"PRICE DISCOVERY AND VOLATILITY SPILLOVER IN SPOT INDEX AND INDEX FUTURES MARKETS: EVIDENCE FROM TURKEY"

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JULY 2011

"PRICE DISCOVERY AND VOLATILITY SPILLOVER IN SPOT INDEX AND INDEX FUTURES MARKETS: EVIDENCE FROM TURKEY"

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Approval of the Graduate School of Social Sciences

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Director

I certify that this thesis satisfies all the requirements as a thesis for the degree of Master of Art.

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This is to certify that we have read this thesis and that in our opinion it is fully adequate, in scope and quality, as a thesis for the degree of Master of Art.

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order of last name)

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ABSTRACT

"PRICE DISCOVERY AND VOLATILITY SPILLOVER IN SPOT INDEX AND INDEX FUTURES MARKETS: EVIDENCE FROM TURKEY"

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MA in Financial Economics, Graduate School in Social Sciences

Supervisor: Assoc. Prof. Dr. Ayla OĞUŞ BİNATLI

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This thesis analyzes the price discovery and volatility spillover among spot index and index futures in Turkey, using the daily closing prices of ISE-30 Index as the spot index prices and the daily settlement prices of Turkdex-ISE-30 Index Futures as the index futures prices for period February 2005- December 2010. Employing Johansen VAR method based on Vector Error Correction, this thesis suggests that there is a long run relationship between the prices of spot index and index futures. It is found that the spot index and index futures are cointegrated. Results indicate that index futures prices adjust more to the discrepancy from the long run equilibrium compared to the spot prices. Hence, rejecting the usual result of the futures markets leads spot markets in the price discovery process, the empirical results of this study indicate that spot markets lead futures markets in Turkey and information disseminates first into the spot markets earlier than the futures markets.

Using multivariate GARCH with Diagonal VECH model, this thesis also investigates the volatility spillover in spot index and index futures markets. Based on the empirical results, it is found that there is a volatility spillover between spot index and index futures. This study therefore suggests that spot index plays a leading role in the price discovery process in Turkey, and there exists a strong intermarket dependency in the volatility of the price changes of spot index and index futures.

Keywords: price discovery; Turkish Derivatives Exchanges; Johansen VAR method; VECM; multivariate GARCH model

ÖZET

"SPOT ENDEKS VE ENDEKS VADELİ PİYASALARINDA FİYAT KEŞFİ VE VOLATİLİTE YAYILMASI: TÜRKİYE UYGULAMASI"

Karhan, Gülce

Finansal Ekonomi Yüksek Lisans Programı

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Bu çalışmada spot endeks fiyatı olarak İMKB 30 Endeksinin günlük kapanış fiyatları,vadeli endeks fiyatı olarak ise VOB-İMKB 30 Endeksi vadeli işlem sözleşmelerinin günlük uzlaşma fiyatları kullanılarak, Şubat 2005-Aralık 2010 dönemi için spot endeks ve endeks vadeli piyasalarında fiyat keşfi ve volatilite yayılması incelenmektedir. Yöney hata düzeltme modeline (VECM) dayanan Johansen VAR methodu kullanılarak, spot endeks ve endeks vadeli işlem sözleşmelerinin fiyatları arasında uzun dönemli ilişkinin varlığı tespit edilmiştir. Spot endeks ve endeks vadeli piyasalarının eştümleşik olduğu ortaya çıkmıştır. Sonuçlar, vadeli endeks fiyatlarının uzun dönemli sapmalara karşı daha fazla düzeltme gösterdiğini ortaya koymaktadır. Bu nedenle, fiyat keşfi aşamasında vadeli piyasaların spot piyasaya öncülük ettiğine dair alışılagelen sonucun tersine, bu

çalışmanın ampirik sonuçları spot piyasanın vadeli piyasaya öncülük ettiğini ve bilginin vadeli piyasadan önce spot piyasada yayıldığını ifade etmektedir.

Bu çalışmada ayrıca, köşegen VECH modeline dayanan çok değişkenli GARCH kullanılarak, spot endeks ve vadeli endeks piyasaları arasındaki volatilite yayılması araştırılmaktadır. Amprik sonuçlara bağlı olarak, spot endeks ve vadeli endeks arasında volatilite yayılması bulunmuştur. Bu çalışmadan elde edilen bulgular, Türkiye'de fiyat keşfi aşamasında spot endeksin öncü rol oynadığını ve spot endeks ve vadeli endeks fiyat değişimlerinin volatiliteleri arasında güçlü bir etkileşim olduğunu ortaya koymaktadır.

Anahtar Kelimeler: fiyat keşfi; Vadeli İşlem ve Opsiyon Borsası; Johansen VAR methodu; yöney hata düzeltme modeli (VECM); çok değişkenli GARCH modeli

To My Parents and My Eternal Love “Sami Can”

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1. INTRODUCTION

As the capital is the main need of the firms to continue their activities, many of them use equity trading to raise capital. Also, the households use equity trading to invest their savings by means of financial institutions. Depending on ongoing interaction of the market participants over centuries, equity trading has played a crucial role in the financial world.

By the financial market liberalization and globalization, the risk exposure of the market participants has increased and the concept of risk management has become important all over the world. As a result, derivative markets have appeared and developed rapidly to respond to the need of managing risks. Although derivative markets have a relatively short history, derivatives are widely used as a popular financial tool not only to manage risks but also to speculate and do arbitrage. The emergence of derivatives has led to radical changes in financial transactions, including flexibility, lower transaction costs and leverage effect. So, the market participants have started to find new trading strategies in order to minimize their risks and maximize their returns by trading in both markets. The flow of transactions from spot markets to future markets (or vice versa) has enhanced their relationship and their substantial growth. Therefore, the research interest in clarifying the relationship between spot and futures markets has increased over time and their relation has become an important area of study in the literature.

Under the efficient market hypothesis, the same information set should be reflected in both spot and future markets at the same time and the payoff from both markets should be equal. Trading in spot and future markets should lead to the same financial results for the informed investors and the reactions of both markets should be same. Under this hypothesis, there should be no arbitrage opportunities. However, in reality, one market reacts to the same information set faster than the other due to the market frictions such as transaction costs, short-sale constraints or institutional settings. Therefore, a lead-lag relationship between spot and futures markets is observed.

The lead-lag relationship on the basis of returns between spot and futures markets has been the main area of study. The studies on the lead-lag relationship between spot and futures markets suggest that the index futures lead the spot index and new information transmits to the futures prices before the stock market. If a lead-lag relation in price changes offers inconclusive evidence, the volatility of price changes represents another way of measuring how information can flow to those two markets (Chan, Chan and Karolyni 1991). As the returns of the spot (future) markets affect those of the other, the volatility of one market also affects the volatility of the other. Volatility is highly related to the rate of information transaction. (Ross 1989). For many investment decisions, volatility is central and symbolizes the anxiety of the investors. The transmission mechanism of volatility is very important for the investors in dealing with their risk exposure.

Understanding the transmission of information from market to market is the study of volatility spillover. When changes in price volatility in one market produce a lagged effect on volatility in the other market, volatility spillover occurs. The interaction between the volatility of different financial markets such as equity markets, bond markets, futures markets and foreign exchange markets may exist and the volatility can transmit from one market to another.

In financial markets, prices are influenced by the portfolio decisions of more than one trader. The portfolio decisions of different traders are shaped by the information transmission in the markets which causes the volatility spillovers between markets.

The objective of this study is to contribute to the literature of price discovery and volatility spillover between markets, through an examination of the volatility spillover between index and index futures in Turkey. Dealing with price discovery process in spot and futures markets and investigating whether there is a volatility spillover between index and index futures in Turkey is an interesting research area for three reasons. The first reason is to answer one of the main questions of the finance for Turkish Capital Markets, whether the same assets in spot and futures markets in Turkey are sold at the same price at each point in time, or whether they react differently due to the different rate of flow of information to the markets. In other words, this study aims to clarify the lead-lag relationship between spot and futures markets and analyze whether there is a transmission of the volatility from one market to the other. Why does this study concentrate on the daily volatility of the cash and futures prices not just on the daily prices changes themselves? There is an important feature of the volatility. Volatility is the variability of an asset's returns, not the direction of the prices. The study of Bookstaber and Pomerantz (1989) emphasizes that the information-volatility relationship is more important than the information-price change relationship. So investigating both price changes and volatilities of the cash and futures prices will provide valuable information about the relationship between spot and futures markets. Secondly, Turkey has emerged as one of the main destinations for international investors and still has a great potential for investments with its increasing reputation among emerging markets thanks to the rapid growth of its financial system and dynamic market economy.

