in relation to the market of the underlying share, this is a fair spread if the share is traded around S\$ 0.1 spread (<https://www.db.com>).

3.8.6 Settlement and Conversion Transactions of Warrants

“Settlement” refers to the change of possession of the warrants that are the subject of a trade, whereas the term “warrant conversion” refers to the transactions which are executed. Intermediary institution warrants are securities that impose responsibility on the issuer. The Exchange does not have any obligation and responsibility for this product. In case of any difficulty of payment which the issuer may experience upon the exercise, the risk completely rests with the investor. Any problems that may occur when the investor is not paid upon the exercise, not delivered the underlying assets which had to be delivered, the underlying assets which need to be purchased from the investor are not purchased, or in case of other liabilities, cannot be covered from the Guarantee Fund. However, the Guarantee Fund

can be utilized in settlement transactions arising from the trading of warrants that takes place on the ISE as with the stocks.

For index warrants in Turkey, reference price is the closing settlement price of the ISE-30 future contracts, which have the same maturity date with the warrants (*Varant Kullanım Kılavuzu*, The Economist Journal, 15 April 2012). The underlying asset' exercise price that is used as indicator/reference price is preferred to be not sensitive to changes and a true reflector of the market condition. The ratio is 1:1000 for the price which is announced by TurkDex and the real index value that this price corresponds to. For warrants whose underlying asset is currency, the reference price is the ask price announced by Central Bank at 15.30 as the indicator of the currency in a day (ISE Circular Letter Number:318, 2010)

In the conversion and expiration of warrants, the following are essential:

- whether the underlying asset is a stock, basket or index,
- type (American or European type),
- nature (call or put),
- settlement method (cash settlement, book-entry delivery),
- at profit, at loss or at breakeven

The warrant holder, holding the warrant on the expiry date after the close of the session, undertakes to fulfill the obligations indicated in the conversion conditions on the expiry date. On the expiration date, the warrant conversion is executed on the Central Registry System (CRS). The settlement of the trades realized on the expiry date must be completed (V+2 end of day) in order that the warrant holder's rights are registered with the Central Registry Agency of Turkey. Therefore, the final holders for the warrant are determined on V+2. The associated rights may be used on V+3, the earliest (ISE Circular Letter Number:318, 2010). If warrant is at-the-money (in the case that the exercise price is less than the market price for a call warrant and vice versa for a put warrant), cash settlement ratio is

announced to Central Registry Agency of Turkey (CRA) and the expiry date at the latest. At Central Registry Agency of Turkey, within this ratio, cash amounts are transferred to the members' account held at Takasbank, by the Central Registry Agency of Turkey. The warrant balances available at the customer accounts are automatically deleted at the end of day V+2. Payments are made through the transfer by CRA by the issuer to the free cash accounts of the intermediary institutions held at Takasbank. The payment date shall be the date when the issuer pays the cash in the account of the Central Registry Agency of Turkey (V+3, the earliest).

The conversion of warrants written on a basket of equities or an index is realized by cash settlement only according to the Circular No:318. In case of warrant conversion via cash settlement, the exercise price and the market price of the underlying asset are compared. If the underlying asset is an index, the index value on which the calculation is based will be the closing value of the index on the expiration date of the warrant unless otherwise stated in the circular. In the case of American style warrants, conversion is realized by the deletion of the warrants upon the client's exercising his rights at pre-determined intervals in the period until the expiry date, and transfer of the cash paid by the issuer to the relevant intermediary institution's free cash account at Takasbank.

In case of warrant conversion via book-entry delivery, the exercise price and the market price of the underlying asset are compared. If the call warrant is in-the-money, the notes will be transferred to the investor after the warrant holder pays the transaction cost. If the put warrant is in-the-money, notes are transmitted to the issuer and the issuer sends the transaction amount to the issuer.

3.8.5 General Overview of The Warrant Market in Turkey

In Turkey, the first warrant was issued by Deutsche Bank AG (London) through the intermediary of Deutsche Securities Menkul Değerler

A.Ş. On August 13, 2010, 4 warrants which are related to ISE-30 index and the stock of Garanti Bank were issued and began to be traded on the market. By the second week after the starting, warrants related to stocks of Is Investment Securities and Koç Holding have appeared on the market. Deutsche Securities Menkul Değerler A.Ş. had issued 153 warrants which have 10 different underlying assets in the first year of the market.

The market, which had begun with just four types of warrant based on two different underlying assets, has progressed in a fast way and within one year from the start, there have occurred 11 different underlying assets and more than 160 issues on warrants in the Turkish warrant market, Below, there are some statistical figures about Turkish Warrant Market: (The Association of Capital Market Intermediary Institutions of Turkey, Turkish Capital Market 2011, May 2012, İstanbul, 2012)

Table 1. Numbers of issued warrants and investors and trading volume in Turkey's warrants market

	2009	2010	2011	% Change
Number of warrants	-	22	175	
Number of investors	-	1,432	2,457	
Trading volume (Million TRY)	-	1,096	9,359	754.3%
Trading volume (\$)		\$ 734	\$5,608	663.7%

Source: The Association of Capital Market Intermediary Institutions of Turkey

According to the statistics of in the table above, by the end of 2011, total transaction volume has been about 9,4 billion TL, whereas it had been about 1 billion TL for 5 months in 2010.

Table 2. Warrants Trading Volume and Numbers According to Investor Type in Turkey's warrants market

Identity	Trading Volume*		2011/09	
	2010	2011	Accounts Number	Portfolio Value
Domestic Investors	58,6%	57,5%	2.521	11.535.663
Domestic Individual Investors	47,9%	42,8	2.406	11.280.162

Identity	Trading Volume*		2011/09	
	2010	2011	Accounts Number	Portfolio Value
Domestic Institutional Investors and Corporations	10,8%	14,8%	15	255.501
Foreign Investors	41,4%	42,5%	8	2.266.579
Foreign Individual Investors	0,0%	0,0%	7	110.579
Foreign Institutional Investors and Corporations	41,4%	42,4%	1	2.156.000

* Source: The Association of Capital Market Intermediary Institutions of Turkey.

** Other data in the table are obtained from Central Registry Agency, Monthly Statistics, 2011/09

Table 3. Total Transaction Volume Rankings in Turkish Warrant Market

Ranking	Share In Total Volume (%)	Cumulative Share (%)
1-5	77,70%	77,70%
6-10	11%	8%
11-20	8,30%	96,50%
21-62	3,50%	100%

Source: The Association of Capital Market Intermediary Institutions of Turkey

According to the statistics above, in 2011, %59 of the number of transactions had been done by domestic investors. Among domestic investors, domestic individual investors are majority, but foreign corporations seem to have the biggest portion of the market among foreign investors. Almost all of the transactions occurred abroad were related to the activities done by the market maker. Number of intermediary institutions had been 62, whereas 58% of the number of transactions had been done by the two of them in 2011. For the first 5 institutions, this ratio is 78%.

In the bear markets, call warrants are expected to be more preferable than the put ones because investors generally look for the products that can make money to them and the psychological reasons. However, when the volatility is high on the market and the country, then put warrants are expected to attract investors more than the call ones. Since warrants have been traded on the secondary markets for the first time since August 2010, it has bridged a gap in Turkish Capital Market. Some of the warrants' advantages are listed below: (www.imkb.gov.tr)

- 1) Warrants offer high gearing with a small investment (premium) in the warrant in comparison to a direct investment in the underlying instrument.
- 2) The risk is limited since the maximum loss is the initial premium (price of the warrant) paid.
- 3) They offer potentially unlimited profits, equivalent to the difference between the predetermined price of the warrant (strike price) and the price of the underlying instrument.
- 4) The potential warrants have to increase attention and interest for the stock market.
- 5) New source of revenue for the ISE as a result of increase in commission earned because of issuing revenues and increasing trading volume.

The table which shows trading value of securitized derivatives in some of the worldwide exchanges in year 2010 is given below.

Table 4. Trading value of securitized derivatives in the worldwide exchanges in 2010

The Exchange	Trading Value of Securitized Derivatives (in million U.S.)
Hong Kong Exchanges	533.879,10
Korea Exchange	354.116,50
Deutsche Börse	79.608,90
SIX Swiss Exchange	37.991,30
London SE Group	34.859,50
NYSE Euronext (Europe)	34.826,50
Tel Aviv SE	32.473,60
Taiwan SE Corp.	6.527,00
Singapore Exchange	4.481,80
Australian SE	3.943,80
NASDAQ OMX Nordic Exchange	2.299,80
BME Spanish Exchanges	2.115,30
The Stock Exchange of Thailand	1.689,90
TSX Group	1.077,10
Bursa Malaysia	1.034,70
Oslo Børs	556,1
Wiener Börse	394
Mexican Exchange	308,6
Johannesburg SE	214,9
Warsaw SE	94,3

Source: World Federation of Exchanges

According to the table, it can be said that trading volume in Hong Kong is the largest one and trading volume has been larger than 1 trillion \$ in total. For Turkey, one of the issuers had announced that expected trading volume would be at the level of 500 million \$ at the end of three years. The improvement of warrants' portfolio value and number of investors in Turkey market can be seen from the graphics below, which has been done according to the data related to November 2011 period obtained from The Central Registry Agency of Turkey.

4.FUTURES CONTRACTS

4.1 Brief Information About Futures Contracts

Futures contracts are legal agreements to buy or sell goods for a specified delivery future date at a price agreed today. The party to the contract who is agreeing to take delivery of the commodity is long in the position, whereas the party who is agreeing to deliver the commodity is short in the position. Futures contracts have the advantage of being quickly traded and liquidity. Future contracts can easily be exchanged and traded in large amounts without changing its price (Chambers, 1998). The gain or loss balance of trading a futures contract is decided by matching the underlying asset's spot price and settlement price and by the type of the position held.

Investors trading future contracts can be categorized as an hedger or speculator. Hedging activity with future contracts is done in order to keep the portfolio value holded as constant against the price changes and volatility in the economic conditions. Speculators, however, aim to get profit from the price changes of underlying asset.

Relationship between futures and spot market can be explained by expectations approach, in which prices are based on people's forecast about future. Price of futures contract whose maturity date is t , will be equal to the expectations about price behavior at time t (Chambers, 1998). Another approach that relates futures and spot market is cost and carry model approach, which says that future prices should be priced not according to spot price but expected price at the maturity (Bolak, 1998).

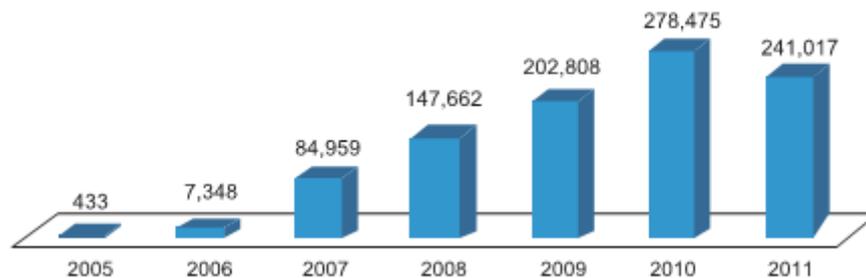
ISE 30 Futures is considered as an attractive alternative to ISE 30 index spot market because of its leverage effect, short selling opportunities and lower transaction costs, it attracts a rising number of market participants since its establishment (*Why To Invest on TurkDex*”, Presentation on <http://www.turkdex.org.tr>, 2012).

4.2 Turkish Derivatives Exchange

Future contracts are traded on Turkish Derivatives Exchange (TurkDex). Established in 2001, Turkish Derivatives Exchange (TurkDex) is the first exchange for derivatives trading in Turkey. The first transaction had been done on 4th February, 2005. TurkDex Exchange Operations System (TEOS) is used for trading activities. Financials; equity index futures (ISE-30 and ISE-100), interest rate futures (T-benchmark) and currency futures (US Dollar /TRY and Euro/TRY),wheat futures, cotton futures and gold futures are the mainly traded instruments on the market.

During the normal session held between 9.15 a.m. and 17.15 p.m. without lunch break, computerized system matches automatically buy and sell orders on a price and time priority basis which is called “continuous auction trading method” (Karhan, 2011). Custody Bank Inc. (Takasbank) is responsible for clearing transactions like the way for Istanbul Stock Exchange and this responsibility compensate for the counterparty risk of issuer. Traders have to open an account with the authorized members of Turkdex and investors are required to deposit some collateral before the execution of trade. Profits and losses are calculated and accounts are marked to market at end of each business day. Capital Markets Board of Turkey (CMB) is the governing and auditing body for exchange traded derivatives contracts. Below there is the graph of total trading value of ISE-30 Futures.

Figure 4. Trading Volume of ISE-30 Index Futures Contracts



**Numbers are in millions of USD.*

Source: www.turkdex.org.tr

As seen on the figure, by the end of 2011, the trading volume of IS-30 Index futures contract has reached to 241.017 million USD with an evident increase. Also, trading volume of TurkDex has been at 286.521 million USD level as the nominal value with 63.952.177 unit of contracts. These numbers have been 263.057 million USD and 74.287.630 in 2011, respectively (*Why To Invest on TurkDex*”, Presentation on <http://www.turkdex.org.tr>, 2012).

4.3 Specifications of ISE-30 Future Contracts

ISE-30 Index Futures contract (ISE-30 futures) has been said to be the most liquid financial instrument in the financial system of Turkey and one of the most active equity index futures contract in the world with the ease and low cost of trading (Takmaz, 2009). Some of the important characteristics of ISE-30 future contracts described by Turkish Derivatives Exchange, are listed below:

(www.turkdex.org.tr)

- Contract size is calculated by dividing index value by 1000 and multiplying the quotient by 100.
- Its minimal small contract size can be attractive for many investors (contract size is around \$4,000 by October 2012)
- Daily price limit is the 15% of the established base price for each contract with a different contract month. Value of one tick is 0,0025 index point and it corresponds to 2,5 TRY.
- Contract months are February, April, June, August, October and December.
- Final settlement is the last business day of each contract month and settlement is done by cash.
- Final settlement price is average of all ISE National-30 Index values executed at ISE within the last 30 minutes before the close of the session of Exchange on the last trading day.

5.METHODOLOGY

5.1. Data

The main data set for the study consists of the 5 minutes time interval closing values of the ISE 30 index futures traded at the Turkdex and ISE 30 index put and call warrants traded at ISE and issued by Deutsche Bank and Is Investment, which are considered from January 6, 2012 to February 29, 2012 period; from May 8, 2012 to June 29, 2012 period and from July 2, 2012 to August 31, 2012 period for near month futures contracts, near month and mostly heavily traded put and call warrants. The near month futures have been analyzed as they are mostly heavily traded. The period is selected because daily prices of the ISE 30 stock index are very volatile and in these periods derivative products take the patience of investor. Each time series in three different periods include 2.769, 2.847 and 3.066 data respectively. For the tests to process the data, the Eviews (7.2) and IBM SPSS Statistics (20) software have been used. The selected most traded futures contract and warrant contracts in the given period are respectively listed below:

Table 5. List of Warrants and Futures Contracts Used in the Study

Original Code	Type	Name In This Study	Maturity Date	Strike Price
IX0300212	Future Contract	Future	29.02.2012	-
IX0300612	Future Contract	F_IX0300612	29.06.2012	-
IX0300812	Future Contract	F_IX0300812	31.08.2012	-
OZDBHV	Call Warrant	Warrant_70C	29.02.2012	70
OZDBCX	Call Warrant	Warrant_65C	29.02.2012	65
OZDSTV	Put Warrant	Warrant_65P	29.02.2012	65
OZDCAV	Call Warrant	W_IX0300612_70C	29.06.2012	70
OZIAHV**	Call Warrant	W_IX0300612_74C	29.06.2012	74
OZDCCV	Call Warrant	W_IX0300612_75C	29.06.2012	75
OZDTTV	Put Warrant	W_IX0300612_65P	29.06.2012	65
OZDTVV	Put Warrant	W_IX0300612_70P	29.06.2012	70
OZDCIV	Call Warrant	W_IX0300812_75C	31.08.2012	75
OZDCFV	Call Warrant	W_IX0300812_80C	31.08.2012	80
OZDUPV	Put Warrant	W_IX0300812_70P	31.08.2012	70
OZDUSV	Put Warrant	W_IX0300812_75P	31.08.2012	75

**Issued by Is Yatirim, while other warrants are issued by Deutsche Bank.

All the required data information for the study has been retrieved and compiled from the Foreks Data Provider. Futures contracts have different trading hours compared to warrants because they are traded on different markets. Futures contracts are traded on Turkdex during 9:15 am to 17:30 pm, whereas warrants on ISE are traded from 9:50 am to 17.30 pm. Also, Turkdex doesn't have a lunch break. Because of these, for simplicity, in order to match the data, we use warrants and futures data only when both markets are open for trading between 09:50-12.30 and 14.20-17:30 in a day.

5.2. Parametric Method

Traditionally parametric methods like Granger's causality, cross-correlation function and vector autoregressive model are used to study the lead-lag effect in any related time series of securities returns. The method relies on regressing the return or price changes of related time series at a fixed time interval (5 minutes) and tries to identify any lead-lag relationships from the significance of the estimated coefficients. While this method is supported by econometric theory, and has been widely used, in this section, some information are given about the selected parametric methods.

5.2.1. Cross Correlation Function

The cross correlation functions described in the field of time series analysis help when a time series is wanted to be modelled as a function of its past values and past random errors. When the effects of past and current values of other series are wanted to be included in the model, the correlations of the response series and the other series must be considered. (Box, 2008)

The cross correlation coefficient at lag k is estimated by

$$r_{xy}(k) = \frac{C_{xy}(k)}{S_x S_y}$$

$$C_{xy}(k) = \begin{cases} \frac{1}{n} \sum_{t=1}^{n-k} (x_t - \bar{x})(y_{t+k} - \bar{y}), & k = 0, 1, 2, 3, \dots \\ \frac{1}{n} \sum_{t=1}^{n+k} (x_{t-k} - \bar{x})(y_t - \bar{y}), & k = -1, -2, -3, \dots \end{cases}$$

The following notation is used:

X, Y:	Any two series of length n
$r_{xy}(k)$	Sample cross correlation coefficient at lag k
S_x	Standard deviation of series X
S_y	Standard deviation of series Y
$C_{xy}(k)$	Sample cross covariance at lag k

5.2.2. Vector Autoregression Model

VAR Model is the basic multivariate model that is used to represent a set of dynamically dependent stationary time series. Consider a set of n process X_1, X_2, \dots, X_n . It is defined that the first order vector autoregressive process, or VAR(1) process, as (Brooks, 2008).

$$\begin{aligned} X_{1t} &= \alpha_1 + \beta_{11}X_{1,t-1} + \dots + \beta_{1n}X_{n,t-1} + \varepsilon_{1t} \\ &\vdots \\ X_{nt} &= \alpha_n + \beta_{n1}X_{1,t-1} + \dots + \beta_{nn}X_{n,t-1} + \varepsilon_{nt} \end{aligned}$$

The VAR(1) process is written in matrix form as

$$\mathbf{X}_t = \boldsymbol{\alpha} + \mathbf{B}\mathbf{X}_{t-1} + \boldsymbol{\varepsilon}_t$$

where

$$\mathbf{X}_t = \begin{pmatrix} X_{1t} \\ \vdots \\ X_{nt} \end{pmatrix}, \quad \boldsymbol{\alpha} = \begin{pmatrix} \alpha_1 \\ \vdots \\ \alpha_n \end{pmatrix}, \quad \mathbf{B} = \begin{pmatrix} \beta_{11} & \dots & \beta_{1n} \\ \vdots & \ddots & \vdots \\ \beta_{n1} & \dots & \beta_{nn} \end{pmatrix}, \quad \boldsymbol{\varepsilon}_t = \begin{pmatrix} \varepsilon_{1t} \\ \vdots \\ \varepsilon_{nt} \end{pmatrix}$$

A p^{th} order vector autoregressive process, VAR(p), is a process of the form

$$\mathbf{X}_t = \boldsymbol{\alpha} + \mathbf{B}_1\mathbf{X}_{t-1} + \dots + \mathbf{B}_p\mathbf{X}_{t-p} + \boldsymbol{\varepsilon}_t$$

5.2.3. Granger Causality

Granger causality analysis is a method for investigating whether one time series can correctly forecast another. This method is based on

multiple regression analysis. At individual level, many studies performed F statistics on the residuals (Goebel et al., 2003)

Granger causality really implies a correlation between the current value of one variable and the past values of others, it doesn't mean changes in one variable cause changes in another. By using a F-test to jointly test for the significance of the lags on the explanatory variables, this in effect tests for 'Granger causality' between these variables. It is possible to have causality running from variable X to Y, but not Y to X; from Y to X, but not X to Y and from both Y to X and X to Y, although in this case interpretation of the relationship is difficult. The 'Granger causality' test can also be used as a test for whether a variable is exogenous. i.e. If no variables in a model affect a particular variable, it can be viewed as exogenous.

If we have two time series X and Y, the paired model is as following:

$$Y_t = \sum_{n=1}^p A_n X_{(t-p)} + \sum_{n=1}^p B_n Y_{(t-p)} + CZ_t + E_t$$

$$X_t = \sum_{n=1}^p A'_n Y_{(t-p)} + \sum_{n=1}^p B'_n X_{(t-p)} + C'Z_t + E'_t$$

X_t and Y_t represent the two time series at time t. $X_{(t-p)}$ and $Y_{(t-p)}$ represent the time series at time t-p, p representing the number of lagged time points (order). A_n and A'_n are signed path coefficients. B_n and B'_n are autoregression coefficients. E_t and E'_t are residual.

5.2.4. Impulse Response Functions

The impulse response functions can be used to produce the time path of the dependent variables in the VAR, to shocks from all the explanatory variables. If the system of equations is stable any shock should decline to zero, an unstable system would produce an explosive time path. A

common, but technically unsound, interpretation of an impulse-response function is the effect of a primitive impulse $\varepsilon_{i,t}$ on $y_{j,t+k}$.

A basic VAR(1) model is mentioned below:

$$s_t = A_1 s_{t-1} + u_t$$

where s is a stock price return, if we then assume a simple two stock price system, then the matrices and vectors in full would be:

$$\begin{bmatrix} s_{1t} \\ s_{2t} \end{bmatrix} = \begin{bmatrix} \beta_{11} & \beta_{12} \\ \beta_{21} & \beta_{22} \end{bmatrix} \begin{bmatrix} s_{1t-1} \\ s_{2t-1} \end{bmatrix} + \begin{bmatrix} u_{1t} \\ u_{2t} \end{bmatrix}$$

The next step is to calculate the value for each dependent variable, given a unit shock to the variable s_{1t} at time $t = 0$. The value of each dependent variable can be determined at $t=0, 1, 2, 3$ etc. There is no effect in the variable due to the way the model is set up, however if the s_{2t} variable had been significantly different to zero, then the shock would have affected both variables.

$$s_1 = A_1 s_0 \quad \text{where } s_0 = \begin{bmatrix} u_{10} \\ u_{20} \end{bmatrix}$$

This process continue until the value of the dependent variable either becomes zero (stable) or very large (unstable). The same process could have been done for with s_{2t} , although in this case the dependent variable would have been affected by both explanatory variables, giving two separate time paths.