After the global financial crisis occurred in 2008, Turkey is among the countries whose risk premium indicators have dramatically decreased owing to its rapid recovery period. Turkey became the fastest growing country among OECD countries and second fastest growing country among the G-20 countries with its first quarter growth rate of 11.8 percent and the fastest growing country among G-20 countries with its second quarter growth rate of 10.3 percent in 2010.[1] As a result of these economic improvements, credit rating agencies upgraded the credit rate (in terms of foreign currency) of Turkey. As of 15 January 2010, the credit rates for Turkey was Ba2 (stable) in Moody's, BB- (stable) in Standard & Poor's and BB+ (stable) in Fitch. Then as of 21 January 2011, the credit rates were adjusted to Ba2 (positive), BB (positive) and BB+ (positive) respectively.[2] The risk perception of the international investors for Turkey has been decreasing and the foreign capital flows have been increasing over time since the full economic liberalization was implemented. The Istanbul Stock Exchange is an attractive investment location with its rapid growth over years among the emerging stock markets. Its capitalization has increasing significantly. Thirdly, although TurkDEX is a very young exchange, it has reached a very high trading volume especially in the last four years. The attractiveness of the futures is increasing due to its potential for managing risks in the Turkish Capital Markets. So, understanding price discovery mechanism and volatility spillover between spot and futures markets plays a crucial role in building a dynamic investment portfolio and managing risks for both international and domestic investors.

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[1] Annual Economic Report 2010, Republic of Turkey Ministry of Finance
[2] Republic of Turkey Prime Ministry Undersecretariat of Treasury, Turkish Economy Presentation January 2011

The literature on price discovery process and volatility spillovers between spot and futures markets in developed markets is voluminous, whereas there are far fewer studies focusing on emerging futures markets. Therefore, this study tries to enlarge the existing literature for emerging futures markets by examining Turkey, one of the fastest growing economies in the world. Being an important emerging market economy, Turkey is a very attractive investment opportunity for international portfolio investors because of its expanding capital markets; there are quite a limited number of studies that examine the link between spot and futures markets in Turkey. Baklaci and Tutek (2006), Baklaci (2007) and Kasman and Kasman (2008) analyze the relationship between spot and futures markets but the time period of their studies is limited due to the short history of TurkDEX. Differently, Tokat and Tokat (2010) investigate the dynamics of volatility interaction between Turkish spot and futures markets.

In this study, a relatively extended data has been used, covering the period from February 2005 to December 2010. Also, the results of this study have implications for understanding the way of information flows between the two markets and will provide valuable information for both foreign and domestic individual investors, institutional investors and fund managers.

This study is structured as follows: Chapter 2 covers detailed information on the Istanbul Stock Exchange (ISE) and the Turkish Derivatives Exchange (TurkDEX), including their brief history, their institutional settings, their role in global financial environment and their comparison giving statistical data over years. Also the information about the spot index (ISE 30 Index) and index futures contracts (TurkDEX ISE 30 Index Futures) is provided in Chapter 2. The foreign and Turkish empirical literature on the linkages between spot and futures markets, literature on price discovery and volatility spillovers between spot and futures markets is reviewed in Chapter 3. Chapter 4 discusses the econometric methodology. The data and econometric analysis is explained in Chapter 5. Chapter 6 summarizes the study and provides some concluding remarks.

2. DETAILED INFORMATION ON THE EXCHANGES OF BOTH SPOT AND FUTURES MARKETS

This chapter provides detailed information on the Istanbul Stock Exchange (ISE) and Turkish Derivatives Exchange (TurkDEX) including their brief history, their institutional settings, their role in global financial environment and their comparison giving statistical data over years. Also the information about the spot index (ISE 30 Index) and index futures contracts (TurkDEX ISE 30 Index Futures) is provided in this chapter.

2.1. ISTANBUL STOCK EXCHANGE (ISE)

This part of the chapter covers detailed information on Istanbul Stock Exchange (ISE) including its brief history, its institutional settings, its role in global financial environment and its statistical data over years and also provides the information about the spot index (ISE 30 Index).

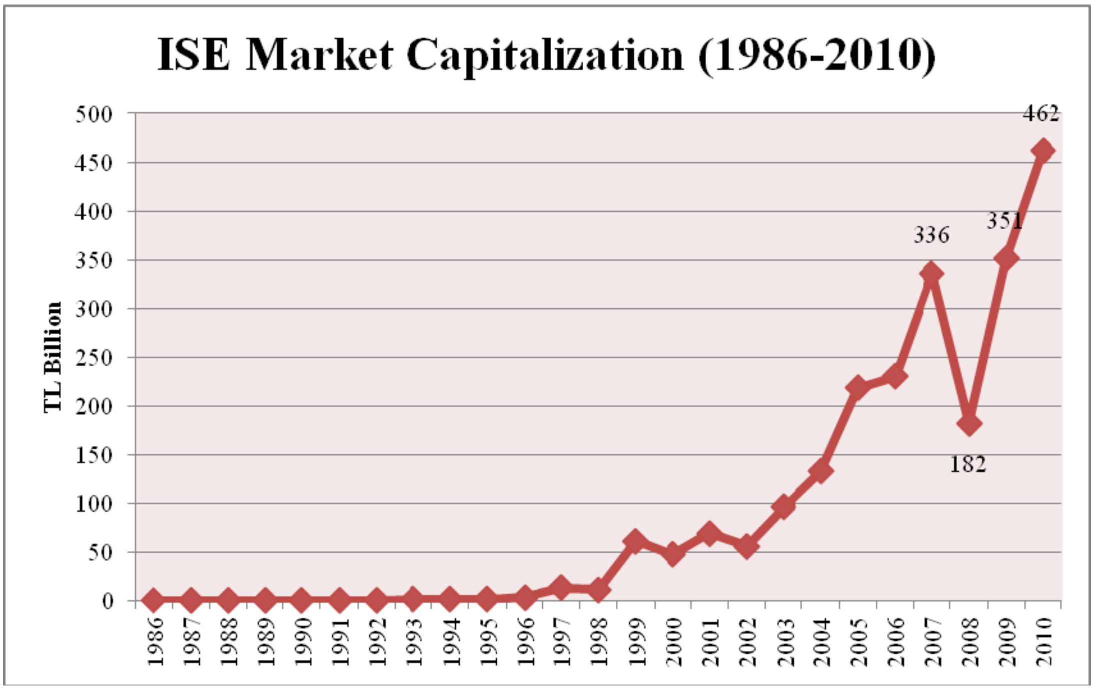
2.1.1. BRIEF HISTORY OF ISTANBUL STOCK EXCHANGE

For the development of the Turkish economy, the capital markets and stock exchange, 24 January 1980 was a milestone. As a part of the Economical Stability

Decisions of January 24, the capital market in Turkey was reorganized. In 1981, the Capital Market Law was enacted, and Capital Market Board, the main regulatory body responsible for supervision and regulation of Turkish securities market was established in Ankara in 1982. The Capital Market Board began preparations for the legal and institutional infrastructure of Turkey's capital markets, and drew up new stock exchange legislation. On 19 October 1984, the Ministry of State passed a resolution for the establishment of the Istanbul Stock Exchange. Consequently, the sole stock exchange of Turkey was established on 26 December 1985, although it did not start to operate until 3 January in 1986.

After the 1980s, liberalization process started in capital markets and by the enactment of Decree No: 32 (1989), the capital flows are fully liberalized in Turkey. Due to these accelerated developments in capital flows, the ISE experienced a rapid development, which is clearly seen in Figure 1. At its date of establishment, its capitalization was 1 million TL. As a result of the liberalization arrangements of the capital flows in Turkey, its capitalization multiplied and in 2010 reached to 462 billion TL. Since its establishment, a sharp decrease only occurred in the recent global financial crisis in 2008, and its capitalization decreased to 182 billion TL from 336 billion TL. However, thanks to rapid recovery of Turkish Economy in the post-crisis year, its capitalization improved rapidly.

Figure 1 ISE Market Capitalization



Source: www.ise.org

The ISE has had a growing reputation among the emerging markets in recent years related to its faster growth and expansion of ISE, liberalization of capital markets and ameliorating equity culture in Turkey. In Table 1, the total value of share trading of emerging markets is provided. In terms of the value of share trading (USD millions), Istanbul Stock Exchange is among the top ten emerging markets, with 411,469 million USD.

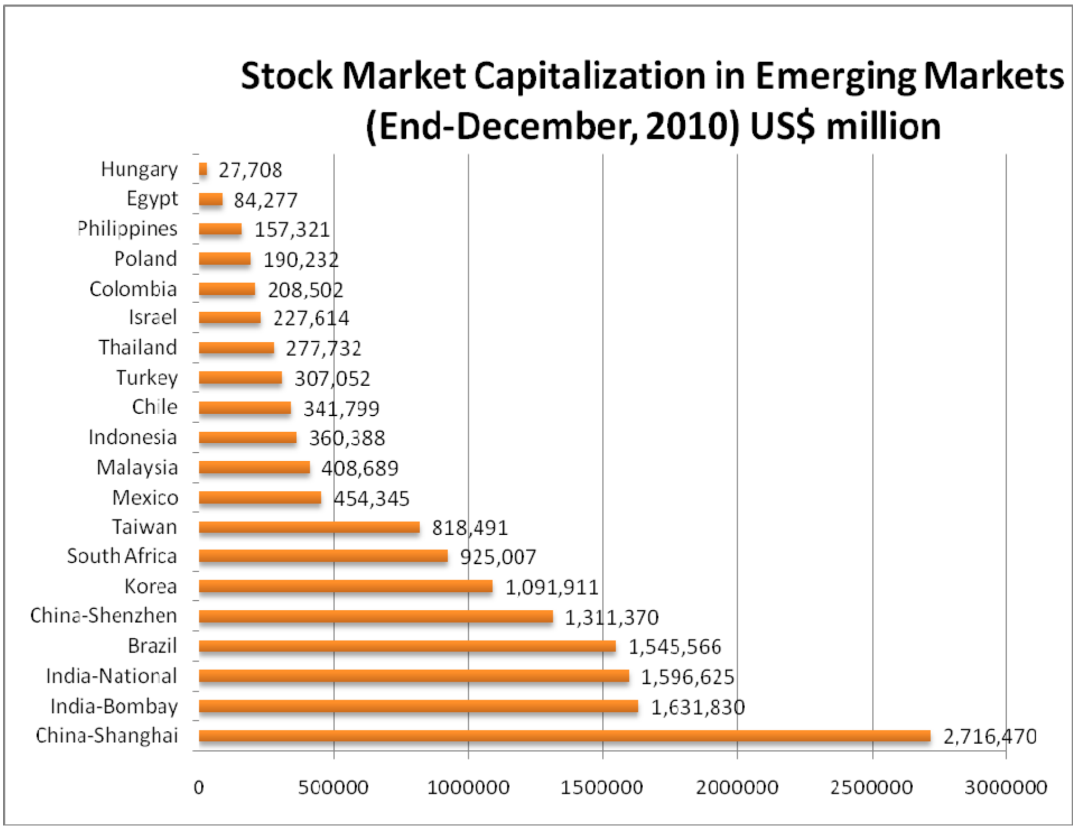
Table 1 Total Value of Share Trading (USD millions)

COUNTRY	NAME OF THE STOCK EXCHANGE	2010 END OF YEAR
China	Shanghai Stock Exchange	4,496,193.50
China	Shenzhen Stock Exchange	3,572,529.10
Korea	Korea Exchange	1,607,247.30
Taiwan	Taiwan SE Corp.	903,061.70
Brazil	BM&FBOVESPA	868,813.00
India	National Stock Exchange India	801,017.20
Turkey	**Istanbul Stock Exchange**	**411,469.20**
South Africa	Johannesburg SE	340,025.10
India	Bombay SE	258,695.60
Thailand	The Stock Exchange of Thailand	214,086.00
Mexico	Mexican Exchange	119,119.40
Malaysia	Bursa Malaysia	112,291.70
Indonesia	Indonesia SE	103,842.50
Israel	Tel-Aviv SE	102,694.30
Poland	Warsaw SE	69,230.70
Chile	Santiago SE	53,818.20
Egypt	Egyptian Exchange	38,397.40
Colombia	Colombia SE	28,269.00
Hungary	Budapest SE	26,276.90
Philippines	Philippine SE	21,778.00

Source: www.world-exchanges.org (World Federation of Exchanges/Focus January 2011)

Additionally, as it is seen in Figure 2, Turkey achieved 307,052 million USD of domestic market capitalization by the end of December 2010.

Figure 2 Stock Market Capitalization in Emerging Markets

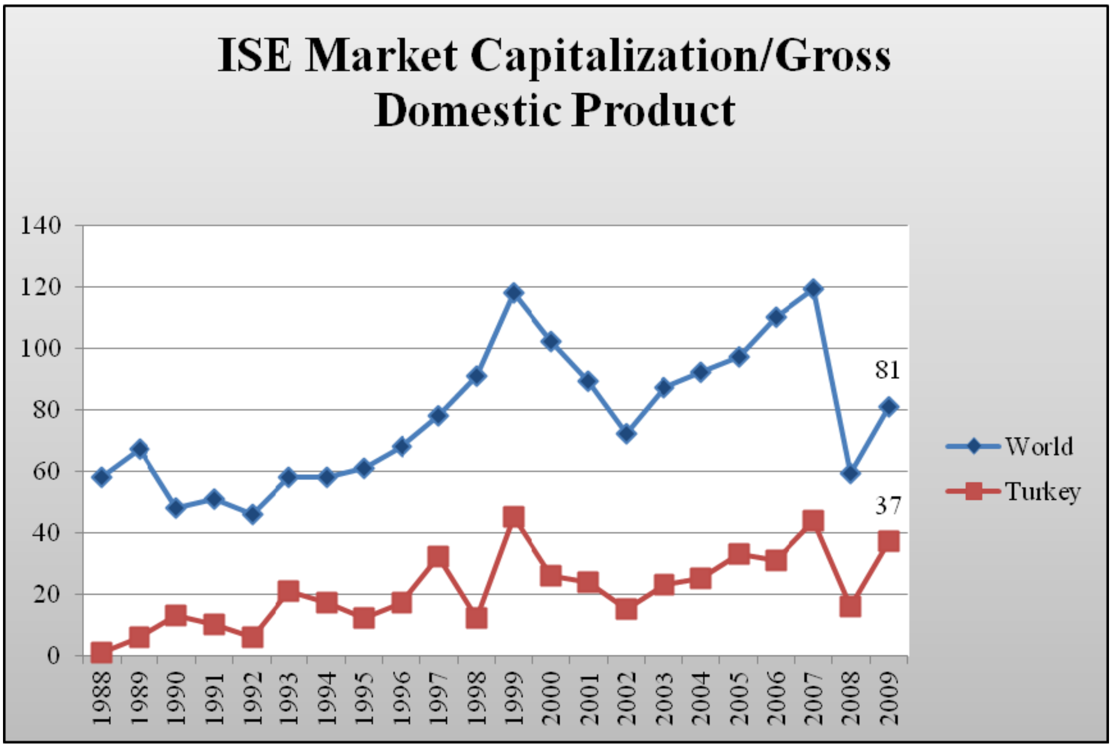


Source: www.world-exchanges.org (World Federation of Exchanges/Focus January 2011)

[a] *Investment trusts are not included.*

Figure 3 shows the market capitalization of the ISE is equal to 37 per cent of the Turkish Gross Domestic Product (GDP), while this ratio is around 80-90 per cent for all countries at the end of 2009. It is clear that there is a potential for increasing its market capitalization for ISE. ISE aims to reach to the world average by its increasing attractiveness for both domestic and foreign investments.

Figure 3 ISE Market Capitalization/ Gross Domestic Product



Source: *www.ise.org*

On October 2nd, 2009, the Istanbul International Financial Center Strategy and Action Plan was published by the High Planning Council on the Official Journal. In article 11, it is stated that the inclusion of non-public companies in the capital markets will be encouraged in order to broaden the capital base. It is also stated that Istanbul's growing role as a regional and global financial center will increase the inflow of international funds and contribute significantly to economic growth. As the growth of Istanbul Stock Exchange is important in promoting Istanbul's role as a global financial center, it organized IPO Turkey Summit between May 6 and 7 in 2010 with the aim of encouraging the utilization of capital market by the companies through the promotion of public offerings. During 1990-2000, an average of 24 companies went public each year, but this decreased to 6 in the period 2001-2009. However, as the direct result of the IPO Summit, in 2010 this number is increased to

16[3]. Figure 4 demonstrates that by the end of 2010, the number companies traded in ISE increased to 331.