5.2.5. Variance Decomposition

Variance decompositions explain VAR system dynamics by giving the proportion of the movements in the dependent variables that are due to their 'own' shocks, versus shocks to the other variables. A shock to the i^{th} variable will directly affect that variable and it will also be transmitted

to all of the other variables in the system through the dynamic structure of the VAR. Variance decompositions determine how much of these steps ahead forecast error variance of a given variable is explained by innovations to each explanatory variable for $s=1, 2, \dots$. In practice, it is usually observed that own series shocks explain most of the (forecast) error variance of the series in a VAR and to some extent, impulse responses and variance decompositions offer very similar information (Brooks, 2008).

5.3. Non-Parametric Counting Method

Kui (2007) propose a non-parametric counting method to avoid making assumptions that are required in the regression approaches. The counting method begins with the assignment of price change directions to the two time series separately as can be seen from the algorithm below: (Kui, 2007)

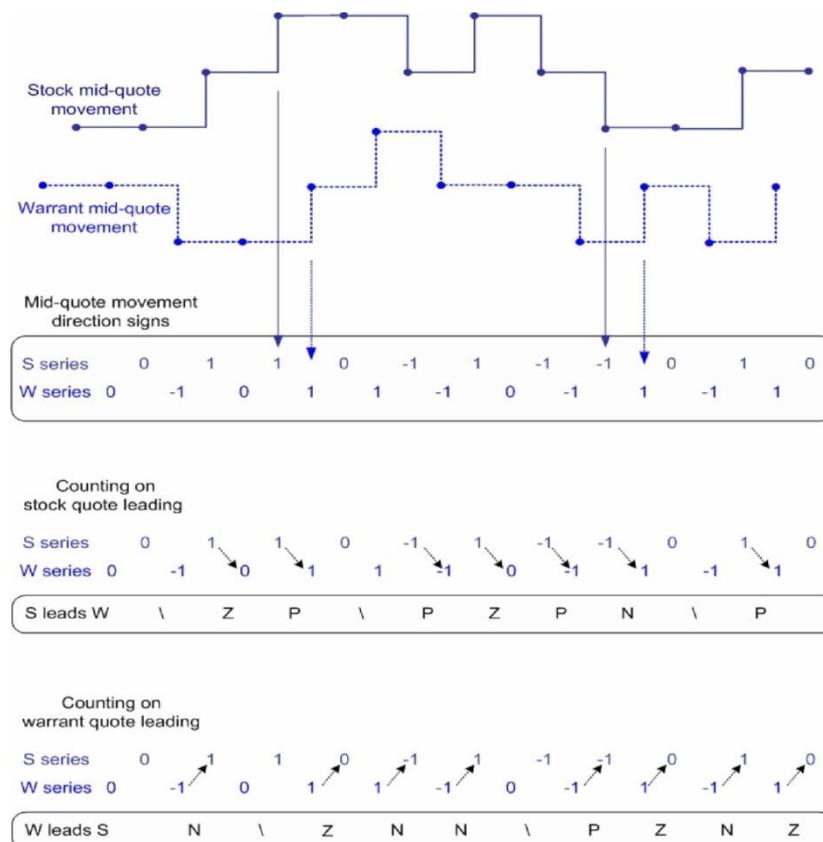


Figure 5. The algorithm of Kui (2007)'s counting methods to detect the lead-lag relationships between warrants and their underlying stocks

Kui convert the series of quote midpoints to a series of up tick, zero tick, and down tick. An up (down) tick occurs when the current quote midpoint is higher (lower) than the last quote midpoint. If there is no change in the midpoint, but only the bid or ask size is updated, such a quote is referred as zero tick. Thus, the time series of transactions' prices are transformed into a series comprising of only three outcomes, +1, 0, or -1, for each update. These three outcomes are, up tick, zero tick, and down tick, respectively. Kui first examined the sign of the W (warrants) series for each non-zero sign in the S (stocks) series. First, he analyzed the sign of the W series upon the occurrence of every non-zero sign in the S series to see the leading or lagging effect from the S series to the W series. Then, he analyzed the sign of the S series to see whether any leading or lagging effect of W series exists on S series. The symbol 'P' is assigned as the economically correct movement according to the nature of the relation between a call or a put warrant with the underlying security. The symbol 'N' is used for coding the wrong movements. For example, for a call warrant, when an uptick is followed by a down tick, or a down tick is followed by an uptick, the symbol 'N' is used since the two series move in the opposite direction. If one of the series, has more quote updates than the other series, in other words if a non-zero quote update may not have a corresponding quote update in the other series, then the symbol 'Z' is used. After assigning these symbols to each update of quote midpoint, the numbers of these three symbols have been counted and its significance is tested.

In this study, an exact time interval of 5 minutes is preferred instead of last mid quote because there are deficiencies of ISE warrants' trading volume, synchronization the markets in terms of trading times between ISE and Turkdex and infrequent trading differences which are effective on quote updates. Every 5 minutes update is signed by the direction of change in the last quotes. If there is no leading effect, the quote

updates would be simultaneous and random, and only a few economically correct movements of 'P' and 'N' would be observed randomly in the series. Also, the number of leads observed would be the same from either F or W series, with neither of them is counted significantly larger than the other. However, if one security is leading the other in quote update, different amount of leading counts from F or W series can be observed. Besides, the number of 'P' symbols, which represents economically correct movement according to the nature of the relation, should be larger than the number of 'N' symbols. To test the statistical significance of the difference between these two numbers, the chi-square statistic is used.

6.EMPRICAL RESULT

In this chapter, the lead-lag relationship of index futures on ISE 30 with its warrants on is explored and explained. This chapter is devoted to the analysis of Turkish futures and warrants data covering the three different periods: 1) 06.01.2012 - 29.02.2012 period; 2) 08.05.2012 - 29.06.2012 period; 3) 02.07.2012 - 31.08.2012 period. Analysis of this period will introduce an idea on the lead-lag relationship between futures contracts market and warrant market. Cross correlation function, vector autoregressive model and counting method are used in order to investigate the lead-lag relationship between futures contracts market and warrant market. Residuals tests based on autocorrelation and non-stationary variances are ignored in this study because high frequency data intraday data are used for the analyses and the focus has been kept on analysis of price changing effects, not on the variance in the prices. Because of these, ARCH effect and variance spillover effect analyses were not done. Investigating these effects of changing variances in prices on warrants can be subject to a further research. The outline of this chapter is as follows: descriptive statistics of the data is selected, cross correlation function, Vector Autoregression (VAR) and counting methodologies are explained, and unit root tests and Granger causality are employed. The natural logarithmic price series of futures, call and put warrants are shown in Appendix Figure 20, 21 and 22.

6.1. Descriptive Statistics

Descriptive statistics regarding the logarithmic returns series calculated

- from 1 future contract and 3 warrants between 06.01.2012 - 29.02.2012 period are provided in Table 29,
- from 1 future contract and 5 warrants between 08.05.2012 - 29.06.2012 period are provided in Table 30,

- from 1 future contract and 4 warrants between 02.07.2012 - 31.08.2012 period are provided in Table 31.

From the statistics above, it can be seen that the mean returns for futures and call warrants series are positive. Put warrant has negative mean as expected. Other moments are skewness and kurtosis, which measure the symmetry of returns to the means and tail behaviours of returns, respectively. Being positively skewed, series are distributed non-symmetrically. Revealed by the excess kurtosis, returns series for the both markets are fat tailed, which means they indicate peakedness. The Jarque-Bera statistic that is significant at 1% level supports the argument of non-normal distribution of the log return series. Logarithmic return series of futures, call and put warrants for each period mentioned above are shown in Appendix Figure 21, 22 and 23, respectively. The frequency distribution of each period's log returns series are shown in Figure 24, 25 and 26 in Appendix.

6.2. Unit Root Test

In econometric models the relation between two time series should be tested initially to conclude whether or not the series are stationary or have trend. The relationship between two time series may be non-stationary due to trend. Since their averages, variances, and covariances change time-dependently in general, they have heteroscedasticity (Engle, 1987). The variables to be employed in the model need to be stationary. When analysis is conducted with a non-stationary time series, a spurious regression problem occurs. In that case a series with no actual inter-relationship may seem as if they are interrelated. (Ozata, 2010). In this study, the unit root test was employed to test the stationarity of variables and the Augmented Dickey-Fuller (ADF) test as the unit root test was applied on the series.

In this study, the ADF test has been used to test first the stationary of the time series composed of the 5-minutes log prices of futures

and warrants in data set. The optimal delay length in application of the ADF test has been set using the Schwarz Information Criterion (SIC) as it gives more unbiased results in comparison to the other information criteria such as Akaike, Hannan-Quinn. Upon having found out that level of the series is not stationary, their first degree differences are taken to stabilize their averages and variances, and subjected to the unit root test again. If t-statistics in nominal term is smaller than MacKinnon critical values' nominal term, it is concluded that times series are non-stationary (Çelik, 2012). As also seen in the Table 6, it has been concluded that the variables are first degree stationary. Table 6 summarizes the ADF test results. This result can be interpreted as any variable without asterisk is not stationary in its own level. On the other hand, all variables in the analysis are stationary in the first difference, since ADF test statistics, which are shown in the right side of the table below, are larger than the MacKinnon (1996) one-sided t-value (which is -3,459) at 1% significant level and probabilities are less than the significance level (1%).

Table 6. ADF Test Results

	Variables	ADF Test Statistics	P ⁺ (Sig.)		Variables	ADF Test Statistics	P ⁺ (Sig.)
Level (Constant)	LNFUTURE	-1.5585	0.5038	First Difference (Constant)	LNFUTURE	-52.1630*	0.0001
	LNWARRANT_70C	-1.5630	0.5014		LNWARRANT_70C	-62.6812*	0.0001
	LNWARRANT_65C	-1.5270	0.5199		LNWARRANT_65C	-58.4664*	0.0001
	LNWARRANT_65P	-0.0735	0.9504		LNWARRANT_65P	-25.7867*	0.0000
	LNF_IX0300612	0.2285	0.9744		LNF_IX0300612	-54.2362*	0.0001
	LNW_IX0300612_70C	-0.8103	0.8156		LNW_IX0300612_70C	-63.0660*	0.0001
	LNW_IX0300612_74C	-2.6403	0.0850		LNW_IX0300612_74C	-39.6696*	0.0000
	LNW_IX0300612_75C	-2.7759	0.0619		LNW_IX0300612_75C	-44.1243*	0.0000
	LNW_IX0300612_65P	-0.0053	0.9570		LNW_IX0300612_65P	-34.3066*	0.0000
	LNW_IX0300612_70P	1.3531	0.9989		LNW_IX0300612_70P	-36.6921*	0.0000
	LNF_IX0300812	-0.5332	0.8823		LNF_IX0300812	-54.6034*	0.0001
	LNW_IX0300812_75C	-1.2082	0.6732		LNW_IX0300812_75C	-55.8729*	0.0001
	LNW_IX0300612_80C	-2.5661	0.1002		LNW_IX0300612_80C	-32.0020*	0.0000
	LNW_IX0300812_70P	-0.5725	0.8742		LNW_IX0300812_70P	-21.6333*	0.0000
LNW_IX0300812_75P	0.1013	0.9659	LNW_IX0300812_75P	-38.0963*	0.0000		

⁺ MacKinnon (1996) one-sided p-values, it is equal to (-3,4324) at 1%.

* Significant at 1% level

As a result, it can be said that null hypothesis is rejected and first degree differences of futures and warrants data don't have unit root problem and they are stationary time series.

6.3. Cross Correlation Function

One of the measure of price efficiency is the cross-correlation between current index futures returns and lagged index warrant returns. In a given period, the correlation between 5-minutes log-index futures returns at time t and index warrants returns at time $t-1$ ($\text{corr}(r_{i,t}; r_{m,t-1})$) is computed. The zero point on the X axis shows the variable in the same period "t", and, negative part of it shows the past, while positive part shows the future time.

The cross correlation function between futures and warrants is practically negligible and stays within 95% confidence interval. On the contrary, the cross correlation function between futures and warrants is significantly different than zero at the 5% level. From Figure 27 to Figure 38, the cross correlation functions between futures and warrants are shown. From Figure 39 to Figure 50, cross correlogram graphs are shown with the lead-lag coefficients for each lag length. The solid lines are 95% confidence interval for the autocorrelations of independent and identically distributed random variables process. As seen in Table 7, as a result of cross correlation functions, it can be said that from 5 minutes (1 lag) to 20 minutes cross correlation have been found, because correlation factor seems to be higher than the bounds at time "t" in these periods. However, most of the correlation have been found among about 3-4 lags. In figures, the right side of the zero lag shows that the futures market leads the warrants markets. Conversely, the left side of the zero lag shows that the warrants market leads the futures markets in figures.

Table 7. Results of Cross Correlation Analyses

Time Period	Related Future and Warrant	Direction of Relationship	Orientation of Relationship	Time period for leading
Period 1 (6.1.2012 - 29.2.2012)	DLFUTURE - DLWARRANT_70C	Future leads Warrant	Positive way	During the first 10 minutes
	DLFUTURE - DLWARRANT_65C	Future leads Warrant	Positive way	During the first 10 minutes
	DLFUTURE - DLWARRANT_65P	Future leads Warrant	Negative way	During the first 5 minutes
Period 2 (08.05.2012 - 29.06.2012)	DLN_F_IX0300612 - DLN_W_IX0300612_70C	Future leads Warrant	Positive way	During the first 5 minutes
	DLN_F_IX0300612 - DLN_W_IX0300612_74C	Future leads Warrant	Positive way	During the first 15 minutes
	DLN_F_IX0300612 - DLN_W_IX0300612_75C	Warrant leads Future	Positive way	During the first 15 minutes
	DLN_F_IX0300612 - DLN_W_IX0300612_65P	Future leads Warrant	Negative way	During the first 5 minutes
	DLN_F_IX0300612 - DLN_W_IX0300612_70P	Warrant leads Future	Negative way	During the first 5 minutes
Period 3 (02.07.2012 - 31.08.2012)	DLN_F_IX0300812 - DLN_W_IX0300812_75C	Both-way relationship	Positive way	During the first 20 minutes
	DLN_F_IX0300812 - DLN_W_IX0300812_80C	Both-way relationship	Positive way	During the first 10 minutes
	DLN_F_IX0300812 - DLN_W_IX0300812_70P	Both-way relationship	Negative way	During the first 5 minutes
	DLN_F_IX0300812 - DLN_W_IX0300812_75P	Warrant leads Future	Negative way	During the first 10 minutes

6.4. VAR Model

In this part, short-term dynamics are investigated between futures and warrants market using the vector autoregression (VAR) model. VAR model is a preferable way of estimating accurately between the macroeconomic variables which cannot be separated such as being exogenous or endogenous (Uysal, 2008). Before modelling, the lag length of VAR model must be decided. Regarding selection of the lag-length of a model, there are three criteria: Akaike Information Criteria (AIC), Schwarz Information Criteria (SIC) and Hannan Quinn Criteria (HQ). However, in the literature some researchers choose the SIC as a bayesian and unbiased statistic and some researchers choose the lowest level of test value of all these three criteria results. SIC is generally selected due to its superior large sample properties and its strong consistency (Abuk, 2011). Especially, SIC's lag length results are lower compared to AIC, which is also preferable by researchers. In this study, AIC's optimal lag length results are about 6-8 lags, however, it's not selected since in Turkey leading effect doesn't known to be exist so long. These selections are presented in Table 32-43 that show optimal test results, where the selected lag of each criterion is denoted by “*”.

Firstly, short-term dynamics between DLFUTURE and DLWARRANT_70C series are analyzed. Hence, lag 6, lag 3 and again lag 4 are chosen regarding AIC, SC and HQ methodologies. The SIC selection is used for identifying which lag will be selected, because one lag cross correlation has been found between the futures and warrants markets in

Section 6.3. The first VAR model is performed using 3 lags of the stationary variables DLFUTURE and DLWARRANT_70C. In the VAR model, values in parenthesis show “t” values, whereas the other values correspond to coefficient. To decide whether the variable is significant or not, t values in parentheses are compared with the standard deviation value at that confidence level. These values are about 1.65 for %10 level, 1.96 for %5 level and 2.33 for %1 level. As lag 3 is chosen, the first VAR (3) model is evaluated and the model results is shown in Table 8. The first VAR (3) model's results show that the ordered first 3 lag of DLFUTURE have a positive impact on DLWARRANT_70C and a significant relationship with DLWARRANT_70C in the short-run in 99% confidence interval. In addition, the model also show that the first lag of DLWARRANT_70C have a positive impact on DLFUTURE and a significant relationship with DLFUTURE in the short-run in 95% confidence interval.

Table 8. VAR model results for DLFUTURE and DLWARRANT_70C

	DLNFUTURE	DLNWARRANT_70C
DLNFUTURE(-1)	-0.025887 [-1.00679]	7.391319 [16.9947]*
DLNFUTURE(-2)	-0.059993 [-2.16933]**	3.647715 [7.79784]*
DLNFUTURE(-3)	-0.033384 [-1.26272]	1.777624 [3.97499]*
DLNWARRANT_70C(-1)	0.002946 [1.94778]**	-0.491117 [-19.1965]*
DLNWARRANT_70C(-2)	0.002039 [1.23178]	-0.253550 [-9.05757]*
DLNWARRANT_70C(-3)	0.001715 [1.14518]	-0.134979 [-5.32755]*
C	0.000068 [2.02009]	0.000078 [0.13802]
R-squared	0.002752	0.127340
Adj. R-squared	0.000582	0.125442
Akaike AIC	-9.852913	-4.196509
Schwarz SC	-9.837914	-4.181509

* Significant at 1% level

** Significant at 5% level

*** Significant at 10% level

Secondly, short-term dynamics between DLFUTURE and DLWARRANT_65C series is analysed. Hence, lag 3 is chosen regarding SIC methodology. The second VAR model is performed using 3 lags of the stationary variables DLFUTURE and DLWARRANT_65C. As lag 3 is

chosen, the second VAR (3) model is evaluated and the model results is shown in Table 9. It shows that the ordered first 3 lag of DLFUTURE have a positive impact on DLWARRANT_65C and a significant relationship with DLWARRANT_65C in the short-run in 90% confidence interval.

Table 9. VAR model results for DLFUTURE and DLWARRANT_65C

	DLNFUTURE	DLNWARRANT_65C
DLNFUTURE(-1)	0.005153 [0.20678]	4.173524 [20.1336]*
DLNFUTURE(-2)	-0.051248 [-1.87851]	2.055354 [9.05783]*
DLNFUTURE(-3)	-0.038724 [-1.45759]	1.026119 [4.64354]*
DLNWARRANT_65C(-1)	0.000504 [0.16883]	-0.451507 [-18.1781]*
DLNWARRANT_65C(-2)	0.003578 [1.12658]	-0.187143 [-7.08425]*
DLNWARRANT_65C(-3)	0.004188 [1.46339]	-0.064353 [-2.70369]*
C	0.000065 [1.95548]	0.000188 [0.67647]
R-squared	0.002111	0.141743
Adj. R-squared	-0.000059	0.139876
Akaike AIC	-9.852272	-5.615516
Schwarz SC	-9.837272	-5.600516

* Significant at 1% level

** Significant at 5% level

*** Significant at 10% level

When we looked at short-term dynamics between DLFUTURE and DLWARRANT_65P series, lag 3 is chosen regarding SIC methodology. The third VAR model is performed using 3 lags of the stationary variables DLFUTURE and DLWARRANT_65P. As lag 3 is chosen, the last VAR (3) model is evaluated and the model results is shown in Table 10. It shows that the ordered first 3 lag of DLFUTURE have a negative impact (as expected) on DLWARRANT_65P and a significant relationship with DLWARRANT90_65P in the short-run in 99%

Table 10. VAR model results for DLNFUTURE and DLWARRANT_65P

	DLNFUTURE	DLNWARRANT_65P
DLNFUTURE(-1)	0.009545 [0.49037]	-5.176991 [-5.89312]*
DLNFUTURE(-2)	-0.028661 [-1.46441]	-1.545749 [-1.75006]***
DLNFUTURE(-3)	-0.006000 [-0.30716]	-2.841753 [-3.22384]*
DLNWARRANT_65P(-1)	0.000171 [0.40589]	-0.388165 [-20.3818]*
DLNWARRANT_65P(-2)	0.000286 [0.63236]	0.023081 [1.12895]
DLNWARRANT_65P(-3)	0.000326 [0.77310]	-0.212030 [-11.1502]*
C	0.000066 [1.97482]	-0.002092 [-1.38685]
R-squared	0.001476	0.250391
Adj. R-squared	-0.000696	0.248761
Akaike AIC	-9.851635	-2.232549
Schwarz SC	-9.836636	-2.217550

* Significant at 1% level

** Significant at 5% level

*** Significant at 10% level

We analyse short-term dynamics between DLN_F_IX0300612 and DLN_W_IX0300612_70C series. Hence, lag 3 is chosen regarding SC methodology. The VAR model is performed using 3 lags of the stationary variables DLN_F_IX0300612 and DLN_W_IX0300612_70C. As lag 3 is chosen, the last VAR (3) model is evaluated and the model results is shown in Table 11. The last VAR (3) model's results show that the ordered first 3 lag of DLN_F_IX0300612 have a positive impact (as expected) on DLN_W_IX0300612_70C and a significant relationship with DLN_W_IX0300612_70C in the short-run in 99% confidence interval. In addition, the model also shows that the first lag of DLN_W_IX0300612_70C have a positive impact on DLN_F_IX0300612 and a significant relationship with DLN_F_IX0300612 in the short-run in 99% confidence interval.

Table 11. VAR model results for DLN_F_IX0300612 and DLN_W_IX0300612_70C

	DLN_F_IX0300612	DLN_W_IX0300612_70C_
DLN_F_IX0300612(-1)	-0.079893 [-2.85523]*	7.842886 [14.0778]*
DLN_F_IX0300612(-2)	-0.001884 [-0.06365]	6.241466 [10.5897]*
DLN_F_IX0300612(-3)	0.025018 [0.89684]	3.577508 [6.44133]*
DLN_W_IX0300612_70C(-1)	0.004315 [3.10586]*	-0.495129 [-17.8989]*
DLN_W_IX0300612_70C(-2)	0.000984 [0.65026]	-0.356198 [-11.8284]*
DLN_W_IX0300612_70C(-3)	-0.002126 [-1.52930]	-0.229526 [-8.29181]*
C	3.05E-05 [1.06620]	-8.12E-05 [-0.14252]
R-squared	0.005968	0.108271
Adj. R-squared	0.003864	0.106384
Akaike AIC	-10.13208	-4.149621
Schwarz SC	-10.11742	-4.134964

* Significant at 1% level

** Significant at 5% level

*** Significant at 10% level

We analyse short-term dynamics between DLN_F_IX0300612 and DLN_W_IX0300612_74C series. Hence, lag 10, lag 2 and again lag 2 are chosen regarding AIC, SC and HQ methodologies. The VAR model is performed using 2 lags of the stationary variables DLN_F_IX0300612 and DLN_W_IX0300612_74C. As lag 2 is chosen, the last VAR (2) model is evaluated and the model results is shown in Table 12. The last VAR (2) model's results show that the ordered first 2 lag of DLN_F_IX0300612 have a positive impact (as expected) on DLN_W_IX0300612_74C and a significant relationship with DLN_W_IX0300612_74C in the short-run in 99% confidence interval. In addition, the model also show that the first lag of DLN_W_IX0300612_74C have a positive impact on DLN_F_IX0300612 and a significant relationship with DLN_F_IX0300612 in the short-run in 99% confidence interval.

Table 12. VAR model results for DLN_F_IX0300612 and DLN_W_IX0300612_74C

	DLN_F_IX0300612	DLN_W_IX0300612_74C_
DLN_F_IX0300612(-1)	-0.037565 [-1.94701]**	3.745501 [5.87532]*
DLN_F_IX0300612(-2)	-0.000120 [-0.00623]	4.025703 [6.30341]*
DLN_W_IX0300612_74C(-1)	0.002504 [4.32549]*	-0.028036 [-1.46586]
DLN_W_IX0300612_74C(-2)	0.000642 [1.11126]	-0.091021 [-4.76904]*
C	3.02E-05 [1.05770]	-0.000267 [-0.28289]
R-squared	0.007328	0.027165
Adj. R-squared	0.005930	0.025795
Akaike AIC	-10.13488	-3.139321
Schwarz SC	-10.12442	-3.128855

* Significant at 1% level

** Significant at 5% level

*** Significant at 10% level

We analyse short-term dynamics between DLN_F_IX0300612 and DLN_W_IX0300612_75C series. Hence, lag 2 is chosen regarding SC methodology. The VAR model is performed using 2 lags of the stationary variables DLN_F_IX0300612 and DLN_W_IX0300612_75C. As lag 2 is chosen, the last VAR (2) model is evaluated and the model results is shown in Table 13. The last VAR (2) model's results show that the ordered first 2 lag of DLN_F_IX0300612 have a positive impact (as expected) on DLN_W_IX0300612_75C and a significant relationship with DLN_W_IX0300612_75C in the short-run in 90% confidence interval. In addition, the model also show that the first lag of DLN_W_IX0300612_75C have a positive impact on DLN_F_IX0300612 and a significant relationship with DLN_F_IX0300612 in the short-run in 90% confidence interval.

Table 13. VAR model results for DLN_F_IX0300612 and DLN_W_IX0300612_75C

	DLN_F_IX0300612	DLN_W_IX0300612_75C_
DLN_F_IX0300612(-1)	-0.044170 [-2.22843]**	4.941213 [5.91630]*
DLN_F_IX0300612(-2)	-0.001228 [-0.06213]	1.531284 [1.83895]***
DLN_W_IX0300612_75C_(-1)	0.001927 [4.11245]*	-0.227022 [-11.5009]*
DLN_W_IX0300612_75C_(-2)	0.000827 [1.76174]***	-0.102537 [-5.18673]*
C	3.09E-05 [1.08078]	-0.000462 [-0.38389]
R-squared	0.006630	0.048256
Adj. R-squared	0.005231	0.046915
Akaike AIC	-10.13418	-2.652384
Schwarz SC	-10.12371	-2.641918

* Significant at 1% level

** Significant at 5% level

*** Significant at 10% level

We analyse short-term dynamics between DLN_F_IX0300612 and DLN_W_IX0300612_65P series. Hence, lag 2 is chosen regarding SIC methodology. The VAR model is performed using 2 lags of the stationary variables DLN_F_IX0300612 and DLN_W_IX0300612_65P. As lag 2 is chosen, the last VAR (2) model is evaluated and the model results is shown in Table 14. The last VAR (2) model's results show that the ordered first two lag of DLN_F_IX0300612 have a negative impact (as expected) on DLN_W_IX0300612_65P and a significant relationship with it in the short-run in 99% confidence interval.

Table 14. VAR model results for DLN_F_IX0300612 and DLN_W_IX0300612_65P

	DLN_F_IX0300612	DLN_W_IX0300612_65P_
DLN_F_IX0300612(-1)	-0.018389 [-0.94924]	-4.986206 [-4.93302]*
DLN_F_IX0300612(-2)	0.013304 [0.68757]	-1.573486 [-1.55850]
DLN_W_IX0300612_65P_(-1)	-0.000131 [-0.36097]	-0.413158 [-21.8566]*
DLN_W_IX0300612_65P_(-2)	3.68E-06 [0.01015]	-0.224583 [-11.8807]*
C	2.90E-05 [1.01147]	-0.001805 [-1.20654]
R-squared	0.000513	0.150328
Adj. R-squared	-0.000895	0.149131
Akaike AIC	-10.12804	-2.218735
Schwarz SC	-10.11758	-2.208269

* Significant at 1% level

** Significant at 5% level

*** Significant at 10% level

We analyze short-term dynamics between DLN_F_IX0300612 and DLN_W_IX0300612_70P series. Hence, lag 10, lag 4 and again lag 4 are chosen regarding AIC, SC and HQ methodologies. The VAR model is performed using 4 lags of the stationary variables DLN_F_IX0300612 and DLN_W_IX0300612_70P. As lag 4 is chosen, the last VAR (4) model is evaluated and the model results are shown in Table 15. The last VAR (4) model's results show that the ordered first four lag of DLN_F_IX0300612 have a negative impact (as expected) on DLN_W_IX0300612_70P and a significant relationship with DLN_W_IX0300612_70P in the short-run in 99% confidence interval (The fourth lag has been significant in 90% confidence interval).

Table 15. VAR model results for DLN_F_IX0300612 and DLN_W_IX0300612_70P

	DLN_F_IX0300612	DLN_W_IX0300612_70P
DLN_F_IX0300612(-1)	-0.022621 [-1.16546]	-5.344752 [-5.85782]*
DLN_F_IX0300612(-2)	0.013161 [0.67456]	-4.777574 [-5.20925]*
DLN_F_IX0300612(-3)	-0.010511 [-0.53749]	-2.434398 [-2.64812]*
DLN_F_IX0300612(-4)	-0.008000 [-0.41212]	-1.659019 [-1.81810]***
DLN_W_IX0300612_70P(-1)	-0.000551 [-1.34722]	-0.393247 [-20.4432]*
DLN_W_IX0300612_70P(-2)	6.34E-05 [0.14576]	-0.319934 [-15.6414]*
DLN_W_IX0300612_70P(-3)	-0.000540 [-1.24050]	-0.173645 [-8.49082]*
DLN_W_IX0300612_70P(-4)	-0.000494 [-1.20704]	-0.140296 [-7.29084]*
C	2.77E-05 [0.96456]	-0.002607 [-1.93190]
R-squared	0.002091	0.151568
Adj. R-squared	-0.000727	0.149172
Akaike AIC	-10.12659	-2.425907
Schwarz SC	-10.10774	-2.407057

* Significant at 1% level

** Significant at 5% level

*** Significant at 10% level

When short-term dynamics are analyzed between DLN_F_IX0300812 and DLN_W_IX0300812_75C series, lag 3 is chosen regarding SIC methodology. The VAR model is performed using 3 lags of the stationary variables DLN_F_IX0300812 and DLN_W_IX0300812_75C. As lag 3 is chosen, the last VAR (3) model is evaluated and the model results is shown in Table 16. The last VAR (3) model's results show that the ordered first three lag of DLN_F_IX0300812 have a positive impact (as expected) on DLN_W_IX0300812_75C and a significant relationship with in the short-run in 99% confidence interval. In addition, the model also show that the first two lag of DLN_W_IX0300812_75C have a positive impact on DLN_F_IX0300812 and a significant relationship with DLN_F_IX0300812 in the short-run in 99% confidence interval.

Table 16. VAR model results for DLN_F_IX0300812 and DLN_W_IX0300812_75C

	DLN_F_IX0300812	DLN_W_IX0300812_75C_
DLN_F_IX0300812(-1)	-0.105824 [-5.21424]*	2.559958 [8.85392]*
DLN_F_IX0300812(-2)	-0.060220 [-2.88439]*	1.788938 [6.01458]*
DLN_F_IX0300812(-3)	0.000528 [0.02619]	1.706866 [5.94691]*
DLN_W_IX0300812_75C_(-1)	0.018582 [13.1178]*	-0.107686 [-5.33597]*
DLN_W_IX0300812_75C_(-2)	0.003702 [2.50837]*	-0.086378 [-4.10773]*
DLN_W_IX0300812_75C_(-3)	0.002011 [1.26381]	-0.069340 [-3.05946]*
C	2.46E-05 [1.28936]	9.58E-05 [0.35173]
R-squared	0.054729	0.037767
Adj. R-squared	0.052872	0.035877
Akaike AIC	-10.86469	-5.551684
Schwarz SC	-10.85091	-5.537906

* Significant at 1% level

** Significant at 5% level

*** Significant at 10% level

When short-term dynamics between DLN_F_IX0300812 and DLN_W_IX0300812_80C series are analyzed, lag 2 is chosen regarding SIC methodology. The VAR model is performed using 2 lags of the

stationary variables DLN_F_IX0300812 and DLN_W_IX0300812_80C. The VAR (2) model's results show that the ordered first two lag of DLN_F_IX0300812 have a positive impact (as expected) on DLN_W_IX0300812_80C and a significant relationship with in the short-run in 99% confidence interval. In addition, the model also shows that the first two lag of DLN_W_IX0300812_80C have a positive impact on DLN_F_IX0300812 and a significant relationship with DLN_F_IX0300812 in 90% confidence interval.

Table 17. VAR model results for DLN_F_IX0300812 and DLN_W_IX0300812_80C

	DLN_F_IX0300812	DLN_W_IX0300812_80C_
DLN_F_IX0300812(-1)	-0.076459 [-3.35349]*	7.726419 [11.2648]*
DLN_F_IX0300812(-2)	-0.034671 [-1.54045]	2.582584 [3.81433]*
DLN_W_IX0300812_80C_(-1)	0.004959 [6.57776]*	-0.326860 [-14.4110]*
DLN_W_IX0300812_80C_(-2)	0.001450 [1.91426]***	-0.135635 [-5.95055]*
C	2.73E-05 [1.39839]	-0.000175 [-0.29852]
R-squared	0.014222	0.066500
Adj. R-squared	0.012932	0.065279
Akaike AIC	-10.82433	-4.016406
Schwarz SC	-10.81449	-4.006568

* Significant at 1% level

** Significant at 5% level

When short-term dynamics between DLN_F_IX0300812 and DLN_W_IX0300812_70P series are analyzed in Table 18, lag 12, lag 4 and again lag 4 are chosen regarding AIC, SC and HQ methodologies. The VAR model is performed using 4 lags of the stationary variables DLN_F_IX0300812 and DLN_W_IX0300812_70P. The VAR (4) model's results show that the ordered first lag of DLN_F_IX0300812 have a negative impact (as expected) on DLN_W_IX0300812_70P and a significant relationship in the short-run in 99% confidence interval. In addition, the model also show that the first lag of DLN_W_IX0300812_70P have a negative impact on DLN_F_IX0300812 and a significant relationship with it in the short-run in 95% confidence interval.

Table 18. VAR model results for DLN_F_IX0300812 and DLN_W_IX0300812_70P

	DLN_F_IX0300812	DLN_W_IX0300812_70P
DLN_F_IX0300812(-1)	0.008111 [0.44278]	-9.102150 [-5.76470]*
DLN_F_IX0300812(-2)	-0.004810 [-0.26132]	-2.480189 [-1.56314]
DLN_F_IX0300812(-3)	0.038420 [2.08554]**	-4.148456 [-2.61245]*
DLN_F_IX0300812(-4)	0.016077 [0.87723]	-1.156862 [-0.73232]
DLN_W_IX0300812_70P(-1)	-0.000448 [-2.12251]**	-0.452170 [-24.8378]*
DLN_W_IX0300812_70P(-2)	-0.000137 [-0.59176]	-0.260794 [-13.0933]*
DLN_W_IX0300812_70P(-3)	0.000300 [1.29801]	-0.134195 [-6.73464]*
DLN_W_IX0300812_70P(-4)	-0.000113 [-0.53438]	-0.116980 [-6.42085]*
C	2.38E-05 [1.21186]	-0.001644 [-0.97164]
R-squared	0.004740	0.176377
Adj. R-squared	0.002131	0.174218
Akaike AIC	-10.81229	-1.898990
Schwarz SC	-10.79457	-1.881271

* Significant at 1% level

** Significant at 5% level

*** Significant at 10% level

While analyzing short-term dynamics between DLN_F_IX0300812 and DLN_W_IX0300812_75P series in Table 19, lag 3 is chosen regarding SIC methodology. The VAR model is performed using 3 lags of the stationary variables DLN_F_IX0300812 and DLN_W_IX0300812_75P. The last VAR (3) model's results show that the ordered first three lag of DLN_F_IX0300812 have a negative impact (as expected) on DLN_W_IX0300812_75P and a significant relationship with in the short-run in 99% confidence interval. In addition, the model also show that the first three lag of DLN_W_IX0300812_75P have a negative impact on DLN_F_IX0300812 and a significant relationship with DLN_F_IX0300812 in the short-run in 99% confidence interval (the second and third lag has been significant in 90% confidence interval).

Table 19 VAR model results for DLN_F_IX0300812 and DLN_W_IX0300812_75P

	DLN_F_IX0300812	DLN_W_IX0300812_75P
DLN_F_IX0300812(-1)	-0.006853 [-0.36879]	-3.297089 [-3.28141]*
DLN_F_IX0300812(-2)	-0.013124 [-0.70609]	-3.549855 [-3.53202]*
DLN_F_IX0300812(-3)	0.024980 [1.34981]	-2.541965 [-2.54015]*
DLN_W_IX0300812_75P(-1)	-0.001564 [-4.56362]*	-0.228995 [-12.3597]*
DLN_W_IX0300812_75P(-2)	-0.000634 [-1.80619]***	-0.127865 [-6.73885]*
DLN_W_IX0300812_75P(-3)	-0.000664 [-1.93310]***	-0.088231 [-4.74917]*
C	2.12E-05 [1.08299]	-0.001659 [-1.56683]
R-squared	0.008947	0.055606
Adj. R-squared	0.007001	0.053751
Akaike AIC	-10.81739	-2.836689
Schwarz SC	-10.80362	-2.822911

* Significant at 1% level

** Significant at 5% level

*** Significant at 10% level

6.5. Granger Causality

In the second part of the VAR analysis, all variables are treated as if they are not cointegrated and Granger causality tests are applied in order to get an idea about the relationship between the futures and the warrants market. Test is applied to the first differenced variables since all the variables are found to be non-stationary (I(1)). The Granger causality framework allows for testing the existence and the direction of causality between the variables.

Granger causality test results are shown in Table 20-22. Lag lengths are decided according to Schwarz Information Criterion (SIC) criteria used in the VAR model in Section 6.4.

Table 20. Granger cause test results for Jan 6 - Feb 29, 2012 period

Null Hypothesis:	Obs	F-Statistic	Prob.
DLNWARRANT_70C does not Granger Cause DLNFUTURE (Lag=3)	2765	1.46523	0.2220
DLNFUTURE does not Granger Cause DLNWARRANT_70C (Lag=3)		99.7910	0.0000*
DLNWARRANT_65C does not Granger Cause DLNFUTURE (Lag=3)	2765	0.87454	0.4535
DLNFUTURE does not Granger Cause DLNWARRANT_65C (Lag=3)		139.684	0.0000*
DLNWARRANT_65P does not Granger Cause DLNFUTURE (Lag=3)	2765	0.28917	0.8333
DLNFUTURE does not Granger Cause DLNWARRANT_65P (Lag=3)		15.4982	0.0000*

**Significant at %1 confidence level*

Table 21. Granger cause test results for May 8 - Jun 29, 2012 period

Null Hypothesis:	Obs	F-Statistic	Prob.
DLN_W_IX0300612_70C_ does not Granger Cause DLN_F_IX0300612 (Lag=3)	2844	5.23352	0.0013*
DLN_F_IX0300612 does not Granger Cause DLN_W_IX0300612_70C (Lag=3)		81.4312	0.0000*
DLN_W_IX0300612_74C_ does not Granger Cause DLN_F_IX0300612 (Lag=2)	2844	9.8210	0.0000*
DLN_F_IX0300612 does not Granger Cause DLN_W_IX0300612_74C (Lag=2)		35.0585	0.0000*
DLN_W_IX0300612_75C_ does not Granger Cause DLN_F_IX0300612 (Lag=2)	2844	8.8171	0.0002*
DLN_F_IX0300612 does not Granger Cause DLN_W_IX0300612_75C (Lag=2)		18.4972	0.0000*
DLN_W_IX0300612_65P_ does not Granger Cause DLN_F_IX0300612 (Lag=2)	2844	0.07505	0.9277
DLN_F_IX0300612 does not Granger Cause DLN_W_IX0300612_65P (Lag=2)		13.1164	0.0000*
DLN_W_IX0300612_70P_ does not Granger Cause DLN_F_IX0300612 (Lag=4)	2844	1.1577	0.3275
DLN_F_IX0300612 does not Granger Cause DLN_W_IX0300612_70P (Lag=4)		16.6418	0.0000*

**Significant at %1 confidence level*

Table 22. Granger cause test results for Jul 2 - Aug 31, 2012 period

Null Hypothesis:	Obs	F-Statistic	Prob.
DLN_W_IX0300812_75C_ does not Granger Cause DLN_F_IX0300812 (Lag=3)	3062	57.3910	0.0000
DLN_F_IX0300812 does not Granger Cause DLN_W_IX0300812_75C (Lag=3)		39.2094	0.0000
DLN_W_IX0300812_80C_ does not Granger Cause DLN_F_IX0300812 (Lag=2)	3062	21.7447	0.0000
DLN_F_IX0300812 does not Granger Cause DLN_W_IX0300812_80C (Lag=2)		64.7811	0.0000
DLN_W_IX0300812_70P_ does not Granger Cause DLN_F_IX0300812 (Lag=4)	3062	2.33633	0.0533
DLN_F_IX0300812 does not Granger Cause DLN_W_IX0300812_70P (Lag=4)		10.7104	0.0000
DLN_W_IX0300812_75P_ does not Granger Cause DLN_F_IX0300812 (Lag=3)	3062	7.69778	0.0000
DLN_F_IX0300812 does not Granger Cause DLN_W_IX0300812_75P (Lag=3)		9.55807	0.0000

**Significant at %1 confidence level*

When results are analyzed, it can be said that hypothesis would be rejected if probability is less than 0,01 (at 1% significance level) and F-statistic is large. For Jan 6 - Feb 29, 2012 period, since if F-statistics probability is smaller than the significance level (<0,01), the null hypothesis that “*futures contract does not Granger cause the warrant*” is rejected. However, the null hypothesis which is “*warrant does not Granger cause the future contract*” is accepted. So, Granger causality in the context of VAR shows evidence of a unidirectional relationship from futures to warrants exists. These indicate that the futures market helps to induce warrants market. In contrast, the warrants markets don't stimulate the futures market fluctuations.

For the other 2 period, null hypothesis that “*futures contract does not Granger cause the warrant*” is rejected in all cases. However, for the period May 8 - Jun 29, 2012 period, the null hypothesis that “*warrant does not Granger cause the future contract*” is rejected for 3 warrants (W_IX0300612_70C, W_IX0300612_74C and W_IX0300612_75C), while for the other 2 one, they cannot. For Jul 2 - Aug 31, 2012 period, null

hypothesis that “*warrant does not Granger cause the future contract*” cannot be rejected for only W_IX0300812_70P, while it is rejected for the other three. For these situations that null hypotheses which are “*warrant does not Granger cause the future contract*” cannot be rejected, since neither of them seems to lead the other, a bidirectional relationship is said to be existing between futures and warrants.

6.6. Impulse Response Function

The fundamental idea of impulse response function is to analyze impact of unit standard deviation in a random disturbance term upon the current value and future value of various endogenous variables. Here, the method of generalized impulse response is applied and attribute respectively the two variables a positive impact with a unit size of standard deviation. Then, the generalized impulse response function is formulated between futures market and warrants market under the models of VAR, as is shown below from Figure 6 to 17. In figures, x axis stands for lagging period of time (1 unit: 5 minutes) of the impact effect, and ordinate axis stands for response to the impact.

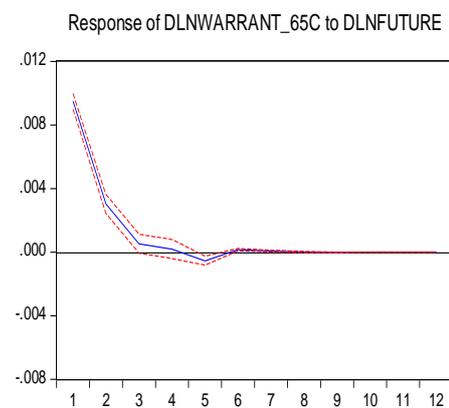
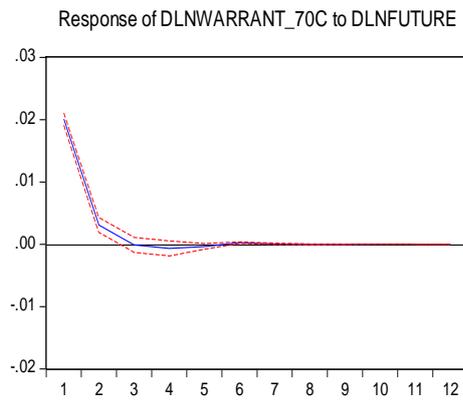
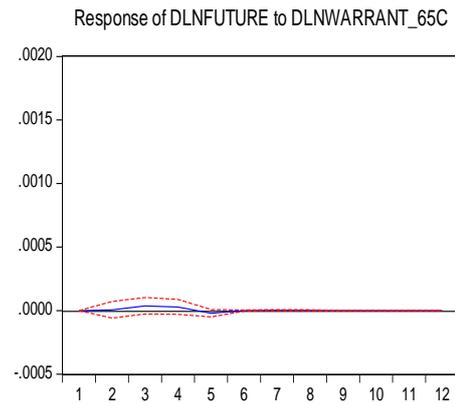
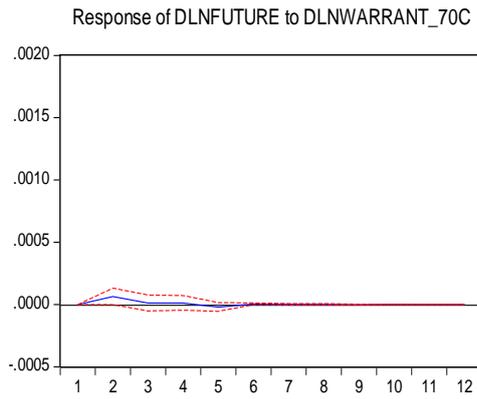


Figure 6. Impulse-Response function graphs of DLFUTURE and DLWARRANT_70C

Figure 7. Impulse-Response function graphs of DLFUTURE and DLWARRANT_65C

In Figure 6a, as for unit positive impact of DLWARRANT_70C, the sequence DLFUTURE is positively affected in the short time, but the influence will go down gradually during 30 minutes. In Figure 6b, as for unit positive impact of DLFUTURE, the sequence DLWARRANT_70C is positively affected in the first five minutes, but the influence will go down sharply after the first 5 minutes and then the influence will go down gradually after 20 minutes.