Figure 4 Number of Companies Traded in ISE

Source: www.ise.org

[b] *Exchange Traded Funds are not included.*

ISE is a member of World Federation Exchange (WFE), Federation of Euro-Asian Stock Exchanges (FEAS), Federation of European Securities Exchanges (FESE), International Securities Services Association (ISSA), International Capital Market Association (ICMA), European Capital Markets Institute (ECMI) and International Organizations of Securities Commissions (IOSCO).[4]

In ISE, the products traded are stocks, government bonds, treasury bills, repo and reverse repo agreements, foreign securities (Eurobonds issued by Turkish Treasury)

[3] Exchange traded funds are not included.

exchange traded funds and warrants. ISE Markets are organized in four-submarkets which are;

i. ISE Stock Market: Publicly-held companies from different sectors are traded by local and foreign investors.

ii. Emerging Companies Market: Some companies do not fulfill the listing requirements of ISE, however promise a development and growth potential. So the securities of these kinds of companies can be traded on the "Emerging Companies Market".

iii. Bonds and Bills Market: This is the only organized market for both fixed income securities trading and repo-reverse repo transactions.

iv. Foreign Securities Market: In this market, foreign debt securities that are issued by the Undersecretariat of Treasury of Turkey and listed on the exchange (Eurobonds) are traded.

The transactions in all markets are done electronically and the market information is announced real-time. As this study deals with ISE Stock Market, especially with ISE-30 Index, only ISE Stock Market will be discussed in the following part.

2.1.2. ISTANBUL STOCK EXCHANGE STOCK MARKET

Stocks and rights coupons of different sector companies, exchange traded funds, investment trusts and warrants are traded on ISE Stock Market. Since November 1994, ISE had full computerized stock trading. In this full automation system, the transactions are done by the principle of "Multiple Price-Continuous Auction" based

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[4] www.ise.org

on price and time priority rule. There are morning (09.30-12.30) and afternoon (14.00-17.30) sessions from Monday to Friday. At the beginning of both sessions, an "Opening Session" (morning: 09.30-09.50/ afternoon 14.00-14.20) occurs with Single Price System. The settlement of securities and cash in the Stock Market occurs on the second business day following the transaction. Clearing and settlement operations are carried out by Takasbank.[5]

Stock Market transactions are done on the National Market, Collective Products Market, Fund Market, Second National Market, Watchlist Companies Market, Primary Market and Wholesale Market. Investors cannot trade directly in ISE, they can trade via ISE members. ISE member intermediary institutions collect orders electronically from investors, and then they transmit the orders to the trading system. Members pay 1 per hundred thousand (0.000010) as the exchange fee charged on their transactions in the stock market and they charge a brokerage fee to the investors. ISE members, who are authorized to engage in short selling activities with the permission of Capital Markets Board (CMB), may execute short selling transactions by applying to ISE. In the opening sessions short selling is not allowed.

Base price set a base for determining the tradable upper and the lower price limits for a stock during a session. It is calculated by rounding the "Weighted Average Price" of the previous session to the nearest price tick. Price tick is the least price variation

[5] Takasbank is the Clearing and Settlement Center for the Istanbul Stock Exchange (ISE), the Clearing House for the Turkish Derivatives Exchange, the Official Custodian for Pension Funds incorporated in Turkey and the National Numbering Agency of Turkey authorized by the Capital Markets Board of Turkey.

that may occur once at a time for each stock. In Table 2, base price range and price ticks in ISE are presented. [6]

Table 2 Base Price Range and Price Tick in ISE

Base Price Range (TRY)	Price Tick (TRY)
0.01–5.00	0.01
5.02–10.00	0.02
10.05–25.00	0.05
25.10–50.00	0.10
50.25–100.00	0.25
100.50–250.00	0.50
251.00–500.00	1.00
502.50–1000.00	2.50
1005.00- over	5.00

Source: *www.ise.org*

2.1.3. STOCK MARKET INDICES

ISE indices calculate price and return performances of all shares on the basis of related markets and sectors. Until 1997, ISE calculated only ISE 100, Financial and Industrials price indices. Then, ISE started to compute also sector and subsector indices based on price and total return as of 1997. While price indices reflect only price changes, return indices takes into account the dividend payments. ISE compute and publish price indices throughout trading sessions whereas return indices are only computed and published at the close of trading session. Related to the decision taken by Capital Market Board on July 2010, stocks traded on the ISE are classified under

[6] In 1 November 2010, ISE changed its price tick scale as showed in Table 1, as a first step of the effort for decreasing the price ticks. Additionally, ISE announced that there will be a second step for decreasing the price ticks (whose details can be found in the website of the exchange) at a future date.

A, B and C groups[7] and ISE stock market indices consist of "A" and "B" listed stocks while "C" listed stocks are excluded. ISE Stock Market indices are;

- ISE 100 Index
- ISE 50 Index
- ISE 30 Index
- ISE 10 Banks Index
- ISE 100-30 Index
- ISE Corporate Governance Index
- ISE All Shares Index
- ISE All-100 Index
- The Greece & Turkey 30 Index
- ISE City Indices
- ISE Sector and Sub-sector Indices including ISE Industrials; ISE Food, Beverage; ISE Textile, Leather; ISE Wood, Paper, Printing; ISE Chemical, Petroleum, Plastic; ISE Non-Metal Mineral Products; ISE Basic Metal; ISE Metal Products; Machinery; ISE Services; ISE Electricity; ISE Transportation; ISE Tourism; ISE Wholesale and Retail Trade; ISE Financials; ISE Banks; ISE Insurance; ISE Leasing, Factoring; ISE Holding and Investment; ISE Technology; ISE Information Technology; ISE Defense; ISE Investment Trusts Index; ISE Second National Market Index.

ISE-100 Index, which contains also ISE 30 Index and ISE 50 Index, has been used as a benchmark index for the National Market over the years. However, in recent years

[7] The classification procedures of the stocks as A, B and C can be found on the ISE website.

the trading volume of ISE National 30 Index has comprised the greater part of the trading volume of ISE National 100 Index. In 2010, the trading value of ISE-30 Index was approximately equal to 76% of that of ISE-100 Index. ISE 30 Index consists of 30 largest companies within all companies traded in ISE 100 Index. These biggest companies including especially the stronger Turkish banks make ISE 30 Index more reliable for investigating stock return movements. Due to the structure of ISE 30 Index, there may be less speculation and manipulation in the price movements of ISE 30 Index compared to ISE 100 Index. Consequently, in this study ISE 30 Index is used as a proxy for the national index.

2.1.4. ISE NATIONAL 30 INDEX

ISE National 30 Index (ISE-30) is a capitalization-weighted index that consists of 30 companies that are highly capitalized and actively traded in National Market of ISE except investment trusts. The selection criteria of these 30 companies are set by ISE. Companies in the National Market are ranked related to their market value of outstanding shares and daily average traded values from the highest to lowest. In addition to these two main selection criteria, there is a final selection procedure. There is also periodic change for constituent stocks within ISE 30 index and the adjustment is made related to some ISE procedures.[8]

2.2. TURKISH DERIVATIVES EXCHANGE (TURKDEX)

Until 2005, Turkish Capital Markets lacked derivatives market which is important for maintaining an efficient financial system. In 2001, Turkish Derivatives Exchange (TurkDEX) was formed as the first private exchange in Turkey through a resolution

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(www.ise.org)

of the Cabinet based on the approval of the Capital Markets Board (CMB) of Turkey and trading began in February 4, 2005. TurkDEX, established as a self governing joint stock company[9], is the only and first entity authorized by the Capital Markets Board to launch a derivatives exchange in Turkey.

Since its operation started, TurkDEX has been growing sharply and continuously in terms of its trading volume (based on nominal value and number of contracts) and members, even in times of high market volatility and uncertainty.

The tremendous trading volume of TurkDEX is shown in Figure 5. By the end of 2010, the trading volume of TurkDEX has been 431,682 million TRY as the nominal value and 63,952,177 as the number of contracts. The record trading volume was achieved in 24 February 2011 by 3,317,632,983 TRY. As of September 2010, it has 98 members which are all either banks or certified brokerage houses based in Turkey. TurkDEX has been the 24th largest derivatives exchange based on number of futures and options contracts traded and/or cleared in 2009 among the top 30 derivatives exchanges related to Futures Industry Association (FIA) data.