In Figure 7a, as for unit positive impact of DLWARRANT_65C, the sequence DLFUTURE is positively affected in the short time, but the influence will go down gradually during 30 minutes. In Figure 7b, as for unit positive impact of DLFUTURE, the sequence DLWARRANT_65C is positively affected in the first five

minutes, but the influence will go down sharply after the first 5 minutes and then the influence will go down gradually after 20 minutes.

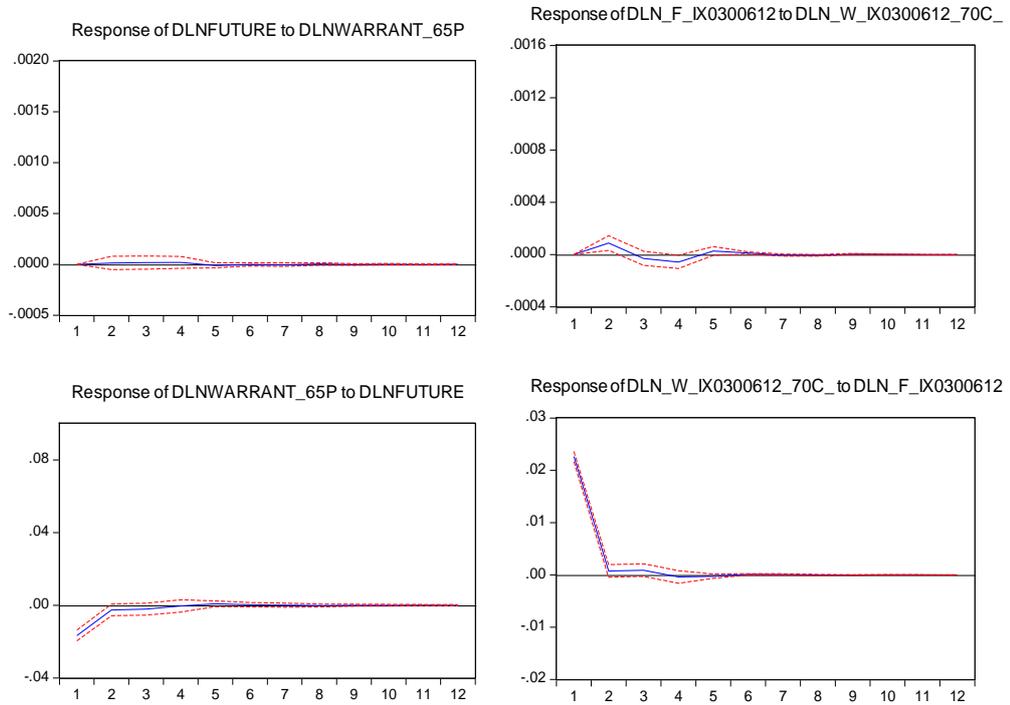


Figure 8. Impulse-Response function graphs of DLFUTURE and DLWARRANT_65P

Figure 9. Impulse-Response function graphs of DLN_F_IX0300612 and DLN W IX0300612 70C

the sequence DLFUTURE is not affected significantly in the short time. In Figure 8b, as for unit positive impact of DLFUTURE, the sequence DLWARRANT_65P is negatively affected in the first five minutes, but the influence will go down sharply after the first 5 minutes and then the influence will go down gradually after 20 minutes.

In Figure 9a, as for unit positive impact of DLN_W_IX0300612_70C, the sequence DLN_F_IX0300612 is positively affected in the short time, but the influence will fluctuate within a narrow range during 30 minutes. In Figure 9b, as for unit positive impact of DLN_F_IX0300612, the sequence DLN_W_IX0300612_70C is positively affected in the first five minutes, but the influence will go down sharply

after the first 5 minutes and then the influence will go down gradually after 20 minutes.

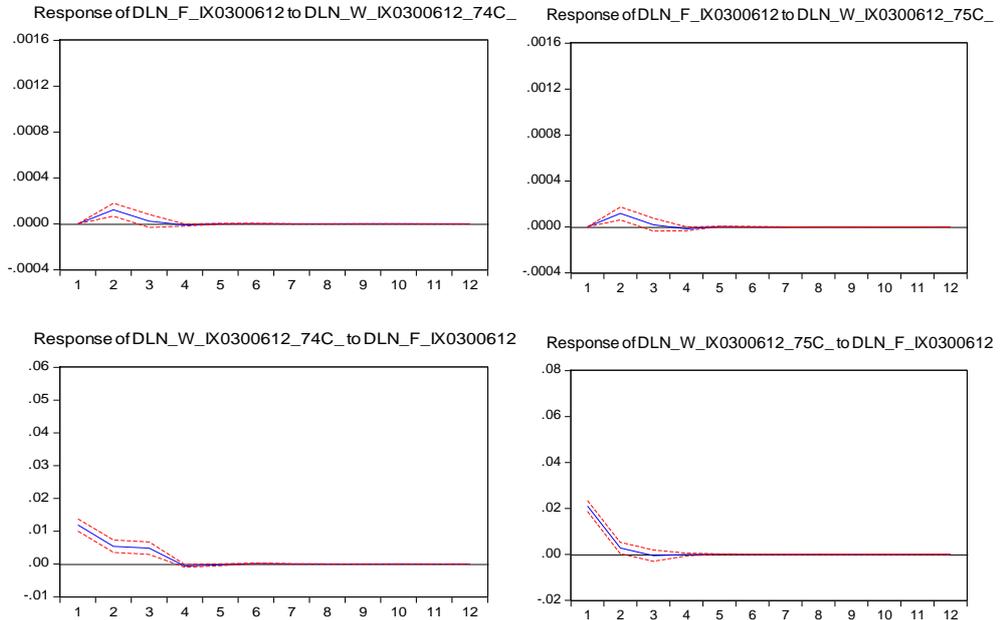


Figure 10. Impulse-Response function graphs of DLN_F_IX0300612 and DLN_W_IX0300612_74C

Figure 11. Impulse-Response function graphs of DLN_F_IX0300612 and DLN_W_IX0300612_75C

In Figure 10a, as for unit positive impact of DLN_W_IX0300612_74C, the sequence DLN_F_IX0300612 is positively affected in the short time, but the influence will go down gradually during 20 minutes. In Figure 10b, as for unit positive impact of DLN_F_IX0300612, the sequence DLN_W_IX0300612_74C is positively affected in the first five minutes, but the influence will go down sharply after the first 5 minutes and then the influence will go down gradually after 15 minutes. In Figure 11a, as for unit positive impact of DLN_W_IX0300612_75C, the sequence DLN_F_IX0300612 is positively affected in the short time, but the influence will go down gradually during 20 minutes. In Figure 11b, as for unit positive impact of DLN_F_IX0300612, the sequence DLN_W_IX0300612_75C is positively affected in the first five

minutes, but the influence will go down sharply after the first 5 minutes and then the influence will go down gradually after 10 minutes.

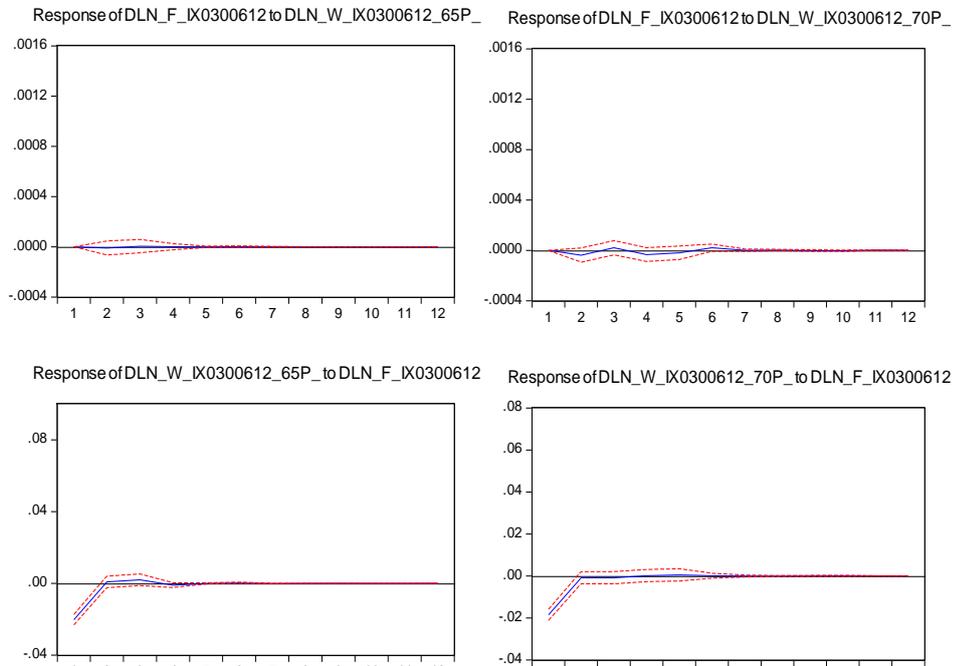


Figure 13. Impulse-Response function graphs of DLN_F_IX0300612 and DLN_W_IX0300612_65P

Figure 12. Impulse-Response function graphs of DLN_F_IX0300612 and DLN_W_IX0300612_70P

In Figure 12a, as for unit positive impact of DLN_W_IX0300612_65P, the sequence DLN_F_IX0300612 is not affected significantly in the short time. In Figure 12b, as for unit positive impact of DLN_F_IX0300612, the sequence DLN_W_IX0300612_65P is negatively affected in the first five minutes, but the influence will go down sharply after the first 5 minutes and then the influence will go down gradually after 5 minutes.

In Figure 13a as for unit positive impact of DLN_W_IX0300612_70P, the sequence DLN_F_IX0300612 is negatively affected in the short time, but the influence will fluctuate within a narrow range during 30 minutes. In Figure 13b, as for unit positive impact of DLN_F_IX0300612, the sequence DLN_W_IX0300612_70P is negatively

affected in the first five minutes, but the influence will go down sharply after the first 5 minutes and then the influence will go down gradually after 5 minutes.

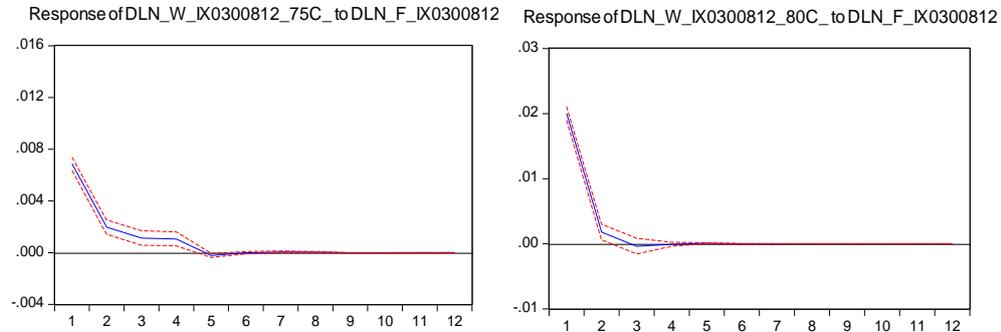
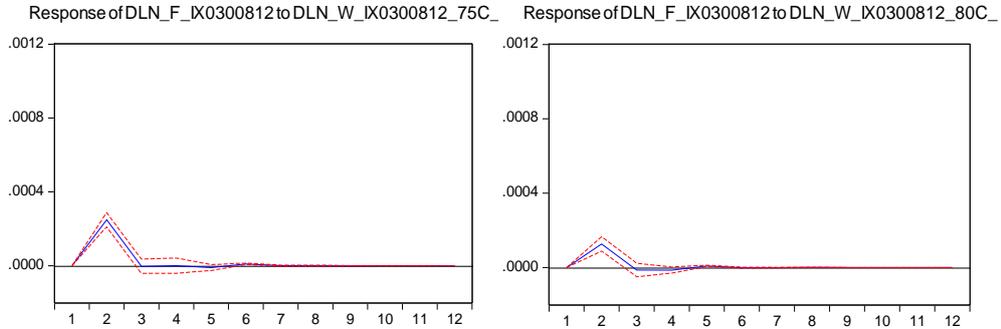


Figure 14. Impulse-Response function graphs of DLN_F_IX0300812 and DLN_W_IX0300812_75C

Figure 15. Impulse Response function graphs of DLN_F_IX0300812 and DLN_W_IX0300812_80C

of DLN_W_IX0300812_75C, the sequence DLN_F_IX0300812 is positively affected in the short time, but the influence will go down gradually during 10 minutes. In Figure 14b, as for unit positive impact of DLN_F_IX0300812, the sequence DLN_W_IX0300812_75C is positively affected in the first five minutes, but the influence will go down sharply after the first 5 minutes and then the influence will go down gradually after 20 minutes. In Figure 15a, as for unit positive impact of DLN_W_IX0300812_80C, the sequence DLN_F_IX0300812 is positively affected in the short time, but the influence will go down gradually during 10 minutes. In Figure 15b, as for unit positive impact of DLN_F_IX0300812, the sequence DLN_W_IX0300812_80C is positively affected in the first five minutes, but the influence will go down sharply

after the first 5 minutes and then the influence will go down gradually after 10 minutes.

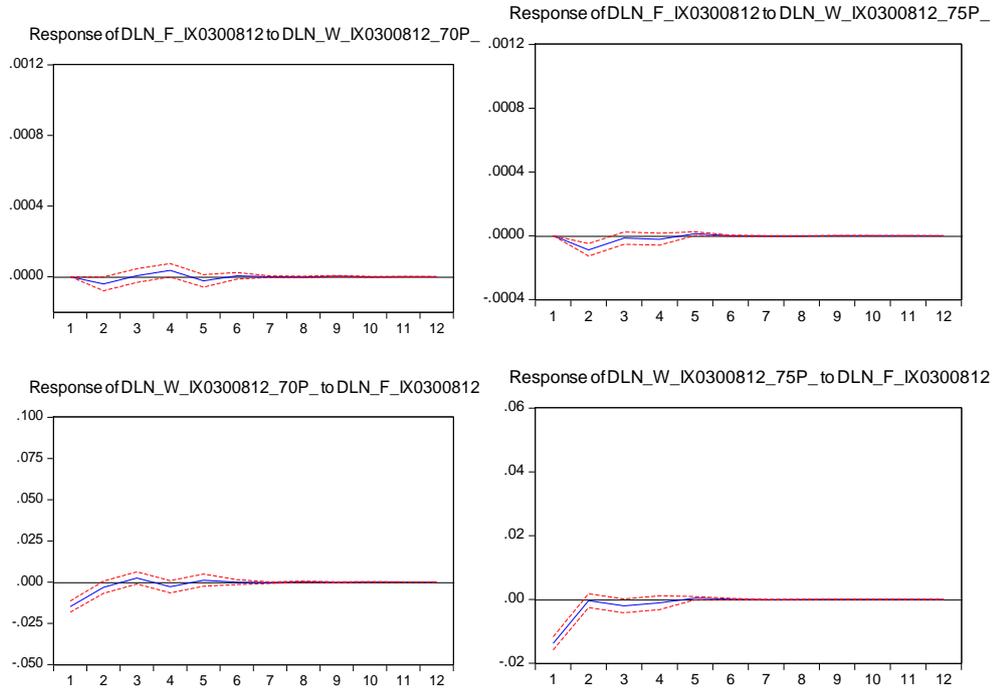


Figure 16. Impulse-Response function graphs of DLN_F_IX0300812 and DLN_W_IX0300812_70P

Figure 17. Impulse-Response function graphs of DLN_F_IX0300812 and DLN W IX0300812 75P

In Figure 16a, as for unit positive impact of DLN_W_IX0300812_70P, the sequence DLN_F_IX0300812 is negatively affected in the short time, but the influence will fluctuate within a narrow range during 30 minutes. In Figure 16b, as for unit positive impact of DLN_F_IX0300812, the sequence DLN_W_IX0300812_70P is negatively affected in the first five minutes, but the influence will go down sharply after the first 5 minutes and then he influence will go down gradually after 20 minutes.

In Figure 17a, as for unit positive impact of DLN_W_IX0300812_75P, the sequence DLN_F_IX0300812 is negatively affected in the short time, but the influence will go down gradually during

20 minutes. In Figure 17b, as for unit positive impact of DLN_F_IX0300812, the sequence DLN_W_IX0300812_75P is negatively affected in the first five minutes, but the influence will go down sharply after the first 5 minutes and then the influence will go down gradually after 10 minutes.

6.7. Variance Decomposition

In variance decomposition analysis, some information about the relative importance of each random innovation to the variables are obtained in the VAR. That is to say, variance decomposition provides the variance of the forecast errors in a specific variable to its own shocks and those of the other variables in the VAR model and explains this by ratio analysis (Pindyck, 1991).

As the variance decomposition of each equation is analyzed, we can reach the following conclusion. Variations in each of the variable are largely explained by shocks to the variable itself. However, almost 40-41% of the variation in call warrants returns variance is caused by the shocks to futures returns variance in Jan 6 - Feb 29, 2012 period. Variation in put warrants returns is not caused by the variation in futures returns. In May 8 - Jun 29, 2012 period, variation in both call and put warrants returns is not caused by the variation in futures returns. In Jul 2 - Aug 31, 2012 period, almost 20-35% of the variation in call warrants returns variance is caused by the shocks to futures returns variance. Variation in put warrants returns is not caused by the variation in futures returns.

Variance decomposition results of three VAR models for Jan 6 - Feb 29, 2012 period is reported in Table 44-46; for May 8 - Jun 29, 2012 period is reported in Table 47-51; for Jul 2 - Aug 31, 2012 period is reported in Table 52-55.

6.8. Nonparametric Counting Method

In this section, the counting method to analyze the lead-lag relationship is applied between index futures and warrants and chi-square test is used to test statistical significance. 3 symbols are assigned for the quote updates in data: The symbol 'P' is assigned as the economically correct movement according to the nature of the relation between a call or a put warrant with the underlying security. The symbol 'N' is used for coding the wrong movements. For example, for a call warrant, when an uptick is followed by a down tick, or a down tick is followed by an uptick, the symbol 'N' is used since the two series move in the opposite direction. If one of the series, has more quote updates than the other series, in other words if a non-zero quote update may not have a corresponding quote update in the other series, then the symbol 'Z' is used. After assigning these symbols to each update of quote update, the numbers of these three symbols have been counted and its significance is tested. The null hypothesis is that there is no significant difference between number of movements coded as N,P and Z. The results are interpreted by looking at significance level (relevancy) level which shows that the null hypothesis is rejected if it is less than 1% at 99% confidence level.

For the case of warrants leading futures in Jan 6 - Feb 29, 2012 period, Table 23 lists the total F quote movements and the numbers of subsequent moves by the warrants. We note that more than 78% of the F movements are not followed as expected ("Z" and "N") by any W quote updates, and only about 22% of the F movements can be identified as 'P' movements. This can be attributed to the fact that futures are more frequently traded and there are more quote updates for futures than on warrants. There are slightly (about 1.3%) less correct 'P' movements than the wrong 'N' movements. However, their difference is small to be statistically or economically significant, as shown by the chi-square test shown in Table 24. Hence, there is no evidence of a leading effect from the index warrants on the futures. The large and significant chi-square values

suggest that at the 99% confidence level, warrants' quotes tend to follow that of future prices in the same direction.

On the other hand, we obtain significant evidence of futures leading warrants. In Table 23, about 26% of W quote movements are led by F updates in the 'P' direction, which indicates a correct price response of warrants to futures price. Results are interpreted by looking at significance level (relevancy) level which are expected to be less than 1% at 99% confidence level. There are slightly (about 6.3%) more correct 'P' movements than the wrong 'N' movements. Table 24 shows that their difference has large and significant chi-square values at the 99% confidence level, warrants' quotes tend to follow that of future prices in the same direction. In short, the counting method finds a leading effect of index futures on the respective warrants.

Table 23 Results of Nonparametric Counting Method for Jan 6 - Feb 29, 2012 period

		Count	Subtable N %	Expected N	Residual
W_Leads_F	N	1936	23.3%	1881.0	55.0
	P	1826	22.0%	1881.0	-55.0
	Z	4542	54.7%		
	Subtotal	8304	100.0%		
F_Leads_W	N	1625	19.5%	1886.0	-261.0
	P	2147	25.9%	1886.0	261.0
	Z	4532	54.6%		
	Subtotal	8304	100.0%		

Table 24. Chi-square test of Nonparametric Counting Method for Jan 6 - Feb 29, 2012 period

	W_Leads_F	F_Leads_W
Chi-Square	3.216	72.239
Df	1	1
Asymp. Sig.	0.073	0.000

For the case of warrants leading futures in May 8 - Jun 29, 2012 period, Table 25 lists the total F quote movements and the numbers of subsequent moves by the warrants. We note that more than 85% of the F movements are not followed as expected ("Z" and "N") by any W quote

updates, and only about 15% of the F movements can be identified as ‘P’ movements. This can be attributed to the fact that futures are more frequently traded and there are more quote updates for futures than on warrants. There are slightly (about 0.7%) less correct ‘P’ movements than the wrong ‘N’ movements. However, their difference is small to be statistically or economically significant, as shown by the chi-square test shown in Table 26. Hence, there is no evidence of a leading effect from the index warrants on the futures.

On the other hand, we obtain significant evidence of futures leading warrants. In Table 25, more than 16% of W quote movements are led by F updates in the ‘P’ direction, which indicates a correct price response of warrants to futures price. There are slightly (about 3.6%) more correct ‘P’ movements than the wrong ‘N’ movements. Table 26 shows that their difference has large and significant chi-square values at the 99% confidence level, warrants’ quotes tend to follow that of future prices in the same direction. In short, the counting method finds a leading effect of index futures on the respective warrants.