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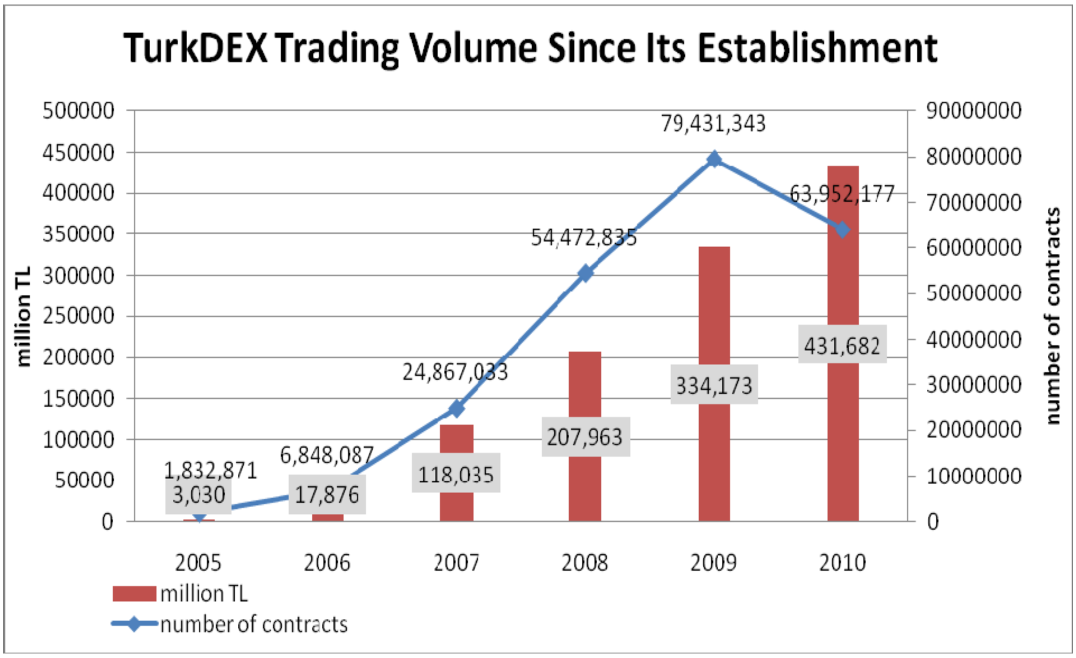
[8] Details of the selection and adjustment procedures can be found on the ISE website. (www.ise.org)
[9] The shareholders of TurkDEX are The Union of Chambers and Commodity Exchanges of Turkey (%25), Istanbul Stock Exchange (%18), Izmir Mercantile Exchange (%17), Yapı Kredi bank (%6), Akbank (%6), Vakıf Securities Inc. (%6), Garanti Bank (%6), İş Securities Inc. (%6), Turkish Association of Securities Dealers (%6), Takasbank (%3) and Sinai Kalkınma Bank (%1).

Figure 5 Trading Volume of TurkDEX since Its Establishment



Source: [*www.turkdex.org*](http://www.turkdex.org)

The product range of TurkDEX is composed of financial and commodity instruments. TurkDEX currently has futures contracts on;

- Equity indices (ISE 30, ISE 100, ISE 30-100 Index Spread)
- Foreign currencies (USD/Turkish Lira- cash settled and physically delivered, EURO/Turkish Lira-cash settled and physically delivered, EURO/USD Cross Currency)
- Debt (T- Benchmark Government Bond)
- Commodities (Wheat, Cotton, Gold, USD/Ounce Gold).

However, the options have not been listed yet. TurkDEX plans to launch options on futures in the near future.

TurkDEX Trading system in TurkDEX is very similar to the trading system of ISE. TurkDEX is a fully electronic exchange with remote access, so no geographical constraints exist to invest at TurkDEX. The futures contracts are traded electronically on TurkDEX trading platform (TurkDEX Exchange Operations System-TEOS) which features market orders, limit orders, on close orders, keep remainder orders, fill or kill orders, fill and kill orders and stop-loss orders. A "multiple-price continuous auction" method determines prices and computerized system automatically matches buying and selling orders related to the price and time priority basis. In TurkDEX, there is a single trading session between 9.15- 17.35 without a lunch break. Similar to ISE, individual investors can not directly trade in TurkDEX. They should open an account with the authorized members of TurkDEX. All investors must deposit some collateral before the execution of trade due to the requirement of "pre-margining system". At the end of the every exchange day, profits and losses are calculated and accounts are marked to market. At the expiry date, the existing open positions are offset with the final settlement prices. Clearing of the transactions are handled by Takasbank which eliminates counterparty credit risk. There is a guarantee fund established by the contributions of the clearing members which serves to share the risk of any default to all members.

The advantageous incentive of TurkDEX is its taxation. TurkDEX is tax free for institutional foreign investors and the local investors don't pay any withholding tax for equity future contracts. But there is a 10% withholding tax for other instruments.

In Table 3, the comparison of the domestic and foreign investors' shares on ISE and TurkDEX is presented. Both domestic and foreign investors make transactions in both ISE and TurkDEX. The largest shares of the transactions belong to domestic investors in TurkDEX, while the foreign investors dominate ISE transactions.

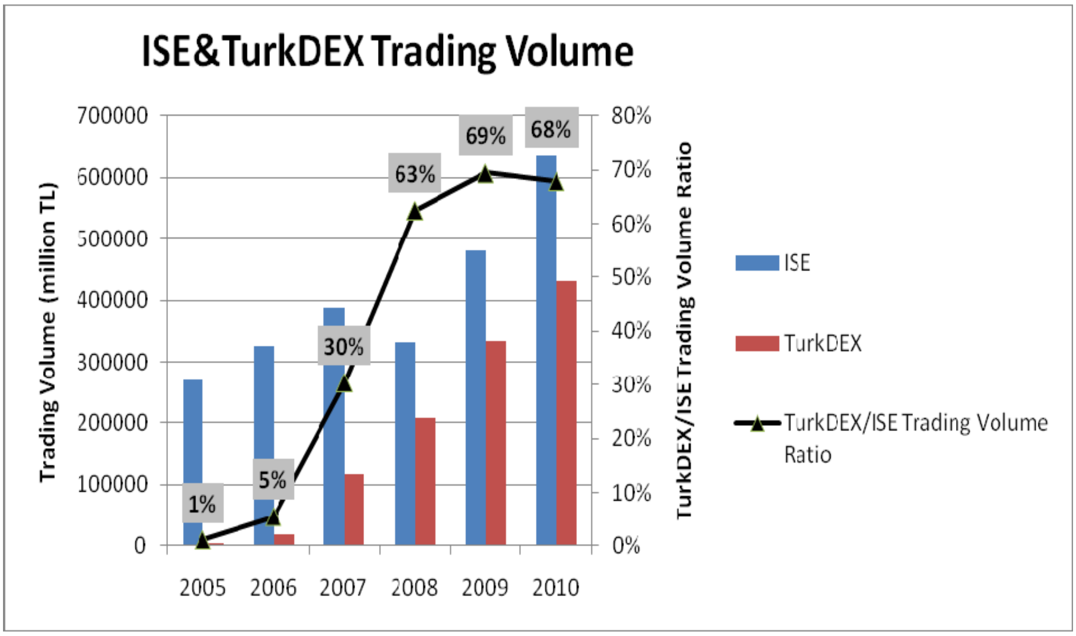
Table 3 Comparison of the Domestic and Foreign Investors' shares on ISE and TurkDEX

	ISE		***TurkDEX***	
Year	**Domestic Investors in ISE**	**Foreign Investors in ISE**	**Domestic Investors in TurkDEX**	**Foreign Investors in TurkDEX**
2005	33.2%	66.8%	86.9%	13.1%
2006	33.9%	66.1%	88.7%	11.3%
2007	29.2%	70.8%	74.9%	25.1%
2008	29.9%	70.1%	77.2%	22.8%
2009	34.2%	65.8%	91.6%	8.4%
2010	33.2%	66.8%	89.3%	10.7%
2011	35.0%	65.0%	86.1%	13.9%

Source: www.turkdex.org, www.ise.org

Within 5 years, the trading volume of TurkDEX has increased by hundred times of its initial trading volume. By comparing to the trading volume of ISE, the sharp growth of TurkDEX in comparison to ISE is clearly seen in Figure 6. In 2010, trading volume in TurkDEX reached 68 percent of the trading volume of ISE.

Figure 6 Comparison of ISE- TurkDEX Trading Volume



Source: www.turkdex.org, www.ise.org

2.2.1. TurkDEX- ISE 30 INDEX FUTURES

The underlying asset of the TurkDEX ISE 30 futures is the ISE National 30 Index, an important benchmark index followed by both domestic and foreign investors. ISE-30 Index Futures contracts are the most liquid financial instruments in the Turkish financial system and one of the most active equity index futures around the world, despite their short history. Financial market participants use them for hedging their spot equity portfolios, investing on the direction of the whole economy or arbitraging. ISE 30 Futures is an attractive alternative to ISE 30 index spot market because of its leverage effect, short selling opportunities and lower transaction costs, so it attracts a rising number of market participants since its establishment. For the period January-June 2010, it has been the 20th contract in the equity index futures ranking of Futures Industry Association (FIA).