Table 25. Results of Nonparametric Counting Method for May 8 - Jun 29, 2012 period

		Count	Subtable N %	Expected N	Residual
W_Leads_F	N	2012	14.1%	2055.5	-43.5
	P	2099	14.8%	2055.5	43.5
	Z	10119	71.1%		
	Subtotal	14230	100.0%		
F_Leads_W	N	1791	12.6%	2049.0	-258.0
	P	2307	16.2%	2049.0	258.0
	Z	10132	71.2%		
	Subtotal	14230	100.0%		

Table 26. Chi-square test of Nonparametric Counting Method for May 8 - Jun 29, 2012 period

	W_Leads_F	F_Leads_W
Chi-Square	1.841	64.972
df	1	1
Asymp. Sig.	0.175	0.000

For the case of warrants leading futures in Jul 2 - Aug 31, 2012 period, Table 27 lists the total F quote movements and the numbers of subsequent moves by the warrants. More than 85% of the F movements are not followed as expected ("Z" and "N") by any W quote updates, and only about 15% of the F movements can be identified as 'P' movements. This can be attributed to the fact that futures are more frequently traded and there are more quote updates for futures than on warrants. There are slightly (about 0.5%) less correct 'P' movements than the wrong 'N' movements. However, their difference is small to be statistically or economically significant, as shown by the chi-square test shown in Table 28. Hence, there is no evidence of a leading effect from the index warrants on the futures.

On the other hand, significant evidence of futures leading warrant is obtained. In Table 27, more than 13% of W quote movements are led by F updates in the 'P' direction, which indicates a correct price response of warrants to futures price. There are slightly (about 3.3%) more correct 'P' movements than the wrong 'N' movements. As Table 28 shows that their difference has large and significant chi-square values at the 99% confidence level, warrants' quotes tend to follow that of future prices in the same direction. In short, the counting method finds a leading effect of index futures on the respective warrants.

Table 27. Results of Nonparametric Counting Method for Jul 2 - Aug 31, 2012 period

		Count	Subtable N %	Expected N	Residual
W_Leads_F	N	1858	15.2%	1827.5	30.5
	P	1797	14.7%	1827.5	-30.5
	Z	8605	70.2%		
	Subtotal	12260	100.0%		
F_Leads_W	N	2060	16.8%	1859.0	201.0
	P	1658	13.5%	1859.0	-201.0
	Z	8542	69.7%		
	Subtotal	12260	100.0%		

Table 28 Chi-square test of Nonparametric Counting Method for Jul 2 - Aug 31, 2012 period

	W_Leads_F	F_Leads_W
Chi-Square	1.018	43.465
df	1	1
Asymp. Sig.	0.313	0.000

In all of the periods, we have reached some evidence that futures contracts lead to warrants because there are economically more correct movements and chi-square test results show that the differences are statistically significant. However, about 55%-71% of total movements corresponded to “Z” in all three periods because there has been no change in W series whereas a change has occurred in prices of future contracts. These have been most probably because of low trading volume in warrants and infrequent trading problem between warrants and future contracts. Because of the high percentage of zero movements, it can be said that results may be not very informative.

7.CONCLUSION

Increasing trading activity in and the existence of organized warrant markets shows that many investors trade in the derivatives markets using advantage of the leverage. A financial market is said to be complete when there is an equilibrium price for every asset in every possible state. In a perfectly efficient financial market, no lead-lag relation should exist between the markets that are based on the same asset and thus have the same information. However, if a market doesn't operate efficiently, then the market participants cannot correctly obtain sufficient information and evaluate the asset values truly. In complete markets, warrant trading has no impact on market participants because the spot or future and the warrant markets should reflect new information simultaneously to the all prices after the arrival of information.

In the literature, studies that have found a leading relationship from futures to spot market have interpreted results in terms of transaction costs and leverage in derivatives market. They have claimed that in the absence of market completeness, informed traders may prefer to trade warrants, or options instead of the underlying spot or future instruments for some reasons. First, reduced transaction costs and increased financial leverage may induce informed traders to trade in the warrant market instead of the spot market, to which the lack of short sales constraints can be added. Second, investors that bet on volatility can do so in the warrants market. Therefore, it can be said that structural differences and trading procedures that make the index futures market to have lower trading costs and the leverage characteristics of the futures market are the main reasons of price discovery role of futures market.

The study also indirectly looks for the relationship between spot market and the warrants market by using futures contracts in this study. An identical infrastructure is tried to be built and analyzed by using futures

contracts, which have the same underlying asset and have the same maturity date. By this way, some parameters' effects that influence value of warrant such as interest rate, time to maturity etc. are considered as constant and reactions to the changes in price of underlying asset can be evaluated *ceteris paribus*.

In the literature, the option price might "discover" or "lead" or "front-run" the underlying spot or future price due to informed traders taking advantage of the leverage that options provide. But there are also studies in the literature, which have findings that spot market leads to future market especially in Turkey. However, there are not sufficient empirical studies to generalize the lead-lag relationship for the emerging countries.

In this study, lead-lag relationship between warrants and futures based on the same underlying instrument is investigated using parametric and non-parametric methods at 5-minutes regular time interval. According to the result of the parametric methods, the series obtained from both futures and warrant prices, prices are stationary at the same level $I(1)$ according to Augmented Dickey-Fuller Unit Root Test. After finding a relationship by cross correlation functions, causality between futures and warrants was investigated with Granger Causality Method. As a result of these, 6 warrants show bilateral causality (either from futures to warrant or from warrant to futures) whereas the other 6 warrants are showing unilateral causality. Then, short-term dynamics are investigated through vector autoregressive model and the model's results showed that first 2-3 lags (about 10-15 minutes) of futures contracts have an impact on warrants and a significant relationship existed between them at the relevant confidence levels. Also, the models sometimes showed that warrants are affected by futures at about 1-3 lags at the relevant significance levels. These results are obtained at the specific lag criteria which is chose according to Schwartz Information Criteria (SIC). According to impulse-response functions, call warrants were positively affected by a positive unit of standard deviation shock to the futures prices. The effects are generally evident in the first 5 minutes and die out after

about 10-20 minutes. Variance decomposition results also showed that some of variations in call warrants' returns were caused by the variation in the futures' returns in first (Jan 6 - Feb 29, 2012) and the third period (Jul 2 - Aug 31, 2012). However, variation in put warrants returns is not caused by the variation in futures returns in either situation. As a result of these analyses, it appears that futures contracts prices may contain useful information about warrant prices.

According to the non-parametric counting method's results, significant evidence of futures leading warrant is obtained. For all three periods in the study, approximately between 14%-26% of warrant quote movements are led by futures' update, which indicates a correct price response of warrants to futures contracts' price. However, there has been no change in W series whereas a change occurred in quotes of future contracts, and as a results about 55%-71% of total movements correspond to "Z" code, which meant to be no simultaneous change among variables. These were most probably because of low trading volume in warrants and infrequent trading problem between warrants and future contracts. Because of the high percentage of "Z" sign, it can be said that results may not be very informative.

As a result, both parametric method's and non-parametric counting method's results shows that futures market lead the warrant markets in Turkey. On the contrary, warrants do not lead futures market. This result is statistically significant. To summarize, between Turkish derivatives and warrant markets, short-run dynamics signal that futures transactions flow information quicker than warrant transactions. The time delay resulting from the pace of information flow make investors informed to take positions and this thesis work gives clue to investors about arbitraging activities and that futures prices lead spot prices about 5-15 minutes in Turkey.

To the best of our knowledge, this thesis is the first study of the lead-lag relationship between warrants and futures in Turkey. Our study

produces evidence that the warrant market maker has risk when it trades against better informed traders and they will always take into account futures market which has the same underlying instrument with warrants. However, as the time passes and transaction volume in warrants market increases, it will be valuable to test efficiency of the markets by studying on this subject further through concentrating on the cointegration and long term relationship issues between futures and warrants market. Moreover, since Turkish Warrant Market is expected to improve, derivatives warrants, which are heavily traded abroad may be issued in Turkey in the future. This study may contain valuable information to have an idea about warrants and the future contract, which has a potential to be underlying asset of warrants in the future in Turkey.

REFERENCES

Articles & Journals in Periodicals

Anthony, J.H. (1988). "The interrelation of stock and options market trading-volume data". *Journal of Finance*, 43 (4), 949-964.

Bakshi, G., Cao, C. & Chen, Z. (2000). "Do call prices and the underlying stock always move in the same direction?". *Review of Financial Studies* 13 (3), 549-584.

Black, F & Scholes, M., (1973), "The pricing of options and corporate liabilities". *Journal of Political Economy*, 81 (3), 637-654.

Boonchuaymetta, Ekkachai & Kongtoranin, Treerapot, *Warrant Pricing Model: An Empirical Study On the Valuation models for Warrants Listed in Thailand*, Assumption University of Thailand Journal, Vol.5, No:2, June 2007, p. 57-59.

Chan, K., Chung, Y.P. & Johnson, H. (1993), "Why option prices lag stock prices: a trading-based explanation", *Journal of Finance*, 48 (5), 1957-1967.

Chan, H.W. & Pinder, S. M., 2000, "The value of liquidity: Evidence from the Derivatives Market", *Pacific-Basin Finance Journal*, 8, 483 – 503

Chan, Yue-Cheong & WEI, K.C. John, "Price and Volume Effects Associated with Derivative Warrant Issuance on the Stock Exchange of Hong Kong", *Journal of Banking and Finance*, 25, 2001, p. 1402.

Chiang, R. & Fong, W.M. (2001). "Relative Informational Efficiency Of Cash, Futures, And Options Markets: The Case Of An Emerging Market", *Journal of Banking and Finance*, 25 (2), 355-375.

ÇELİK, İsmail, "Vadeli İşlem Piyasasında Fiyat Keşfi: İzmir Vadeli İşlem ve Opsiyon Borsasında Ampirik Bir Uygulama", *Türkiye Bankalar Birliği*, 2012, İstanbul

Engle, R.F. & Yoo, B.S. (1987), "Forecasting and testing in co-integrated systems", *Journal of Econometrics*, 35 (1), 143-159.

Easley, D., O'Hara, M. & Srinivas, P.S. (1998). "Option volume and stock prices: evidence on where informed traders trade". *Journal of Finance*, 3 (2), 431-465.

Frank De Jonga & Monique W.M. Donders, *Intraday Lead-Lag Relationships Between the Futures-, Options and Stock Market*, Tilburg University, Center For Economic Research, Discussion Paper, 01/1996, p 4.

Galai, D. & Schneller, M.I. (1978). "*Pricing of warrants and the value of the firm*". *Journal of Finance*, 33 (5), p. 1333-1342.

Goebel, R., Roebroek, A., Kim, D.S. & Formisano, E. (2003). "*Investigating directed cortical interactions in time-resolved fMRI data using vector autoregressive modeling and Granger causality mapping*", *Magnetic Resonance Imaging*, 21 (10), 1251–1261.

Hauser, S. & Lauterbach, B. (1997). "*The relative performance of five alternative warrant pricing models*", *Financial Analysts Journal*, 53 (1), 55-61.

Isabel Abínzano Guillén & Javier Fernández Navas, *Warrant pricing with credit risk*, Spain, March 2007 (online). Available: <http://www.alde.es/encuentros/anteriores/xeea/trabajos/a/pdf/050.pdf>,

Kawaller, I.G., P.D. Koch & T.W. Koch. (1987), "*The Temporal Price Relationship Between S&P500 Futures And The S&P500 Index*", *Journal of Finance* 42, 1309-1329

Kayalıdere, Koray, Aracı, Hakan & Aktaş, Hüseyin (2012), *Interaction Between Derivatives and Spot Markets: An Analysis on VOB*, October 2012, *Journal of Accounting And Finance*.

Koziol, Christian, "*Optimal Exercise Strategies for Corporate Warrants*", *Quantitative Finance*, Vol. 6, No.1, February 2006

Kremer, J.W. and Roenfeldt, R.L. (1992). "*Warrant pricing: Jump-Diffusion vs. Black-Scholes*", *Journal of Financial and Quantitative Analysis*, 28 (2), 255-272.

Lauterbach, B. & Schultz, P. (1990). "*Pricing warrants: An empirical study of the Black-Scholes model and its alternatives*", *Journal of Finance*, 45 (4), 1181-1209.

Leonard, D.C. & Solt, M.E. (1990). "*On using the Black-Scholes model to value warrants*", *Journal of Financial Research*, 13 (2), 81-92.

Lim, Kian-Guan & Terry, Erric, *The Valuation of Multiple Stock Warrants*, Research Paper, September 2002, Singapore Management University.

Manaster, S. & Rendleman, R.C. Jr. (1982). "Option prices are predictors of equilibrium stock prices", Journal of Finance, 37 (4), 1043-1057.

Mayhew, S. (1995). "Implied Volatility". Financial Analysts Journal, 51 (4), 8-20.

Merton, R.C., (1973), "Theory of rational option pricing", The Bell Journal of Economics and Management Science, 4 (1), 141-183.

Özata, E. & Esen, E. (2010). "An Econometric Analysis of Relationship Between Real Wages and Employment ", Anadolu University Journal of Social Sciences, 10 (2), 55-70.

Özen, Ercan, Bozdoğan, Tunga & Zugul, Muhittin, "The Relationship of Causality between the Price of Futures Transactions Underlying Stock Exchange and Price of Cash Market: The Case of Turkey", Middle Eastern Finance and Economics, ISSN: 1450-2889 Issue 4 (2009) EuroJournals Publishing, Inc..

Öztürk, Beyamil, (2008), *İMKB ile VOB Arasındaki Etkileşimin İMKB-30 ve İMKB-100 Bağlamında İrdelenmesi ve Elde Edilen Sonuçların VOB Bünyesinde Gerçekleştirilen İşlemlerin Gözetimi-Denetimi Açısından Değerlendirilmesi*, SPK Denetleme Dairesi, Yeterlik Etüdü, Ankara.

Schwartz, Eduardo S., "Valuation of Warrants: Implementing a New Approach", Journal of Financial Economics 4 (1977) 79-93, Canada
Schulz, G.U. and Trautmann, S. (1994), "Robustness of option-like warrant valuation". Journal of Banking & Finance, 18 (5), 841-859.

Shastri, K. & Sirodom, K. (1995). "An empirical test of the BS and CSR valuation models for warrants listed in Thailand", Pacific-Basin Finance Journal, 3 (4), 465-483.

Stephan, J.A. & Whaley, R.E. (1990). "Intraday price change and trading volume relations in the stock and stock option markets". Journal of Finance, 45 (1), 191-220.

Suntraruk, Phassawan, "Valuation of Warrants in Thailand: Using Black-Scholes Model", Assumption University of Thailand Journal, Vol.5, No:2, June 2007.

Uysal D., Mucuk, M. & Alptekin, V., "Türkiye Ekonomisinde Vektör Otoregresif Model ile Enflasyon-Büyüme İlişkisinin Analizi", ZKÜ Sosyal Bilimler Dergisi, Book 4, Number 8, s. 55-71, 2008, p. 61

Varant Kullanım Kılavuzu, The Economist Journal, 15 April 2012

Veld,Chris & Verboven, Adri, “*An Empirical Analysis of Warrant Prices versus Long Term Call Option Prices*”, *Journal of Business and Accounting*, 22(8), December 1995, p.1127-1128.

Books

Bolak Mehmet, *Finans Mühendisliği Kavram ve Araçları*, İstanbul, Beta Yayınları, 1998

Box, G. E. P., Jenkins,. G. M. & Reinsel, G.C. (2008). *Time series analysis: Forecasting and Control*, Fourth Edition, Wiley, p. 784.

Brooks, Chris (2008), *Introductory Econometrics for Finance*, Second Edition, p.290, Cambridge University Press, New York.

Chambers Nurgül, Türev Piyasalar, İstanbul, Avcıol Basım-Yayın, İstanbul, 1998.

Eitman, D.K., Stonehill, A. I. & Moffett, M. H. (2004), “*Multinational Corporate Finance*” (10th edition), USA, Pearson Education.

Hamilton, J.D (1994). *Time Series Analysis*, First Edition, Princeton University Press; p.820.

Pindyck, Robert. S. ve Daniel L. Rubinfeld (1991), *Econometric Models and Economic Forecasts*, 3rd.Ed., McGraw Hill.

Reilly, Frank K. – NORTON, Edgar, A., *Investments*, The Dryden Press, Orlando, Fourth Edition, 1995, p.523.

Türkmen, Sibel Yılmaz, *Varantlar*, 2012, Beta Yayıncılık, İstanbul

Thesis & Dissertations

Gustafsson, Lars & Lindberg, Marcus; “*Covered Warrants: How the Implied Volatility Changes Over Time*”, Master Thesis in Finance, Jönköping May 2005

Kui, L.Y. (2007). “*Do Warrant Lead The Underlying Stocks and Index Futures?*”. Unpublished Master Thesis, Singapore Management University

Santoso, E. (2000), “*Warrant Pricing: An Empirical Investigation on the Valuation Models For Warrants Traded At The Jakarta Stock Exchange*”; Unpublished Master Thesis, Gadjah Mada University

Takmaz, Sefa, “*Price Discovery In Turkish Index Markets: An Examination of Spot Index And Index Futures*”, Master Thesis, İzmir University Of Economics, July 2009

Presentations

BULUT, Murat, “Hisse Senetleri Piyasası Varant Pazarı”, İMKB Hisse Senetleri Piyasası Müdürlüğü, 2010

Dumanlı, A. (2010). “*Varantların Borsa'ya Kotasyonu*”, Intermediary Institutions’ Warrants: Introductory and Information Meetings' Presentations, Istanbul Stock Exchange.

Istanbul Stock Exchange, “*Intermediary Institutions Warrants Guide*” (online), Available: <http://www.imkb.gov.tr/video/varant/sunumlar/warrants.pdf>

“*Why To Invest on TurkDex*”, 2012, TurkDex (online). Available: <http://www.turkdex.org.tr>, 2012

Internet Sites

<http://www.macquarie.com.au/dafiles/Internet/mgl/au/docs/booklet/asx-understanding-warrants-handbook.pdf>

<http://www.asx.com.au/products/about-asx-warrants.htm>

http://www.ise.org/products/Varant/comparison_of_warrants.aspx (19.09.2011)

http://turkborsa.net/belgeler/varant_brosur.pdf

http://www.dbwarrants.com.sg/EN/binaer_view.asp?BinaerNr=76

<http://www.world-exchanges.org/statistics/monthly-reports> (10.01.2012)

<http://www.tspakb.org.tr/eng/>

<http://www.mkk.gov.tr>

<http://www.turkdex.org.tr>

Legislation

“*Communiqué On The Principles Regarding The Board Registration And Trading Of Covered Warrants*”, Series: III, No.: 37, Published In The Official Gazette Dated 21/7/2009 And No. 27295

“ISE Circular on Warrants”, Circular Letter Number:318, p.6, Istanbul, 05.01.2010

The Association of Capital Market Intermediary Institutions of Turkey, *Turkish Capital Market 2011*, May 2012, İstanbul, 2012

APPENDICES

A. Time Series of Natural Algorithm of Selected Future Contracts and Warrants

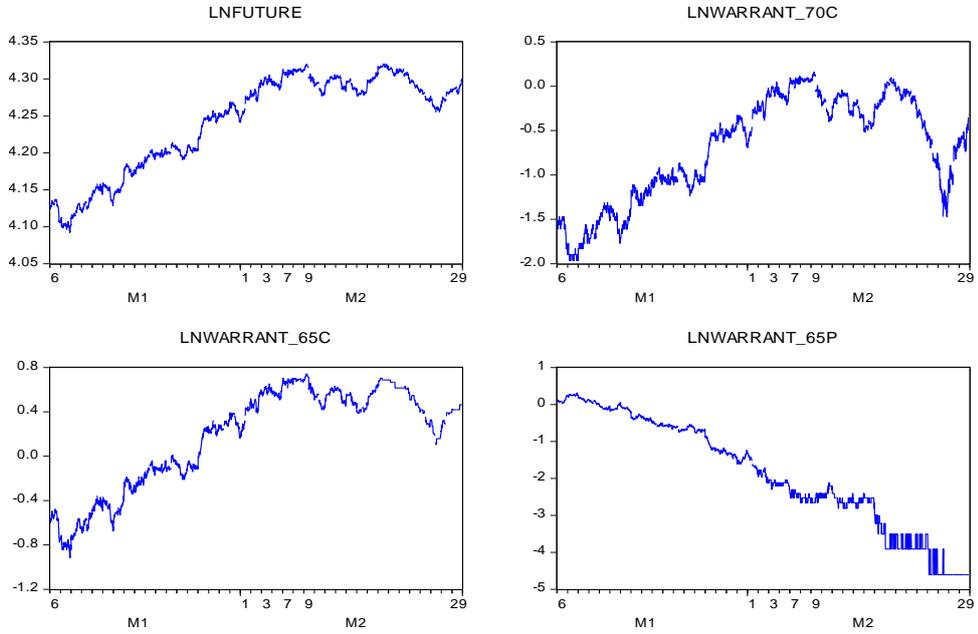


Figure 20. Time series of natural logarithm of selected futures and warrants index prices between Jan 6 - Feb 29, 2012

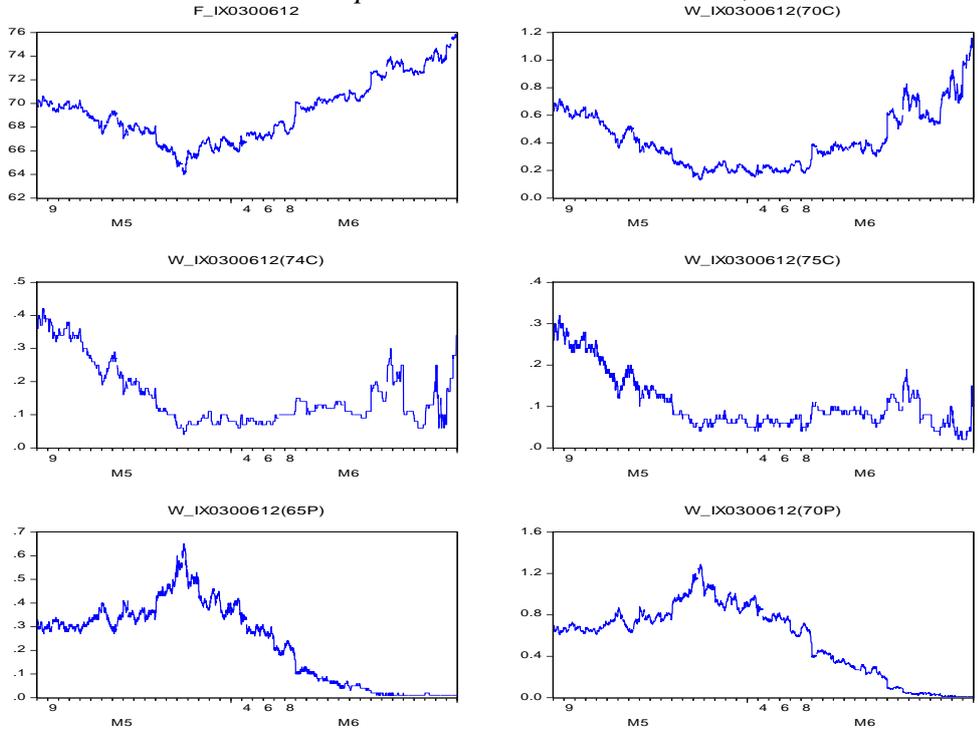


Figure 21. Time series of natural logarithm of selected futures and warrants index prices between May 8 - Jun 29, 2012

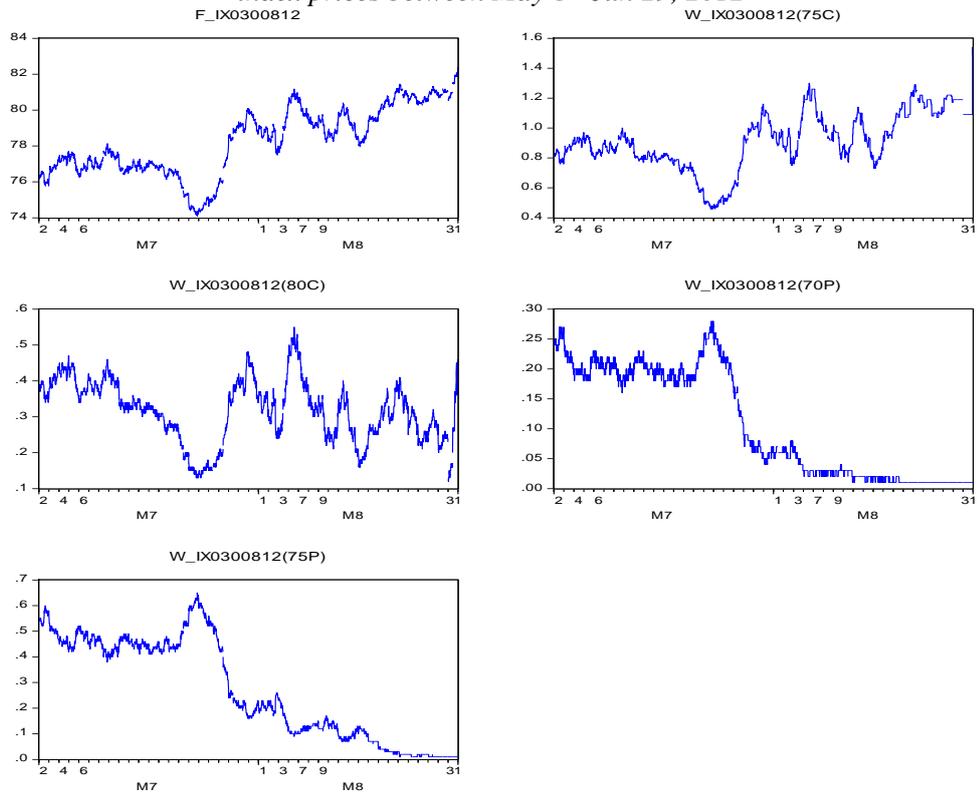


Figure 22. Time series of natural logarithm of selected futures and warrants index prices between Jul 2 - Aug 31, 2012

B. Descriptive Analysis of Return Series of Selected Future Contracts and Warrants

Table 29 Descriptive statistics of natural logarithmic return series of selected futures and warrants index prices between Jan 6 - Feb 29, 2012

	Dln_Future	Dln_Warrant_70c	Dln_Warrant_65c	Dln_Warrant_65p
Mean	0.00006	0.00048	0.00038	-0.00171
Median	0.00000	0.00000	0.00000	0.00000
Maximum	0.01521	0.21511	0.16476	0.69315
Minimum	-0.01378	-0.16034	-0.11411	-0.69315
Std. Dev.	0.00175	0.03171	0.01572	0.09126
Skewness	0.32433	0.29524	0.61961	-0.27449
Kurtosis	11.29925	7.34932	13.62084	27.38021
Jarque-Bera	7992.40	2221.92	13186.97	68588.28
Probability	0.0000	0.0000	0.0000	0.0000

Table 30 Descriptive statistics of natural logarithmic return series of selected futures and warrants index prices between May 8 - Jun 29, 2012

	DLN_F_IX030061_2	DLN_W_IX030061_2_70C	DLN_W_IX030061_2_74C	DLN_W_IX030061_2_75C	DLN_W_IX030061_2_65P	DLN_W_IX030061_2_70P
Mean	0.00003	0.000197	0.00005	-0.00022	-0.00121	-0.00148
Median	0.0000	0.0000	0.000	0.0000	0.0000	0.0000
Maximum	0.016892	0.349674	0.887303	0.510826	0.693147	0.693147
Minimum	-0.017012	-0.344840	-0.820981	-0.693147	-0.693147	-0.693147
Std. Dev.	0.001527	0.032091	0.050960	0.065725	0.086400	0.077818
Skewness	0.182870	0.267655	1.125439	-1.586729	-0.293423	-0.890156
Kurtosis	27.31474	23.20327	87.62854	30.36862	49.55973	56.78618
Jarque-Bera	70123.10	48436.40	849893.5	90018.04	257106.8	343431.9
Probability	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

Table 31 Descriptive statistics of natural logarithmic return series of selected futures and warrants index prices between Jul 2 - Aug 31, 2012

	DLN_F_IX0300812	DLN_W_IX0300812_75C	DLN_W_IX0300812_80C	DLN_W_IX0300812_70P	DLN_W_IX0300812_75P
Mean	0,000025	0,000195	0,000054	-0,001037	-0,001307
Median	0	0	0	0	0
Maximum	0,00948	0,34561	0,26236	0,693147	0,693147
Minimum	-0,00666	-0,12445	-0,57055	-0,69315	-0,69315
Std.Dev.	0,00109	0,01534	0,03356	0,102821	0,060129
Skewness	0,05851	3,45175	-1,69439	-0,0994	-0,91476
Kurtosis	8,63996	93,9423	34,4847	32,55268	74,61124
Jarque-Bera	4064,04	1062298	128062	111540,5	655337,5
Probability	0	0	0	0	0

C. Times Series of Natural Logarithmic Return Series of Selected Future Contracts and Warrants

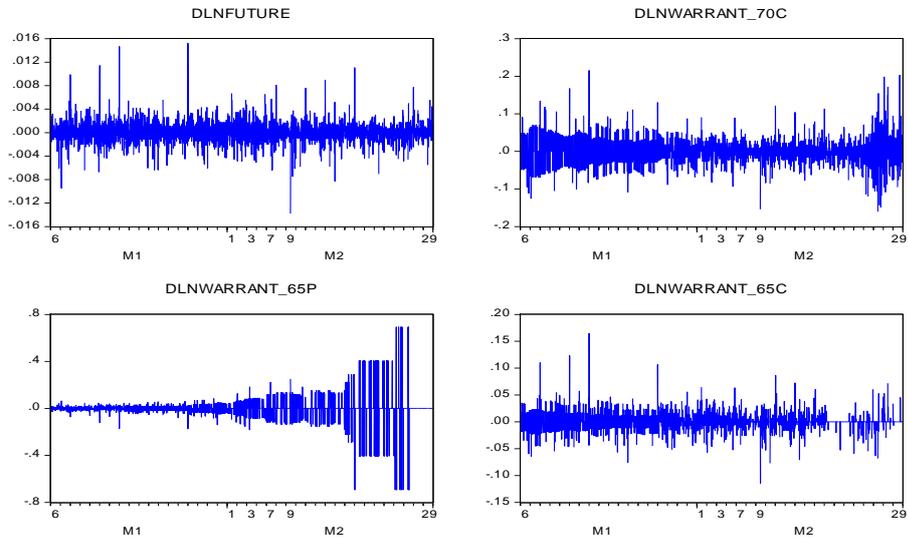


Figure 23. Time series of natural logarithmic return series of selected futures and warrants index prices between Jan 6 - Feb 29, 2012

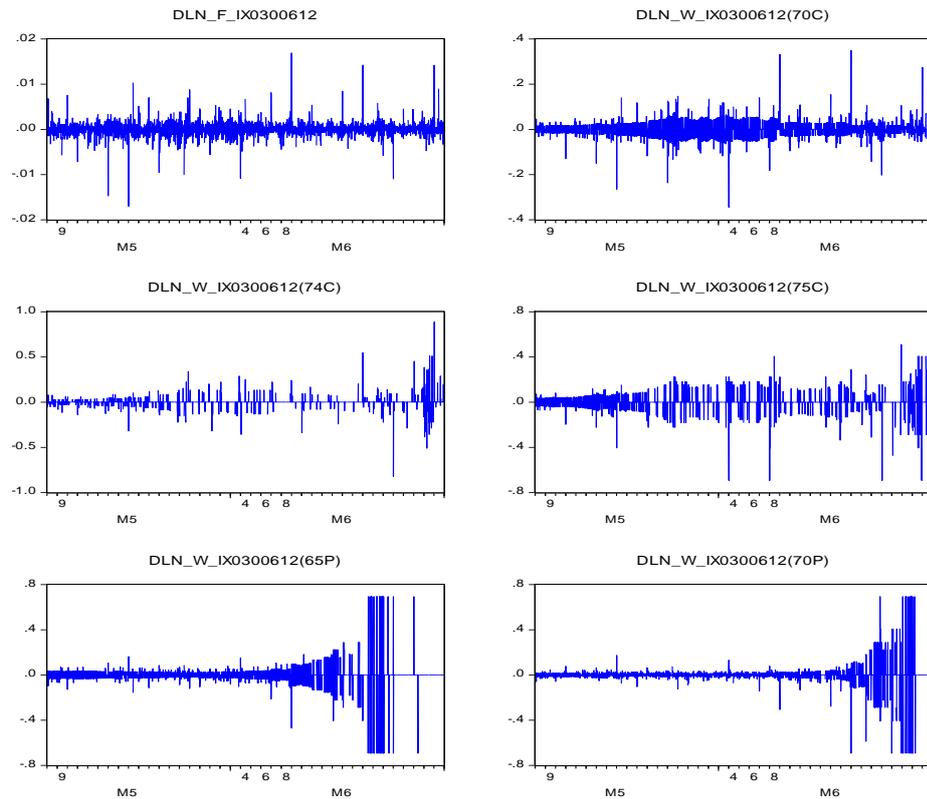


Figure 24. Time series of natural logarithmic return series of selected futures and warrants index prices between May 8 - Jun 29, 2012

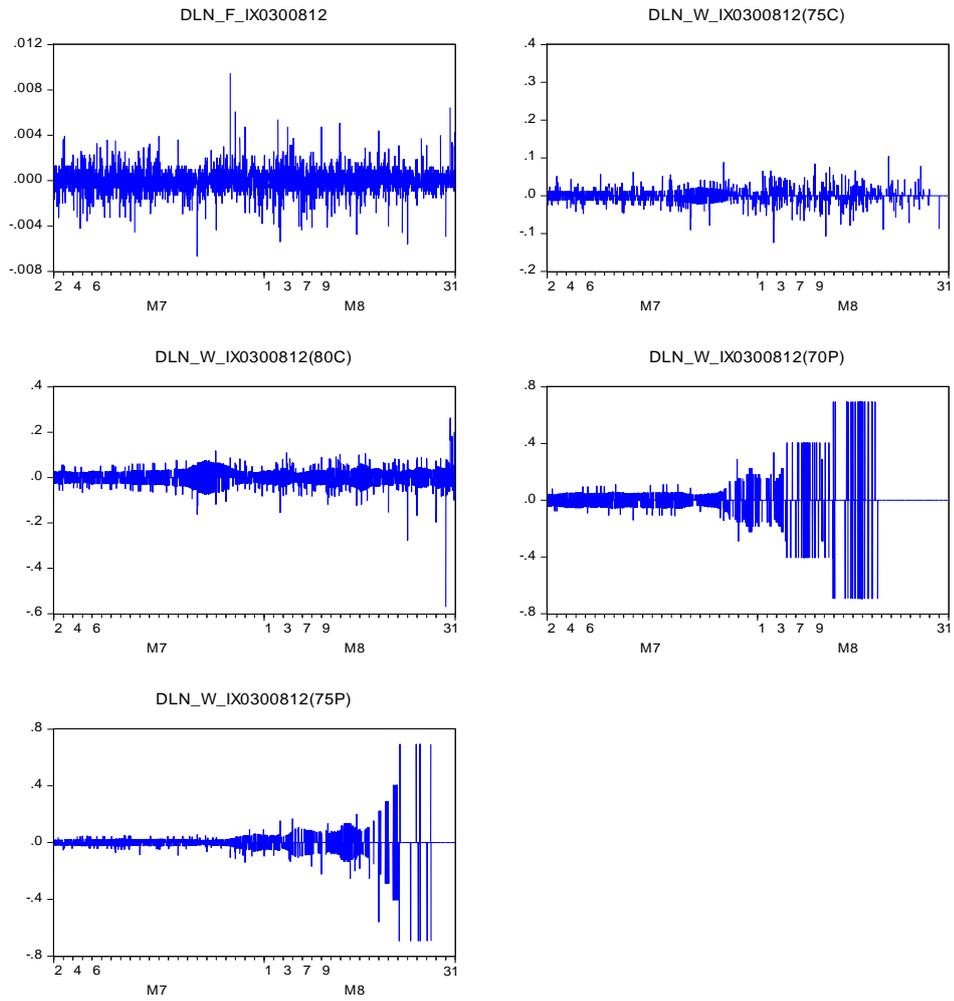


Figure 25. Time series of natural logarithmic return series of selected futures and warrants index prices between Jul 2 - Aug 31, 2012

D. Frequency Distribution of Logarithmic Return Series of Selected Future Contracts and Warrants

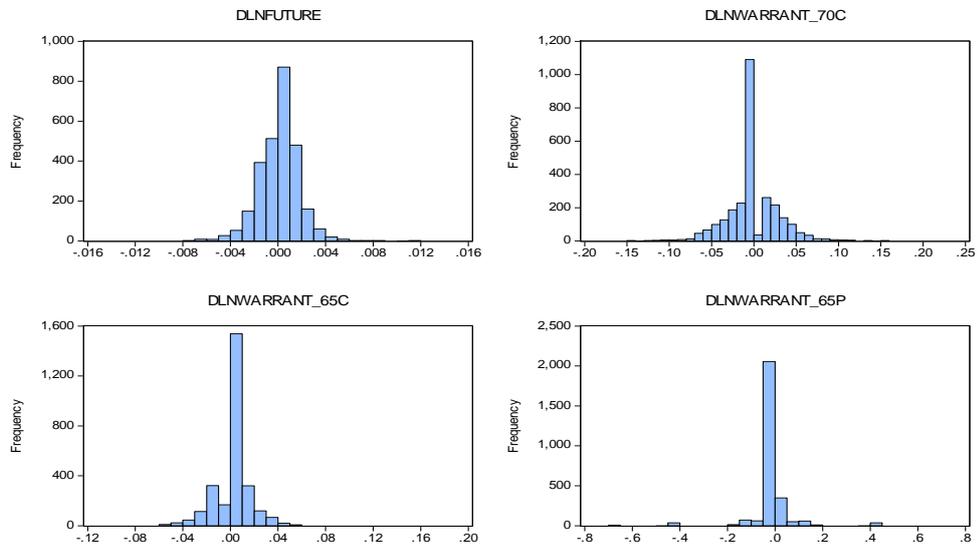


Figure 26. Frequency distributions of natural logarithmic return series of selected futures and warrants index prices between Jan 6 - Feb 29, 2012

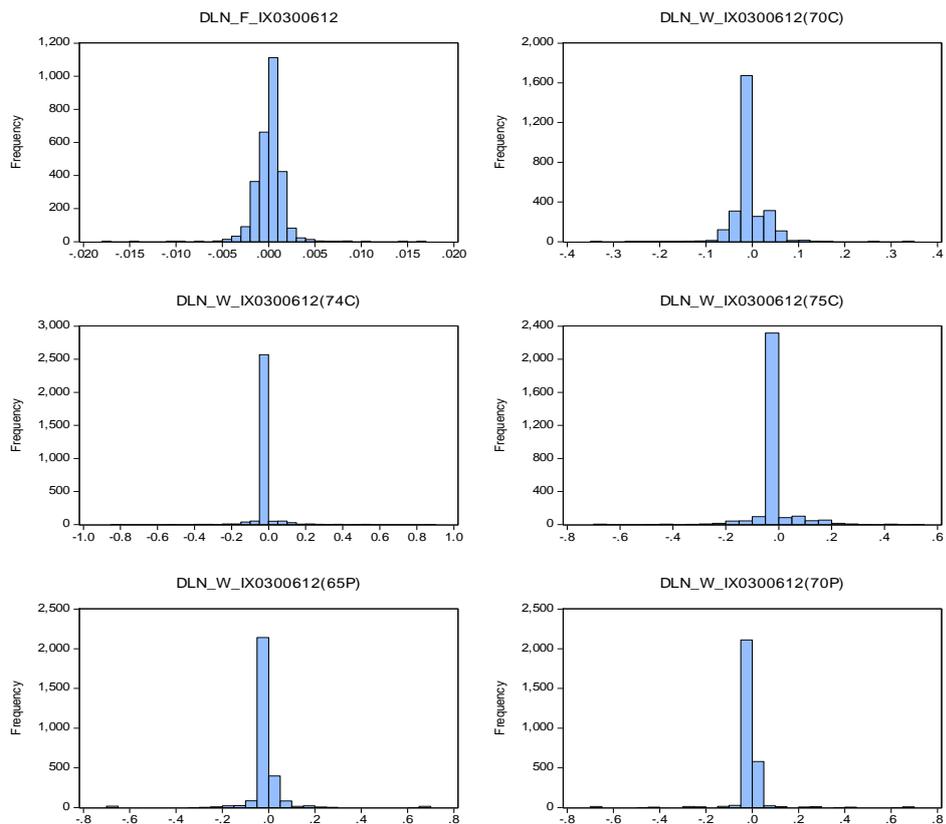


Figure 27. Frequency distributions of natural logarithmic return series of selected futures and warrants index prices between May 8 - Jun 29, 2012

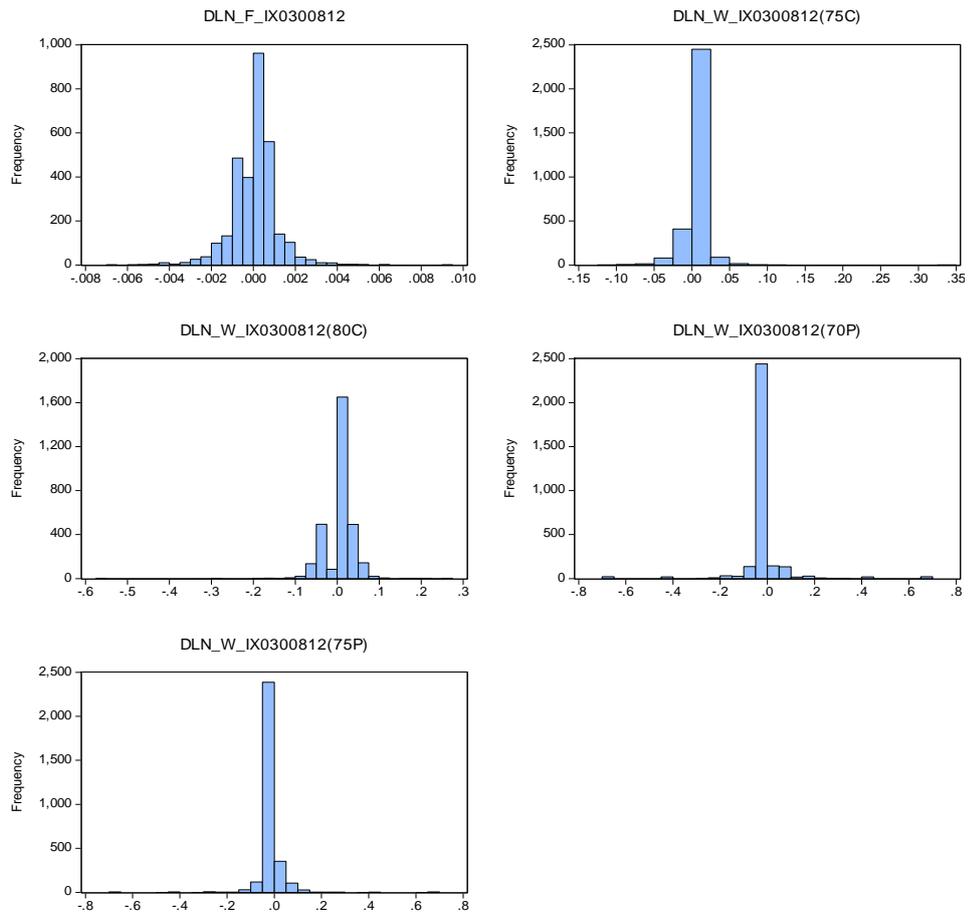


Figure 28. Frequency distributions of natural logarithmic return series of selected futures and warrants index prices between May 8 - Jun 29, 2012

E. Cross Correlation Functions Between Each Warrant And Future

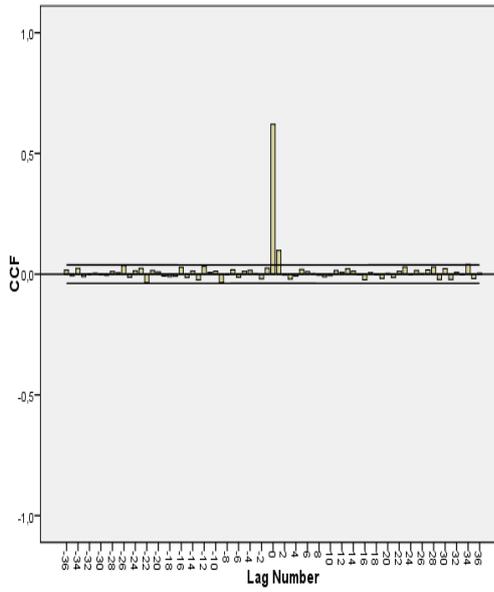


Figure 29. Cross Correlation between DLFUTURE and DLWARRANT70C between Jan 6 - Feb 29, 2012

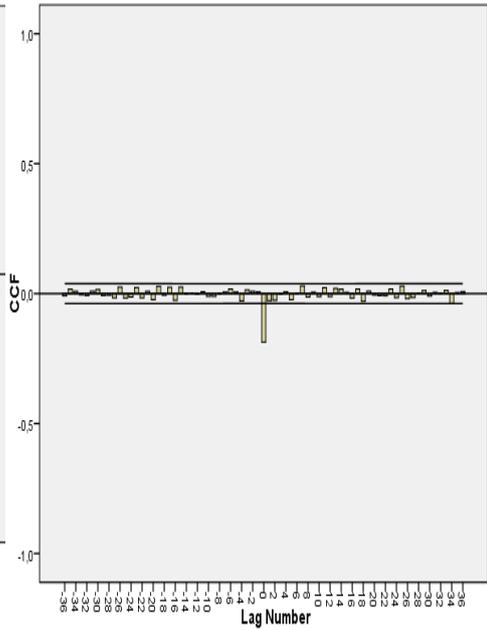


Figure 31. Cross Correlation between DLFUTURE and DLWARRANT65P between Jan 6 - Feb 29, 2012