Contract specifications of TurkDEX ISE 30 Index Futures are given in Table 4. The initial margin is 900 TRY and the maintenance margin is 675 TRY[10], 75% of the initial margin, for these contracts. Exchange transaction fee in TurkDEX is 0.004 percent of monthly transaction volume for ISE 30 futures. Tax advantages, small contract size (approximately 5000 USD) and small bid-ask spreads (tick size is 2.5 TRY) are also attractive for both domestic and foreign investors. The absolute position limit is 20,000 for each contract; however, when the number of open interest exceeds 20,000 the system checks the percentage limit which is 10% of total open interest for the related contract month. Although, domestic investors are dominant in the total trading volume of TurkDEX, overseas investors dominate the open interest number of TurkDEX ISE-30 Futures[11].

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[10] According to market conditions, margin levels are dynamically adjusted by TurkDEX.
[11] As of 30.06.2010, foreign investors 'shares constitute %57 of the total open positions in TurkDEX ISE 30 Index futures. (www.turkdex.org.tr)

Table 4 Contract Specifications of TurkDEX-ISE 30 Futures

Underlying Asset	Value calculated based on the stock prices of the companies included in ISE National-30 stock price index by using the index's calculation method.
Contract Size	Value calculated by dividing the index value by 1,000 and multiplying the quotient by TRY 100 (ISE National-30 Index/1,000)*TRY 100(Example: 47.325*100=TRY 4,732.5).
Price Quotation	ISE National-30 Index value, divided by 1,000 shall be quoted significant to three decimals.
Daily Price Limit	± 15% of the established Base Price for each contract with a different contract month.
Minimum Price Fluctuation (Tick)	0.025 (25 ISE National-30 Index points) Value of one tick corresponds to TRY 2.5.
Contract Months	February, April, June, August, October and December (Contracts with three different expiration months nearest to the current month shall be traded concurrently. If December is not one of those three months, an extra contract with an expiration month of December shall be launched.)
Final Settlement Day	Last business day of each contract month. In case domestic markets are closed for half day due to an official holiday, expiry date shall be the preceding business day.
Last Trading Day	Last business day of each contract month. In case domestic markets are closed for half day due to an official holiday, last trading day shall be the preceding business day.
Settlement Method	Cash Settlement
Final Settlement Price	Arithmetic average of all ISE National-30 Index values executed at the ISE within the last 30 minutes before the close of the trading session of the Exchange on the last trading day shall be used as the last settlement price of the futures contract. If the ISE trading session closes before that of the Exchange, as calculation method being the same, calculations shall be made based on the ISE National-30 Index values executed during the last 30 minutes before the closing of the ISE trading session. In case there is a failure or flaw in the calculation of the index and/or import of index values by the Exchange during the last 30 minutes due to technical difficulties, the last settlement price shall be calculated as the arithmetic average of the available data. The last settlement price is rounded to the nearest price tick.
Daily Settlement Price	Daily settlement price is established at the closing of each trading session as follows: 1. Weighted average price of all the transactions performed within the last 10 minutes before the closing of the trading session based on the quantity thereof shall be established as the daily settlement price. 2. If number of transactions performed within the last 10 minutes before the closing of the trading session is less than 10, weighted average of the last 10 transactions before the closing shall be calculated instead. 3. If the daily settlement price cannot be calculated using the above-explained methods, daily settlement price may be determined by using below explained methods separately or in combination. o weighted average price of all the transactions performed throughout the trading session, o previous day's settlement price, o average of the best bid and best ask quotations at the closing of the trading session, o theoretical futures prices to be calculated using the interest rate to be determined by the Exchange for the time period until the expiration date of the contract, spot price of the underlying asset or daily settlement price valid for other contracts with different contract months.

Source: www.turkdex.org

Additionally, the Commodity Futures Trading Commission (CFTC) which is the regulator of futures markets in the United States issued a “no-action letter” allowing the offer and sale of TurkDEX ISE 30 Index Futures in the United States in 2010. With this approval, ISE 30 Index futures can be bought and sold easily by all US investors via authorized members of TurkDEX.

3. LITERATURE REVIEW

Research on how news and financial disturbances from one market influence the volatility pattern of other markets has been growing for many years. Researchers investigate volatility spillovers between different financial markets due to the increasing financial integration around the world.

There are numerous studies investigating the relation between spot and futures markets. Obviously, the studies on the relation between spot markets and futures markets focus on mainly on price discovery and there is relatively less research on the risk spillover, especially volatility spillover between these two markets.

The studies of the behavior of volatility between markets commonly use ARCH-GARCH framework. Engle (1982) proposed the Auto Regressive Conditional Heteroskedasticity (ARCH) model and the generalization of this model (GARCH) is proposed by Bollerslev (1986). ARCH-GARCH model characterize the time-varying property of volatility successfully. GARCH model-based theory of volatility spillovers is first pioneered by Engle, Ito and Lin (1990).

Mostly the volatility transmission mechanism among the major financial equity markets has been examined. Especially after the global crash of stock markets in

October 1987, many researchers have concentrated on the interaction of the equity markets. Hamao, Masulis and Ng (1990), Lin Engle and Ito (1994) and Booth, Martikainen and Tse (1996) have some interesting studies investigating volatility spillovers between international equity markets.

The research of Hamao, Masulis and Ng (1990) is focused on the short run interdependence of prices and price volatility of major stock indexes for Tokyo, London and New York, which are three major international stock markets by employing MA(1)- GARCH (1,1)-M model to open-to-close returns. They find unidirectional price volatility spillovers from New York to Tokyo, London to Tokyo and New York to London. In contrast to the study of Hamao et al., Lin, Engle and Ito (1994) estimate a signal extraction model with GARCH processes. Related to their study, there are bidirectional spillovers between New York and Tokyo.

Booth, Martikainen and Tse (1996) investigate price and volatility spillovers among the Danish, Norwegian, Finnish and Swedish stock markets for the period 2 May 1988 to 30 June 1994 utilizing multivariate EGARCH model. Their results suggest that returns and volatilities of each of these Scandinavian Stock Markets are highly dependent on their own past values. There are both price and volatility spillovers from the Swedish stock market to the Finnish stock market, volatility spillover from the Finnish stock market to the Swedish stock market.

In many studies, it is found that the information flows systematically to the futures market before cash markets. Consequently, returns of the stock market weakly predict returns of the futures markets. A common notion exists that traders prefer to go to the spot markets after the futures markets.

According to Koutmos and Tucker (1996), the factors of this usual result can be explained briefly. Index responds to the new information set after the futures markets because all stocks in the index are not traded at different prices at all times. Also, investors with strong predictions about the direction of the market prefer to trade index futures rather than the index itself due to the lower transactions costs or margin requirements. Chan (1992) examined the impact of nonsynchronous trading, intensity in trading activities in two markets, the market-wide information and firm-specific information on the intraday relationships between the returns of major market index (MMI), MMI futures and S&P 500 futures for the period August 1984- June 1985 and January- September 1987. His study significantly suggests that the lead-lag relationship depends on the extent of market-wide movement, whereas there is no significant evidence suggesting that the lead-lag pattern is affected by the nonsynchronous trading and the relative intensity of trading activity in cash and futures markets.

In the literature, the relationship between spot markets and futures markets has been examined by concentrating on mostly price discovery role of the futures. The regressions for the lead-lag behavior between cash and futures markets estimate the intraday relation between cash and futures index returns. Some studies investigate both price discovery role and volatility spillovers between these two markets. Reviewing the literature on the information-price changes relationship and information-volatility relationship across spot and futures markets, it is seen that the results are controversial.

Kawaller, Koch and Koch (1987) estimating a three stage least-squares regression, examine the intraday price relationship between S&P 500 index and index futures using minute-to-minute data. Their study tries to answer whether the futures markets play price discovery role for spot prices and whether the relationship between spot and futures prices on expiry days is different from that on non-expiry days. Their evidence is that the movements of futures prices lead the movements of index prices by 20 to 45 minutes. However, the movements in the index rarely lead the movements in futures for approximately one minute. In addition, they find that the character of the relationship between spot and futures prices on expiry days is not significantly different from that on non-expiry days.

According to Chan, Chan and Karolyni, (1991), volatility of returns in the spot and cash markets is a substitute for information flow. They investigate the intraday relationship between price changes and price changes volatility of the S&P 500 stock index and stock index futures for the period August 1, 1984- December 31, 1989. They examine intraday volatility spillovers between spot and futures markets, while at the same time controlling for lead-lag relations in their price changes using five-minute intraday returns. Employing a bivariate GARCH model, they find a strong intermarket dependence in the volatility process and bidirectional information flow between two markets. Price innovations in either market will disseminate to the other and can predict the future volatility in the other market. Their evidence is not consistent with the likely result of futures serving role of price discovery and emphasizes that both markets serve important price discovery roles.

In line with the findings of Bollerslev, Chou and Kroner (1992) that the most important feature of speculative price changes are higher moment dependencies, Koutmos and Tucker (1996) examine higher moment interdependencies between stock index returns and stock index futures returns of S&P 500. They use a bivariate error correction EGARCH model which preserves the long-run equilibrium relationship linking the spot and futures markets while describing short-term dynamics. The results suggest that the innovations in the future markets increase volatility in the stock market in an asymmetric pattern and bad news rises volatility more than good news. In addition, their study shows that there is a unidirectional volatility spillover only from futures markets to the spot markets. Stock markets innovations do not influence the volatility of the futures markets. Their evidence is contrary to the findings of Chan et al. (1991), but supports the usual results that futures lead spot markets.

Iihara, Kato and Tokunaga (1996) have considered the volatility interaction among the cash index and futures index. Employing the models in ARCH class incorporating time variation in the volatility of intraday returns of NSA (Nikkei Stock Average) and NSA futures during the period March 1989 through August 1990, they investigate the intermarket dependence of the returns and return volatility between two markets. Their study observes unidirectional information flow from the futures to the stock market suggesting the market-wide information firstly flows to futures, then to cash markets.

Min and Najand (1999) investigate the lead-lag relationship in both returns and volatilities between spot and futures markets in Korea. They use 10 minute returns for KOSPI 200 index for the period of five months in 1996 employing Granger causality test. According to their results, the returns of futures market strongly leads the returns of cash market by as long as 30 minutes, while a bidirectional causality is more prevalent between cash and futures market regarding the volatility interaction and they conclude that the volatility relationship depends on sample period.

The study of Tse (1999) examines intraday price discovery process by using VECM and Hasbrouck (1995) common trend model and volatility spillovers by employing a bivariate EGARCH model to minute-by-minute data of DJIA index and index futures. The findings of both VECM and Hasbrouck (1995) models show that futures play dominant role in the price discovery process. Also, his study suggests bidirectional information flow between two markets. However, volatility spillovers from futures market to the stock market is more than the reverse direction. Additionally, the bad news influence volatility of both markets more than good news as an asymmetric effect. Tse concludes that the DJIA futures is more informationally efficient than the underlying stock market indicating inherent leverage, low transaction costs and the short sale possibilities in the futures for possible reasons.

Bhar (2001) aims to clarify the linkages between the spot (Australian All Ordinaries Share Price Index- AOI) and futures contracts (SPI) on this index through the second moment, the relative asymmetry and the volatility spillovers in Australia using a bivariate EGARCH model. The evidence of his study is the cross- market spillovers between the equity market and index market. Additionally, these two markets exhibit asymmetric volatility effects. Negative innovations have a greater impact on volatility than positive innovations.

An interesting study is done by Darrat, Rahman and Zhong (2002). They examine the impact of index futures trading on spot market volatility by incorporating the volatility of several macroeconomic variables to capture their effects on asset prices. They employ E-GARCH model to monthly data of S&P500 for 1987-1997 including the volatilities of the inflation rate, industrial production index, term structure of interest rates, risk premium, monetary base and federal budget deficit to the model.

They find that unidirectional volatility transmission. Spot volatility leads futures volatility, but futures volatility do not lead spot volatility. Additionally, they have a "behavioral finance" interpretation of their findings. They argue that when there is a excessive volatility in the cash market, quasi-rational investors prefer futures to hedge themselves due to the impulsive force appeared by the fear of regret.

Alexakis, Kavussanos and Visvikis (2002) examine the lead-lag relationship in daily returns and volatilities of spot and futures market using daily data on FTSE-ASE 20 and FTSE-ASE Mid 40 indices and the futures on these indices. For investigating the lead-lag relationship between returns, they utilize VECM- SURE model and they find that futures returns lead spot returns. After employing a bivariate VECM-GARCH-X model with a restricted BEKK specification for investigating volatility spillovers, the results suggest a weak indication that cash volatility spills over some information in the futures market volatility in the FTSE-ASE 20 market. For the FTSE-ASE Mid 40 market, the results emphasize that there is volatility spillover from futures market to spot market.

The study of Madhusudan Karmakar (2009) investigates lead-lag relationship in the first and second moment between the S&P CNX Nifty and Nifty futures. He also tries to clarify how much of the volatility in one market can be explained by volatility innovations in the other market and how fast these movements transmit between these markets. His VECM model shows the dominant price discovery role of Nifty futures. Using bivariate BEKK model, he finds that the persistent volatility spillovers take place from one market to another bidirectionally, whereas past innovations in futures have unidirectional significant effect on the present spot volatility.

The biggest part of the literature focuses on volatility spillovers between stock index and futures traded in developed markets. However, there is not a lot of volatility transmission research concentrating on emerging futures markets and researchers do not pay much attention to emerging futures markets. As an interesting study, Zhong, Darrat and Otero (2004) examine whether the futures markets in Mexico play the price discovery role efficiently or not. Also, they investigate the impact of the introduction of futures to the spot volatility. They employ EC-EGARCH model to daily data of IPC index (Mexican Price and Quotations Index) for 1999-2002. Their evidence suggests that Mexican futures market is dominant in the price discovery process but they destabilize spot market volatility. A bidirectional volatility transmission is observed. Being another notable study for emerging futures markets, Yang, Yang and Zhou (2011) investigate intraday price discovery with cointegration analysis and volatility spillovers between stock index and stock index futures markets in China, the biggest emerging market. They find that the cash market serves price discovery role rather than futures. They employ bivariate asymmetric ECM-GARCH model with BEKK specification for examining volatility spillovers. The results indicate strong bidirectional intraday volatility dependence between two markets.

Literature on the link between spot and futures markets in Turkey is not large like in developed countries. Baklaci and Tutek (2006), Baklaci (2007) and Kasman and Kasman (2008) analyze the effect of futures trading on spot markets, but their studies do not examine the volatility interaction mechanism between these two markets, whereas the study of Tokat and Tokat (2010) investigates the dynamics of volatility interaction focusing on potential spillovers and asymmetries between these markets.

Baklaci and Tutek (2006) investigate the impact of the introduction of futures trading on spot market for pre and post-futures trading periods by using Istanbul Stock Exchange 30 (ISE 30) futures contracts launched on TurkDEX with GARCH model. They utilize MSCI Emerging Market Index as a proxy variable for capturing the global market wide volatility. Their results suggest that the volatility of underlying spot market is reduced and efficiency is improved by the introduction of Turkish futures market. In his succeeding study, Baklaci (2007) conducts the same research for the currency futures. The results of this study report that currency futures increase the volume of information flow into spot market, but a decrease in the speed of this information flow is observed. He concludes that innovations are reflected to the prices of the futures faster than the spot prices and futures have the leading role in the price discovery process.

Investigating the impact of the introduction of index futures (ISE 30 futures contracts) trading on spot market (ISE 30 index) volatility, having the same objective with Baklaci and Tutek (2006), Kasman and Kasman (2008) examine longer period of time using an asymmetric GARCH model. Suggesting a long-run relationship between spot and future prices, they find that the volatility of spot market has decreased, while the efficiency is increased with the introduction of the futures trading. They also conclude that there is a unidirectional Granger causality running from spot market to futures market and spot market leads the futures in the price discovery process. Their findings are contrary to the results of the study of Baklaci and Tutek (2006).

The recent study of Tokat and Tokat (2010) examine the volatility transmission mechanism between futures and underlying asset spot markets, namely for

USD/TRY, EUR/TRY and ISE 30 index spot and futures markets employing multivariate GARCH model. They find a significant interaction between the second moments. Their study shows the bidirectional transmission mechanism for selected markets, in the other words, either a shock or conditional past volatility in one market influence another market's volatility. Additionally, ISE 30 index market system differs from the foreign exchange market that its volatility has asymmetric behavior and strong asymmetric shock transmission.