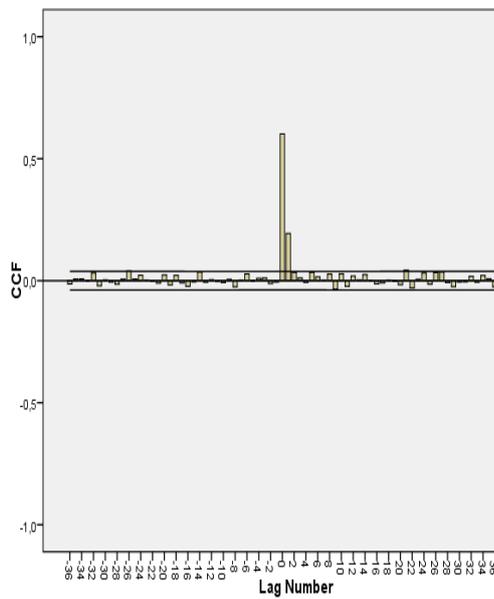


Figure 30. Cross Correlation between DLFUTURE and DLWARRANT65C between Jan 6 - Feb 29, 2012

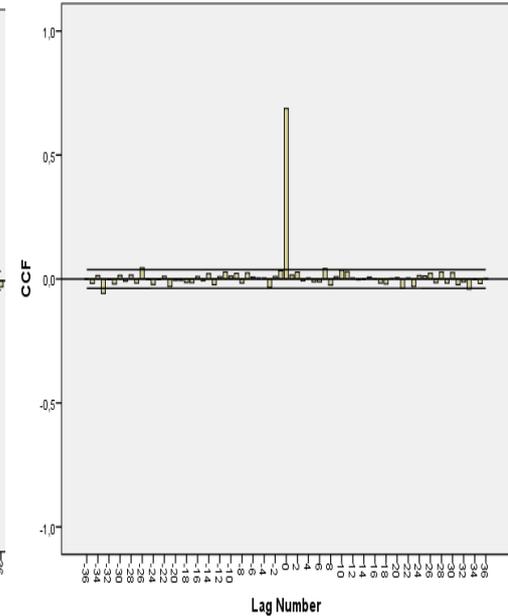


Figure 52. Cross Correlation between DLN_F_IX0300612 with DLN_W_IX0300612_70C between May 8 - Jun 29, 2012

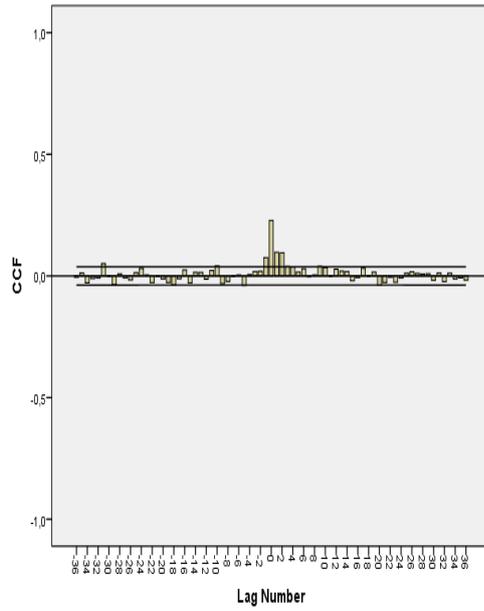


Figure 33. Cross Correlation between DLN_F_IX0300612 with DLN_W_IX0300612(74C) between May 8 - Jun 29, 2012

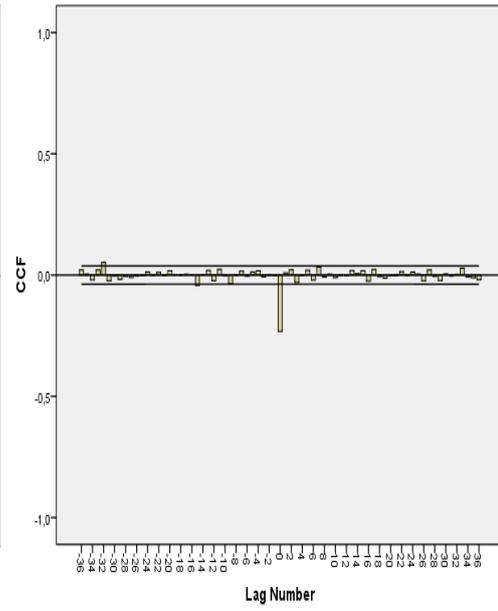


Figure 35. Cross Correlation between DLN_F_IX0300612 with DLN_W_IX0300612_65P between May 8 - Jun 29, 2012

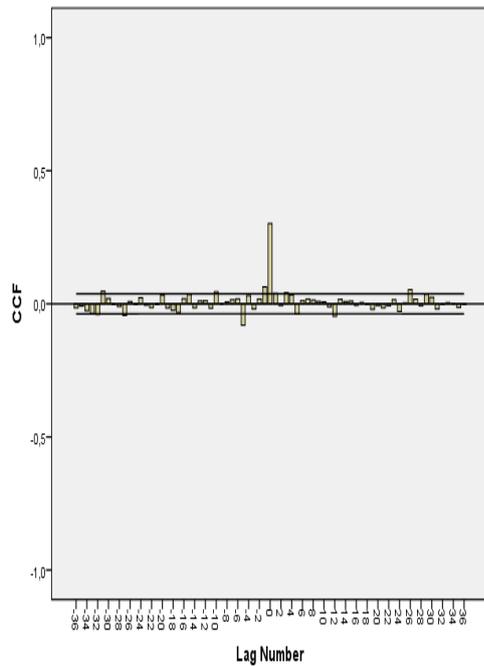


Figure 34. Cross Correlation between DLN_F_IX0300612 with DLN_W_IX0300612(75C) between May 8 - Jun 29, 2012

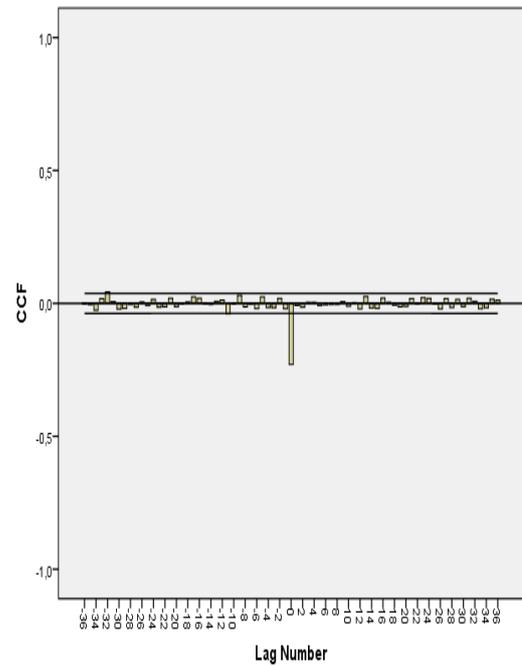


Figure 36. Cross Correlation between DLN_F_IX0300612 with DLN_W_IX0300612_70P between May 8 - Jun 29, 2012

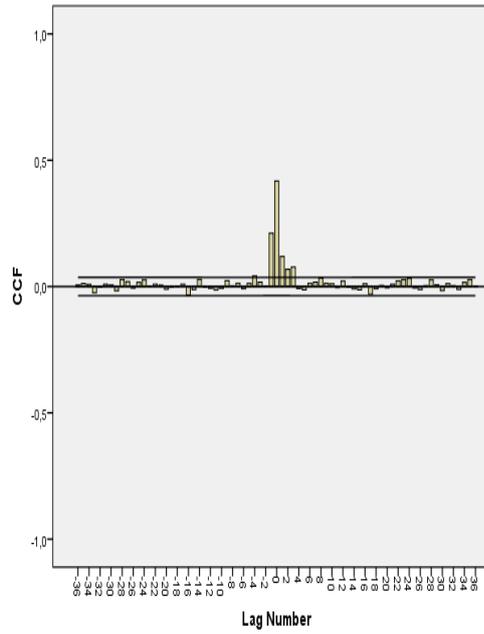


Figure 37. Cross Correlation between DLN_F_IX0300812 with DLN_W_IX0300812_75C between Jul 2 - Aug 31, 2012

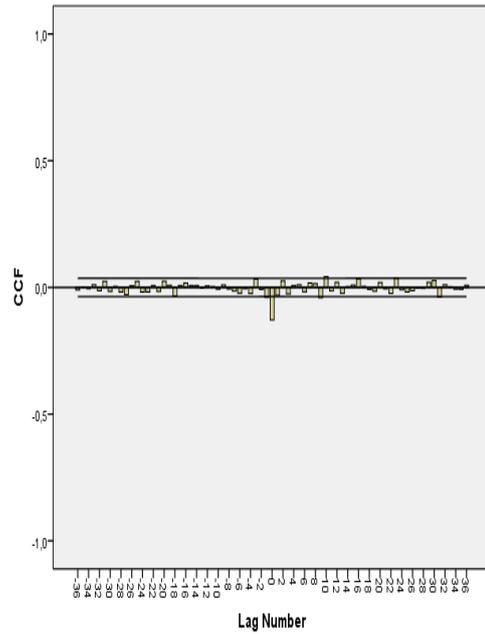


Figure 39. Cross Correlation between DLN_F_IX0300812 with DLN_W_IX0300812_70P between Jul 2 - Aug 31, 2012

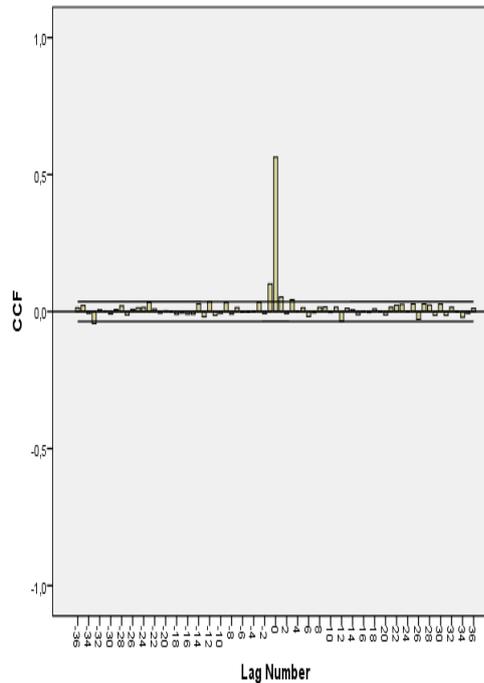


Figure 38. Cross Correlation between DLN_F_IX0300812 with DLN_W_IX0300812_80C between Jul 2 - Aug 31, 2012

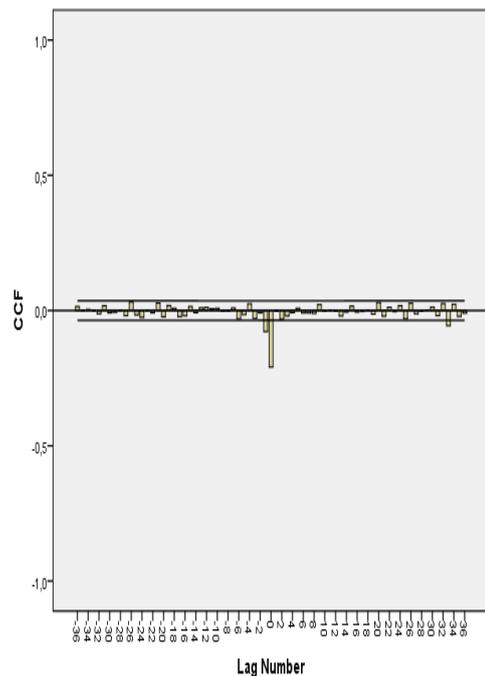


Figure 40. Cross Correlation between DLN_F_IX0300812 with DLN_W_IX0300812_75P between Jul 2 - Aug 31, 2012

F. Cross Correlogram Results of Each Pair of Warrant and Future Contract

Figure 41. Cross Correlogram between DLFUTURE and DLWARRANT65P

DLNFUTURE,DLNWAR RANT_65P(-i)	DLNFUTURE,DLNWAR RANT_65P(+i)	i	lag	lead
**	**	0	-0.1869	-0.1869
		1	0.0065	-0.0272
		2	0.0092	-0.0260
		3	0.0140	-0.0025
		4	-0.0280	0.0069
		5	0.0062	-0.0234
		6	0.0177	0.0015
		7	0.0062	0.0295
		8	-0.0001	-0.0128
		9	-0.0106	0.0057
		10	-0.0104	-0.0114

Figure 42. Cross Correlogram between DLFUTURE and DLWARRANT65

DLNFUTURE,DLNWAR RANT_65C(-i)	DLNFUTURE,DLNWAR RANT_65C(+i)	i	lag	lead
*****	*****	0	0.6014	0.6014
	**	1	-0.0056	0.1935
		2	-0.0111	0.0341
		3	0.0112	0.0112
		4	0.0096	-0.0070
		5	-0.0002	0.0342
		6	0.0280	0.0153
		7	0.0031	0.0025
		8	-0.0251	0.0268
		9	0.0050	-0.0349
		10	-0.0072	0.0285

Figure 43. Cross Correlogram between DLFUTURE and DLWARRANT70C

DLNFUTURE,DLNWAR RANT_70C(-i)	DLNFUTURE,DLNWAR RANT_70C(+i)	i	lag	lead
*****	*****	0	0.6209	0.6209
	*	1	0.0251	0.0984
		2	-0.0195	-0.0036
		3	0.0029	-0.0201
		4	0.0155	-0.0073
		5	0.0116	0.0194
		6	-0.0124	0.0108
		7	0.0184	0.0026
		8	-0.0022	-0.0042
		9	-0.0349	-0.0107
		10	0.0122	-0.0055

Figure 44. Cross Correlogram between DLN_F_IX0300612 and DLN_W_IX0300612_70P

DLN_F_IX0300612,DLN _W_IX0300612_70P_(-i)	DLN_F_IX0300612,DLN _W_IX0300612_70P_(+i)	i	lag	lead
**	**	0	-0.2294	-0.2294
		1	-0.0205	-0.0080
		2	0.0187	-0.0142
		3	-0.0163	0.0039
		4	-0.0160	0.0040
		5	0.0247	-0.0089
		6	-0.0193	-0.0056
		7	-0.0035	-0.0045
		8	-0.0133	-0.0045
		9	0.0305	0.0066
		10	-0.0019	-0.0107

Figure 45. Cross Correlogram between DLN_F_IX0300612 and DLN_W_IX0300612_75C

DLN_F_IX0300612,DLN _W_IX0300612_75C_(-i)	DLN_F_IX0300612,DLN _W_IX0300612_75C_(+i)	i	lag	lead
***	***	0	0.3015	0.3015
*		1	0.0634	0.0392
		2	0.0180	-0.0062
		3	-0.0199	0.0415
		4	0.0308	0.0334
*		5	-0.0802	-0.0379
		6	0.0190	0.0120
		7	0.0157	0.0182
		8	0.0066	0.0141
		9	0.0004	0.0095
		10	0.0450	0.0075

Figure 46. Cross Correlogram between DLN_F_IX0300612 and DLN_W_IX0300612_74C

DLN_F_IX0300612,DLN _W_IX0300612_74C_(-i)	DLN_F_IX0300612,DLN _W_IX0300612_74C_(+i)	i	lag	lead
**	**	0	0.2281	0.2281
*	*	1	0.0752	0.0969
	*	2	0.0193	0.0952
		3	0.0185	0.0392
		4	0.0055	0.0372
		5	-0.0392	0.0153
		6	0.0040	0.0298
		7	-0.0015	-0.0039
		8	-0.0231	0.0039
		9	-0.0315	0.0402
		10	0.0411	0.0343

Figure 47. Cross Correlogram between DLN_F_IX0300612 and DLN_W_IX0300612_65P

DLN_F_IX0300612,DLN_W_IX0300612_65P_(-i)	DLN_F_IX0300612,DLN_W_IX0300612_65P_(+i)	i	lag	lead
**	**	0	-0.2322	-0.2322
		1	-0.0031	0.0089
		2	-0.0005	0.0221
		3	-0.0072	-0.0310
		4	0.0174	-0.0029
		5	0.0128	0.0201
		6	-0.0049	-0.0211
		7	0.0163	0.0332
		8	0.0000	-0.0088
		9	-0.0361	0.0044
		10	-0.0033	-0.0107

Figure 48. Cross Correlogram between DLN_F_IX0300612 and DLN_W_IX0300612_70C

DLN_F_IX0300612,DLN_W_IX0300612_70C_(-i)	DLN_F_IX0300612,DLN_W_IX0300612_70C_(+i)	i	lag	lead
*****	*****	0	0.6875	0.6875
		1	0.0337	0.0158
		2	0.0096	0.0275
		3	-0.0332	-0.0068
		4	0.0043	0.0043
		5	0.0040	-0.0114
		6	0.0078	-0.0113
		7	0.0243	0.0419
		8	-0.0162	-0.0250
		9	0.0228	0.0094
		10	0.0113	0.0359

Figure 49. Cross Correlogram between DLNF_IX0300812 and DLN_W_IX0300812_70P

DLN_F_IX0300812,DLN_W_IX0300812_70P_(-i)	DLN_F_IX0300812,DLN_W_IX0300812_70P_(+i)	i	lag	lead
*	*	0	-0.1287	-0.1287
		1	-0.0395	-0.0312
		2	-0.0081	0.0260
		3	0.0330	-0.0257
		4	-0.0243	0.0080
		5	-0.0049	0.0107
		6	-0.0230	-0.0172
		7	-0.0146	0.0175
		8	-0.0062	0.0153
		9	0.0097	-0.0405
		10	-0.0066	0.0422

Figure 50. Cross Correlogram between DLNF_IX0300812 and DLN_W_IX0300812_75C

DLN_F_IX0300812,DLN_ W_IX0300812_75C_(-i)	DLN_F_IX0300812,DLN_ W_IX0300812_75C_(+i)	i	lag	lead
****	****	0	0.4177	0.4177
**	*	1	0.2110	0.1186
	*	2	0.0024	0.0680
	*	3	0.0166	0.0768
		4	0.0420	-0.0082
		5	0.0128	-0.0129
		6	-0.0089	0.0128
		7	0.0128	0.0169
		8	0.0027	0.0335
		9	0.0232	0.0133
		10	-0.0067	0.0110

Figure 51. Cross Correlogram between DLNF_IX0300812 and DLN_W_IX0300812_80C

DLN_F_IX0300812,DLN_ W_IX0300812_80C_(-i)	DLN_F_IX0300812,DLN_ W_IX0300812_80C_(+i)	i	lag	lead
*****	*****	0	0.5636	0.5636
*	*	1	0.1010	0.0528
		2	-0.0070	-0.0067
		3	0.0337	0.0432
		4	0.0008	0.0016
		5	-0.0010	0.0136
		6	-0.0021	-0.0179
		7	0.0146	-0.0042
		8	-0.0096	0.0152
		9	0.0324	0.0164
		10	-0.0060	-0.0039

Figure 52. Cross Correlogram between DLNF_IX0300812 and DLN_W_IX0300812_75P

DLN_F_IX0300812,DLN_ W_IX0300812_75P_(-i)	DLN_F_IX0300812,DLN_ W_IX0300812_75P_(+i)	i	lag	lead
**	**	0	-0.2088	-0.2088
*		1	-0.0776	-0.0017
		2	-0.0088	-0.0318
		3	-0.0300	-0.0205
		4	0.0255	-0.0073
		5	-0.0149	0.0089
		6	-0.0312	-0.0093
		7	0.0097	-0.0094
		8	-0.0008	-0.0110
		9	-0.0024	0.0221
		10	0.0086	-0.0032

G. Optimal Lag Length Selection Tables According to Akaike Information Criteria (AIC), Schwarz Information Criteria (SIC) and Hannan Quinn Criteria (HQ)

Table 32. Optimal lag selection test results for DLFUTURE and DLWARRANT_70C

Lag	AIC	SIC	HQ
0	-14.40360	-14.39930	-14.40204
1	-14.59544	-14.58255	-14.59079
2	-14.64027	-14.61878	-14.63251
3	-14.66320	-14.63312*	-14.65233
4	-14.67062	-14.63195	-14.65665*
5	-14.67020	-14.62293	-14.65312
6	-14.67245*	-14.61659	-14.65227
7	-14.67181	-14.60735	-14.64852
8	-14.66990	-14.59684	-14.64351
9	-14.66850	-14.58685	-14.63900
10	-14.66838	-14.57814	-14.63578
11	-14.67099	-14.57216	-14.63529
12	-14.67113	-14.56370	-14.63232

* Minimum value in column

Table 33. Optimal lag selection test results for DLFUTURE and DLWARRANT_65C

Lag	AIC	SIC	HQ
0	-15.77076	-15.76646	-15.76921
1	-15.95358	-15.94069	-15.94892
2	-16.00072	-15.97924	-15.99296
3	-16.01825	-15.98817*	-16.00739
4	-16.02460	-15.98592	-16.01063
5	-16.02987	-15.98260	-16.01279*
6	-16.03090	-15.97503	-16.01072
7	-16.02940	-15.96494	-16.00611
8	-16.03356	-15.96051	-16.00717
9	-16.03289	-15.95124	-16.00339
10	-16.03486*	-15.94461	-16.00226
11	-16.03389	-15.93505	-15.99818
12	-16.03268	-15.92525	-15.99387

* Minimum value in column

Table 34. Optimal lag selection test results for DLFUTURE and DLWARRANT_70C

Lag	AIC	SIC	HQ
0	-11.83507	-11.83077	-11.83351
1	-12.07018	-12.05729	-12.06552
2	-12.08338	-12.06190	-12.07562
3	-12.12586	-12.09578*	-12.11500
4	-12.12362	-12.08495	-12.10965
5	-12.13919	-12.09192	-12.12211
6	-12.14081	-12.08495	-12.12063
7	-12.14811	-12.08366	-12.12483

Lag	AIC	SIC	HQ
8	-12.15581	-12.08276	-12.12942*
9	-12.15651*	-12.07486	-12.12701
10	-12.15397	-12.06372	-12.12137
11	-12.15318	-12.05434	-12.11747
12	-12.15068	-12.04325	-12.11187

* Minimum value in column

Table 35. Optimal lag selection test results for DLN_F_IX0300612 and DLN_W_IX0300612_70C

Lag	AIC	SIC	HQ
0	-14.81344	-14.80924	-14.81193
1	-14.98748	-14.97489	-14.98294
2	-15.06328	-15.04229	-15.05571
3	-15.10187	-15.07248*	-15.09127
4	-15.10876	-15.07097	-15.09513*
5	-15.11020	-15.06401	-15.09354
6	-15.11208	-15.05750	-15.09239
7	-15.11349	-15.05051	-15.09077
8	-15.11604*	-15.04467	-15.09029
9	-15.11497	-15.03520	-15.08620
10	-15.11399	-15.02582	-15.08218
11	-15.11341	-15.01684	-15.07857
12	-15.11193	-15.00696	-15.07406

* Minimum value in column

Table 36. Optimal lag selection test results for DLN_F_IX0300612 and DLN_W_IX0300612_74C

Lag	AIC	SIC	HQ
0	-13.30027	-13.29607	-13.29875
1	-13.31640	-13.30380	-13.31185
2	-13.33359	-13.31259*	-13.32601*
3	-13.33627	-13.30688	-13.32567
4	-13.33695	-13.29916	-13.32332
5	-13.33907	-13.29289	-13.32241
6	-13.34537	-13.29078	-13.32568
7	-13.34371	-13.28073	-13.32099
8	-13.34561	-13.27424	-13.31987
9	-13.34729	-13.26752	-13.31852
10	-13.34936*	-13.26118	-13.31755
11	-13.34729	-13.25072	-13.31245
12	-13.34626	-13.24129	-13.30839

Table 37. Optimal lag selection test results for DLN_F_IX0300612 and DLN_W_IX0300612_75C

Lag	AIC	SIC	HQ
0	-12.83306	-12.82886	-12.83155
1	-12.89093	-12.87834	-12.88639
2	-12.90233	-12.88134*	-12.89476*
3	-12.90297	-12.87358	-12.89237
4	-12.90668	-12.86890	-12.89305
5	-12.91127*	-12.86509	-12.89461
6	-12.90907	-12.85448	-12.88938
7	-12.90743	-12.84445	-12.88471
8	-12.90589	-12.83451	-12.88014
9	-12.90406	-12.82429	-12.87529

Lag	AIC	SIC	HQ
10	-12.90541	-12.81723	-12.87360
11	-12.90399	-12.80743	-12.86916
12	-12.90452	-12.79955	-12.86665

Table 38. Optimal lag selection test results for DLN_F_IX0300612 and DLN_W_IX0300612_65P

Lag	AIC	SIC	HQ
0	-12.24607	-12.24187	-12.24455
1	-12.36543	-12.35283	-12.36088
2	-12.41545	-12.39445*	-12.40787
3	-12.41580	-12.38641	-12.40520
4	-12.42344*	-12.38565	-12.40980*
5	-12.42154	-12.37535	-12.40488
6	-12.41954	-12.36495	-12.39985
7	-12.42232	-12.35934	-12.39960
8	-12.41982	-12.34844	-12.39407
9	-12.42193	-12.34216	-12.39315
10	-12.42089	-12.33271	-12.38908
11	-12.42105	-12.32448	-12.38621
12	-12.41863	-12.31367	-12.38077

Table 39. Optimal lag selection test results for DLN_F_IX0300612 and DLN_W_IX0300612_65P

Lag	AIC	SIC	HQ
0	-12.45373	-12.44953	-12.45222
1	-12.53687	-12.52428	-12.53233
2	-12.59129	-12.57030	-12.58372
3	-12.60436	-12.57497	-12.59375
4	-12.62366	-12.58587*	-12.61003*
5	-12.62379	-12.57761	-12.60713
6	-12.62233	-12.56775	-12.60264
7	-12.62127	-12.55829	-12.59856
8	-12.61953	-12.54815	-12.59378
9	-12.62725	-12.54748	-12.59848
10	-12.62777*	-12.53960	-12.59596
11	-12.62712	-12.53055	-12.59228
12	-12.62682	-12.52185	-12.58896

Table 40. Optimal lag selection test results for DLN_F_IX0300812 and DLN_W_IX0300812_75C

Lag	AIC	SIC	HQ
0	-16.51798	-16.51403	-16.51656
1	-16.61672	-16.60488	-16.61247
2	-16.63340	-16.61367	-16.62631
3	-16.64638	-16.61876*	-16.63645
4	-16.65088	-16.61537	-16.63812*
5	-16.65180	-16.60839	-16.63620
6	-16.65303	-16.60173	-16.63459
7	-16.65382	-16.59463	-16.63255
8	-16.65386	-16.58678	-16.62976
9	-16.65561*	-16.58063	-16.62866
10	-16.65485	-16.57198	-16.62507

Lag	AIC	SIC	HQ
11	-16.65394	-16.56317	-16.62132
12	-16.65399	-16.55533	-16.61853

Table 41. Optimal lag selection test results for DLN_F_IX0300812 and DLN_W_IX0300812_80C

Lag	AIC	SIC	HQ
0	-15.14040	-15.13645	-15.13898
1	-15.29093	-15.27909	-15.28667
2	-15.31620	-15.29647*	-15.30911*
3	-15.31715	-15.28953	-15.30723
4	-15.31880	-15.28328	-15.30604
5	-15.31898*	-15.27557	-15.30338
6	-15.31673	-15.26543	-15.29830
7	-15.31461	-15.25542	-15.29334
8	-15.31386	-15.24677	-15.28975
9	-15.31269	-15.23771	-15.28574
10	-15.31370	-15.23083	-15.28392
11	-15.31298	-15.22221	-15.28036
12	-15.31578	-15.21712	-15.28033

Table 42. Optimal lag selection test results for DLN_F_IX0300812 and DLN_W_IX0300812_70P

Lag	AIC	SIC	HQ
0	-12.53546	-12.53151	-12.53404
1	-12.67556	-12.66373	-12.67131
2	-12.71499	-12.69526	-12.70790
3	-12.72070	-12.69308	-12.71077
4	-12.73270	-12.69718*	-12.71994*
5	-12.73420	-12.69079	-12.71860
6	-12.73371	-12.68241	-12.71528
7	-12.73321	-12.67402	-12.71194
8	-12.73237	-12.66529	-12.70827
9	-12.73106	-12.65608	-12.70411
10	-12.73869	-12.65581	-12.70890
11	-12.74416	-12.65339	-12.71154
12	-12.74757*	-12.64892	-12.71212

Table 43. Optimal lag selection test results for DLN_F_IX0300812 and DLN_W_IX0300812_75P

Lag	AIC	SIC	HQ
0	-13.63627	-13.63233	-13.63485
1	-13.68587	-13.67403	-13.68162
2	-13.69775	-13.67802	-13.69066
3	-13.70718	-13.67956*	-13.69725*
4	-13.70560	-13.67008	-13.69283
5	-13.70361	-13.66020	-13.68801
6	-13.70959*	-13.65828	-13.69115
7	-13.70876	-13.64957	-13.68749
8	-13.70663	-13.63954	-13.68252
9	-13.70696	-13.63198	-13.68001
10	-13.70536	-13.62249	-13.67558
11	-13.70388	-13.61312	-13.67126
12	-13.70598	-13.60732	-13.67052

H. Variance Decomposition Tables Between Selected Futures and Warrants

Table 44. Variance Decomposition of DLFUTURE and DLWARRANT_70C

Variance Decomposition of DLFUTURE:				Variance Decomposition of DLWARRANT_70C:			
Period	S.E.	DLNFUTURE	DLWARRANT_70C	Period	S.E.	DLNFUTURE	DLWARRANT_70C
1	0.001753	100.0000	0.000000	1	0.029645	45.99750	54.00250
2	0.001754	99.86609	0.133909	2	0.031667	41.25759	58.74241
3	0.001755	99.86214	0.137864	3	0.031668	41.25663	58.74337
4	0.001755	99.85746	0.142537	4	0.031675	41.28387	58.71613
5	0.001755	99.84304	0.156962	5	0.031720	41.18078	58.81922
6	0.001755	99.84235	0.157653	6	0.031734	41.14956	58.85044
7	0.001755	99.84229	0.157712	7	0.031734	41.14971	58.85029
8	0.001755	99.84223	0.157773	8	0.031734	41.14979	58.85021
9	0.001755	99.84212	0.157883	9	0.031734	41.14897	58.85103
10	0.001755	99.84211	0.157887	10	0.031735	41.14874	58.85126
11	0.001755	99.84211	0.157888	11	0.031735	41.14874	58.85126
12	0.001755	99.84211	0.157888	12	0.031735	41.14874	58.85126

Table 45. Variance Decomposition of DLFUTURE and DLWARRANT_65C

Variance Decomposition of DLFUTURE:				Variance Decomposition of DLWARRANT_65C:			
Period	S.E.	DLNFUTURE	DLWARRANT_65C	Period	S.E.	DLNFUTURE	DLWARRANT_65C
1	0.001753	100.0000	0.000000	1	0.014582	42.36072	57.63928
2	0.001753	99.99899	0.001013	2	0.015710	40.21889	59.78111
3	0.001754	99.95422	0.045777	3	0.015720	40.27625	59.72375
4	0.001755	99.92789	0.072113	4	0.015724	40.27073	59.72927
5	0.001755	99.91218	0.087823	5	0.015738	40.32372	59.67628
6	0.001755	99.91215	0.087848	6	0.015740	40.32163	59.67837
7	0.001755	99.91197	0.088035	7	0.015740	40.32248	59.67752
8	0.001755	99.91188	0.088116	8	0.015740	40.32248	59.67752
9	0.001755	99.91185	0.088150	9	0.015740	40.32261	59.67739
10	0.001755	99.91185	0.088150	10	0.015740	40.32261	59.67739
11	0.001755	99.91185	0.088151	11	0.015740	40.32261	59.67739
12	0.001755	99.91185	0.088151	12	0.015740	40.32261	59.67739

Table 46. Variance Decomposition of DLFUTURE and DLWARRANT_65P

Variance Decomposition of DLFUTURE:				Variance Decomposition of DLWARRANT_65P:			
Period	S.E.	DLNFUTURE	DLWARRANT_65P	Period	S.E.	DLNFUTURE	DLWARRANT_65P
1	0.001754	100.0000	0.000000	1	0.079145	4.439869	95.56013
2	0.001754	99.99429	0.005710	2	0.084691	3.972052	96.02795
3	0.001755	99.98475	0.015251	3	0.085768	3.936156	96.06384
4	0.001755	99.97343	0.026570	4	0.088645	3.686872	96.31313
5	0.001755	99.97007	0.029934	5	0.089944	3.589055	96.41094
6	0.001755	99.97006	0.029935	6	0.090422	3.552476	96.44752
7	0.001755	99.96945	0.030550	7	0.090836	3.520149	96.47985
8	0.001755	99.96898	0.031020	8	0.091087	3.501164	96.49884
9	0.001755	99.96890	0.031096	9	0.091212	3.491564	96.50844
10	0.001755	99.96882	0.031180	10	0.091293	3.485411	96.51459
11	0.001755	99.96875	0.031249	11	0.091342	3.481638	96.51836
12	0.001755	99.96872	0.031276	12	0.091370	3.479508	96.52049

Table 47. Variance Decomposition of DLN_F_IX0300612 and DLN_W_IX0300612_70C

Variance Decomposition of DLN_F_IX0300612:				Variance Decomposition of DLN_W_IX0300612_70C:			
Period	S.E.	DLN_F_IX0300612	DLN_W_IX0300612_70C	Period	S.E.	DLN_F_IX0300612	DLN_W_IX0300612_70C
1	0.001524	100.0000	0.000000	1	0.030349	55.74076	44.25924
2	0.001527	99.67444	0.325557	2	0.031962	50.31109	49.68891
3	0.001527	99.63546	0.364544	3	0.032012	50.23023	49.76977
4	0.001529	99.49577	0.504227	4	0.032015	50.23832	49.76168
5	0.001529	99.46576	0.534241	5	0.032115	49.93231	50.06769
6	0.001529	99.46020	0.539798	6	0.032136	49.86889	50.13111
7	0.001529	99.45919	0.540814	7	0.032137	49.86542	50.13458
8	0.001529	99.45730	0.542704	8	0.032137	49.86501	50.13499
9	0.001529	99.45680	0.543200	9	0.032139	49.86145	50.13855
10	0.001529	99.45671	0.543294	10	0.032139	49.86054	50.13946
11	0.001529	99.45668	0.543323	11	0.032139	49.86046	50.13954
12	0.001529	99.45665	0.543347	12	0.032139	49.86044	50.13956

Table 48. Variance Decomposition of DLN_F_IX0300612 and DLN_W_IX0300612_74C

Variance Decomposition of DLN_F_IX0300612:				Variance Decomposition of DLN_W_IX0300612_74C:			
Period	S.E.	DLN_F_IX0300612	DLN_W_IX0300612_74C	Period	S.E.	DLN_F_IX0300612	DLN_W_IX0300612_74C
1	0.001523	100.0000	0.000000	1	0.050314	5.581008	94.41899
2	0.001528	99.35815	0.641847	2	0.050618	6.639623	93.36038
3	0.001528	99.33509	0.664915	3	0.050998	7.424994	92.57501
4	0.001528	99.32936	0.670645	4	0.051009	7.438200	92.56180
5	0.001528	99.32936	0.670644	5	0.051011	7.440464	92.55954
6	0.001528	99.32926	0.670739	6	0.051011	7.441008	92.55899
7	0.001528	99.32926	0.670740	7	0.051011	7.441022	92.55898
8	0.001528	99.32926	0.670741	8	0.051011	7.441030	92.55897
9	0.001528	99.32926	0.670741	9	0.051011	7.441030	92.55897
10	0.001528	99.32926	0.670741	10	0.051011	7.441030	92.55897
11	0.001528	99.32926	0.670741	11	0.051011	7.441030	92.55897
12	0.001528	99.32926	0.670741	12	0.051011	7.441030	92.55897

Table 49 Variance Decomposition of DLN_F_IX0300612 and DLN_W_IX0300612_75C

Variance Decomposition of DLN_F_IX0300612:				Variance Decomposition of DLN_W_IX0300612_75C:			
Period	S.E.	DLN_F_IX0300612	DLN_W_IX0300612_75C	Period	S.E.	DLN_F_IX0300612	DLN_W_IX0300612_75C
1	0.001523	100.0000	0.000000	1	0.064184	10.77087	89.22913
2	0.001528	99.41561	0.584389	2	0.065700	10.45386	89.54614
3	0.001528	99.40126	0.598737	3	0.065751	10.44559	89.55441
4	0.001528	99.38870	0.611296	4	0.065789	10.43349	89.56651
5	0.001528	99.38832	0.611678	5	0.065790	10.43352	89.56648
6	0.001528	99.38827	0.611735	6	0.065790	10.43346	89.56654
7	0.001528	99.38825	0.611752	7	0.065791	10.43344	89.56656
8	0.001528	99.38825	0.611752	8	0.065791	10.43344	89.56656
9	0.001528	99.38825	0.611753	9	0.065791	10.43344	89.56656
10	0.001528	99.38825	0.611753	10	0.065791	10.43344	89.56656
11	0.001528	99.38825	0.611753	11	0.065791	10.43344	89.56656
12	0.001528	99.38825	0.611753	12	0.065791	10.43344	89.56656

Table 50. Variance Decomposition of DLN_F_IX0300612 and DLN_W_IX0300612_65P

Variance Decomposition of DLN_F_IX0300612:				Variance Decomposition of DLN_W_IX0300612_65P:			
Period	S.E.	DLN_F_IX0300612	DLN_W_IX0300612_65P	Period	S.E.	DLN_F_IX0300612	DLN_W_IX0300612_65P
1	0.001528	100.0000	0.000000	1	0.079724	6.480334	93.51967
2	0.001528	99.99565	0.004353	2	0.085855	5.595766	94.40423
3	0.001528	99.99473	0.005271	3	0.085976	5.632275	94.36772
4	0.001528	99.99473	0.005273	4	0.086436	5.587163	94.41284
5	0.001528	99.99467	0.005326	5	0.086479	5.581572	94.41843
6	0.001528	99.99467	0.005334	6	0.086484	5.581820	94.41818
7	0.001528	99.99467	0.005334	7	0.086489	5.581239	94.41876
8	0.001528	99.99467	0.005335	8	0.086489	5.581210	94.41879
9	0.001528	99.99467	0.005335	9	0.086489	5.581207	94.41879
10	0.001528	99.99467	0.005335	10	0.086489	5.581200	94.41880
11	0.001528	99.99467	0.005335	11	0.086489	5.581200	94.41880
12	0.001528	99.99467	0.005335	12	0.086489	5.581200	94.41880

Table 51. Variance Decomposition of DLN_F_IX0300612 and DLN_W_IX0300612_70P

Variance Decomposition of DLN_F_IX0300612:				Variance Decomposition of DLN_W_IX0300612_70P:			
Period	S.E.	DLN_F_IX0300612	DLN_W_IX0300612_70P	Period	S.E.	DLN_F_IX0300612	DLN_W_IX0300612_70P
1	0.001528	100.0000	0.000000	1	0.071829	6.644144	93.35586
2	0.001529	99.93736	0.062642	2	0.076844	5.818464	94.18154
3	0.001529	99.91973	0.080271	3	0.077671	5.708618	94.29138
4	0.001529	99.87053	0.129474	4	0.077680	5.707602	94.29240
5	0.001529	99.85430	0.145697	5	0.077699	5.708038	94.29196
6	0.001530	99.83610	0.163904	6	0.077958	5.670326	94.32967
7	0.001530	99.83607	0.163931	7	0.077960	5.670165	94.32983
8	0.001530	99.83594	0.164063	8	0.077978	5.667611	94.33239
9	0.001530	99.83580	0.164200	9	0.077979	5.667612	94.33239
10	0.001530	99.83541	0.164590	10	0.077979	5.667565	94.33244
11	0.001530	99.83533	0.164668	11	0.077981	5.667325	94.33268
12	0.001530	99.83532	0.164678	12	0.077981	5.667307	94.33269

Table 52. Variance Decomposition of DLN_F_IX0300812 and DLN_W_IX0300812_75C

Variance Decomposition of DLN_F_IX0300812:				Variance Decomposition of DLN_W_IX0300812_75C:			
Period	S.E.	DLN_F_IX0300812	DLN_W_IX0300812_75C	Period	S.E.	DLN_F_IX0300812	DLN_W_IX0300812_75C
1	0.001057	100.0000	0.000000	1	0.015057	20.83918	79.16082
2	0.001086	94.74490	5.255098	2	0.015253	21.96712	78.03288
3	0.001086	94.74394	5.256061	3	0.015299	22.37735	77.62265
4	0.001087	94.75178	5.248223	4	0.015339	22.73508	77.26492
5	0.001087	94.74616	5.253844	5	0.015351	22.71764	77.28236
6	0.001087	94.73820	5.261802	6	0.015352	22.71756	77.28244
7	0.001087	94.73819	5.261810	7	0.015352	22.71849	77.28151
8	0.001087	94.73819	5.261808	8	0.015352	22.71905	77.28095
9	0.001087	94.73815	5.261855	9	0.015352	22.71904	77.28096
10	0.001087	94.73813	5.261867	10	0.015352	22.71904	77.28096
11	0.001087	94.73813	5.261868	11	0.015352	22.71904	77.28096
12	0.001087	94.73813	5.261868	12	0.015352	22.71904	77.28096

Table 53. Variance Decomposition of DLN_F_IX0300812 and DLN_W_IX0300812_80C

Variance Decomposition of DLN_F_IX0300812:				Variance Decomposition of DLN_W_IX0300812_80C :			
Period	S.E.	DLN_F_IX0300812	DLN_W_IX0300812_80C	Period	S.E.	DLN_F_IX0300812	DLN_W_IX0300812_80C
1	0.00107	100.0000	0.000000	1	0.03245	38.11601	61.88399
2	0.00108	98.64161	1.358386	2	0.03355	35.93427	64.06573
3	0.00108	98.62515	1.374850	3	0.03355	35.94082	64.05918
4	0.00108	98.60827	1.391730	4	0.03358	35.88970	64.11030
5	0.00108	98.60262	1.397385	5	0.03358	35.87880	64.12120
6	0.00108	98.60249	1.397513	6	0.03358	35.87875	64.12125
7	0.00108	98.60243	1.397568	7	0.03358	35.87856	64.12144
8	0.00108	98.60241	1.397594	8	0.03358	35.87851	64.12149
9	0.00108	98.60241	1.397595	9	0.03358	35.87851	64.12149
10	0.00108	98.60240	1.397595	10	0.03358	35.87851	64.12149
11	0.00108	98.60240	1.397595	11	0.03358	35.87851	64.12149
12	0.00108	98.60240	1.397595	12	0.03358	35.87851	64.12149

Table 54. Variance Decomposition of DLN_F_IX0300812 and DLN_W_IX0300812_70P

Variance Decomposition of DLN_F_IX0300812:				Variance Decomposition of DLN_W_IX0300812_70P :			
Period	S.E.	DLN_F_IX0300812	DLN_W_IX0300812_70P	Period	S.E.	DLN_F_IX0300812	DLN_W_IX0300812_70P
1	0.001085	100.0000	0.000000	1	0.093490	2.527284	97.47272
2	0.001085	99.85471	0.145291	2	0.102431	2.199997	97.80000
3	0.001086	99.85191	0.148095	3	0.102575	2.251863	97.74814
4	0.001087	99.74364	0.256357	4	0.102616	2.325746	97.67425
5	0.001087	99.69535	0.304647	5	0.102718	2.333595	97.66641
6	0.001087	99.69376	0.306240	6	0.102992	2.321231	97.67877
7	0.001087	99.69375	0.306251	7	0.103010	2.321954	97.67805
8	0.001087	99.69343	0.306572	8	0.103012	2.322418	97.67758
9	0.001087	99.69266	0.307341	9	0.103012	2.322701	97.67730
10	0.001087	99.69250	0.307502	10	0.103014	2.322656	97.67734
11	0.001087	99.69250	0.307505	11	0.103016	2.322601	97.67740
12	0.001087	99.69249	0.307506	12	0.103016	2.322613	97.67739

Table 55 Variance Decomposition of DLN_F_IX0300812 and DLN_W_IX0300812_75P

Variance Decomposition of DLN_F_IX0300812:				Variance Decomposition of DLN_W_IX0300812_75P :			
Period	S.E.	DLN_F_IX0300812	DLN_W_IX0300812_75P	Period	S.E.	DLN_F_IX0300812	DLN_W_IX0300812_75P
1	0.00108	100.0000	0.000000	1	0.05851	5.567530	94.43247
2	0.00108	99.32953	0.670469	2	0.05995	5.309187	94.69081
3	0.00108	99.31042	0.689580	3	0.06011	5.393675	94.60633
4	0.00108	99.27066	0.729338	4	0.06016	5.416093	94.58391
5	0.00108	99.25744	0.742558	5	0.06021	5.410767	94.58923
6	0.00108	99.25744	0.742559	6	0.06021	5.410937	94.58906
7	0.00108	99.25734	0.742661	7	0.06021	5.411120	94.58888
8	0.00108	99.25722	0.742776	8	0.06021	5.411083	94.58892
9	0.00108	99.25721	0.742788	9	0.06021	5.411077	94.58892
10	0.00108	99.25721	0.742790	10	0.06021	5.411077	94.58892
11	0.00108	99.25721	0.742790	11	0.06021	5.411077	94.58892
12	0.00108	99.25721	0.742790	12	0.06021	5.411077	94.58892