As it is reviewed above, the researches on the price discovery process and on the volatility spillovers between spot and futures markets generally concentrate on the US and other few developed markets. Generally, by employing regression methods and Granger causality test it is found that futures markets are dominant in the price discovery process and futures leads spot markets. Generalized Autoregressive Conditional Heteroskedasticity (GARCH)-type models have been commonly employed to investigate the volatility spillovers between markets. The results for volatility spillovers between spot and futures markets are controversial. The strongest result suggests that there is a unidirectional volatility spillover from the futures markets to spot markets and the inverse direction of the volatility spillovers (from cash to futures) is weakly observed. Also, some results find bidirectional volatility spillovers from spot (futures) market to futures (spot) markets. Consequently, in the literature of volatility spillovers, it is found that there is a certain volatility spillover between spot index and index futures.

4. ECONOMETRIC METHODOLOGY

This study aims to investigate price discovery process and volatility spillover in spot index and index futures markets in Turkey, utilizing daily prices of ISE 30 Index and ISE 30 Index Futures.

In the absence of market frictions, it is expected that the return of a spot index and the return of the associated index futures should be perfectly correlated. According to the efficient market hypothesis, new information is reflected in both spot and futures at the same time. However in reality, market frictions exist and markets do not function efficiently.

In the literature, price discovery process between markets is investigated in a cointegration and in a related error correction model framework.

Given the presence of market imperfections, VECM (Vector Error Correction Model) is used in this study for analyzing the information transmission from spot index and index futures markets and vice versa. Cointegration and error correction models are essential to maintain the equilibrium relationship between the markets. Error correction terms in the VECM reveal the adjustment roles of prices series to restore equilibrium. Then, the multivariate GARCH model is employed for analyzing the volatility spillover between two markets.

Before employing an error correction term in the empirical analysis, the long run relationship between the returns of spot index and index futures should be justified by testing the cointegration. (Koutmos and Tucker, 1996) This study motivates the cost-of-carry relationship to test the cointegration between the spot index and futures contracts. The theoretical relationship between an index futures price and its underlying asset price is known as the cost-of-carry relationship. The cost-of-carry relationship is given by:

$$F_t = S_t e^{(r-d)(T-t)} \tag{1}$$

In this model, under the assumption of the efficient market hypothesis and the non-stochastic pattern of the interest rates and dividend yields, F_t represents the fair index futures price at time t, S_t is the underlying spot price at time t, r represents a continuously compounded riskless rate of return of the T-t period, d means continuously compounded dividend yield over period from t to T by the stocks that are included in the index and (T- t) is the time until the maturity of the futures contract.

Brooks et al. (2001) shows that if the prices of both spot index and index futures are transformed to natural logarithms and the first differences of these logarithmic prices are taken to create return series for both spot index and index futures, the Equation (1) is converted to a linear model in log-returns and it is obtained that:

$$f_t = s_t + (r-d) \tag{2}$$

$f_t = \ln(F_t / F_{t-1})$ and $s_t = \ln(S_t / S_{t-1})$

In the Equation (2), it is clearly seen that futures and spot returns are perfectly contemporaneously correlated and there should be no lead-lag relationship between the returns of spot and futures market under the market efficiency.

There are different methods to test cointegration to determine whether there is a long run relationship between variables. These methods are the Engle Granger (1987), Engle Yoo (1987) and Johansen procedure (1990) based on VAR. In this study, both

Engle-Granger (1987) method and Johansen VAR method are used for examining the cointegration between spot and futures prices. Engle-Granger method estimates at most one cointegrating relationship between the variables, while Johansen VAR method estimates more than one linearly independent cointegrating relationship.

Checking the stationary of time series variables is very important because many of the standard empirical results become spurious by non-stationary variables in a regression. So, in order to form a statistically adequate model, the variables should be checked whether they have unit roots (non-stationary) or not (stationary).

The cointegration between the spot index and index futures prices requires the same order of non-stationary of both series and the stationarity of the linear combination of two series. Both the Augmented Dickey Fuller (ADF) test (Dickey and Fuller, 1979) and the Philips-Perron (P-P) test are employed to test for non-stationary before testing cointegration.

Augmented Dickey Fuller (ADF) regressions are:

$$\Delta Y_t = \alpha_0 + \beta_0 Y_{t-1} + \sum_{i=1}^{k} \beta_i \Delta Y_{t-i} + \varepsilon_t \quad (3)$$

$$\Delta Y_t = \alpha_0 + \alpha_1 t + \beta_0 Y_{t-1} + \sum_{i=1}^{k} \beta_i \Delta Y_{t-i} + \varepsilon_t \quad (4)$$

Equation 3 has intercept and non-trend, Equation 4 has intercept and trend.

In Equation (3), Δ represents the first difference operator; k denotes the number of lags used and ε is the error term; α and β are parameters. The null hypothesis shows that Y_t is non-stationary, and it can be rejected if β_0 statistically significant.

In Equation (4), Δ represents the first difference operator; t represents the time trend; k denotes the number of lags used and ε is the error term; α and β are parameters. The null hypothesis shows that Y_t is non-stationary and it can be rejected if α_1 statistically significant.

Phillips-Peron regression model is given by the following model for a time series Y_t:

$$\Delta Y_i = \alpha_0 + \alpha_1 Y_{t-1} + \varepsilon_t \tag{5}$$

The error term is represented by ε_t. To test for a unit root, the regression t-statistic for the null hypothesis (H_0: α=1), is adjusted nonparametrically to account for possible serial correlation in ε_t.[12]

In ADF test, it is assumed that the error term is independent and has a variance constant. In the other words, ADF test assumes that there is no correlation between error terms having constant variance. Phillips Perron test is similar to ADF test, but it incorporates an automatic correction to the Dickey Fuller procedure to allow for autocorrelated residuals.

After performing unit root tests, cointegration between variables will be investigated.

First, the Engle-Granger model is employed to investigate cointegration.

The Engle-Granger method has 2 steps. First step is to investigate whether all variables are I (1) or not. After testing the orders of integration of these variables by employing unit roots tests, a cointegrating regression should be estimated by using

[12] The detailed analysis of P-P test statistic can be found in any standard text book of econometrics.

OLS. As expected, in this study, the log form of the prices in both spot and futures markets are integrated order one (I (1)).

Price discovery literature claims that futures market leads spot market. Related to this claim, generally the estimated regression for cointegration between spot and futures prices is represented by (Brooks at al, 2001):

$$\ln(S_t) = \gamma_0 + \gamma_1 \ln(F_t) + \varepsilon_t \tag{6}$$

However, Kasman and Kasman (2008) suggest that spot market leads futures market in Turkey. Related to their suggestion, the estimated regression for cointegration between spot and futures prices in Turkey can be represented by:

$$\ln(F_t) = \gamma_0 + \gamma_1 \ln(S_t) + \varepsilon_t \tag{7}$$

In this study, Equation (7) is employed to investigate cointegration. After estimating the cointegrating regression, residuals are saved. Then the orders of integration are tested for residuals and if residuals are I (0), there is cointegration between the variables based on the Engle-Granger method.

In this study, only spot and futures prices are stochastic variables, so there will be one cointegrating relationship at most. Consequenltly, one cointegrating vector is adequate for this study. However, to increase reliability of the results, Johansen VAR method also employed to test cointegration.

A set of g variables ($g \geq 2$) which are I(1), a VAR with k lags, containing these variables could be written:

$$y_t = \beta_1 y_{t-1} + \beta_2 y_{t-2} + ... + \beta_k y_{t-k} + u_t \tag{8}$$

where y_t is vector of variables I(1) and u_t is vector of residuals. To use Johansen test, the Equation (8) should be turned into a vector error correction model (VECM). VECM form can be written as:

$$\Delta y_t = \prod y_{t-k} + \Gamma_1 \Delta y_{t-1} + \Gamma_2 \Delta y_{t-2} + ... + \Gamma_{k-1} \Delta y_{t-(k-1)} + u_t \tag{9}$$

where $\prod = (\sum_{i=1}^{k} \beta_i) - I_g$ and $\Gamma_i = (\sum_{i=1}^{i} \beta_i) - I_g$

The Johansen cointegration test focuses on examination of the $\prod$ matrix. $\prod$ can be interpreted as a long run coefficient matrix since in equilibrium all the Δy_{t-i} will be zero and setting the error terms u_t to their expected value of zero will leave $\prod y_{t-k} = 0$. The cointegration between variables is calculated by looking at the rank of the $\prod$ matrix via its eigenvalue. There are two test statistics trace statistic and max eigenvalue statistic for cointegration under the Johansen approach and described as:

$$\lambda_{trace}(r) = -T \sum_{i=r+1}^{g} \ln(1 - \hat{\lambda}_i) \tag{10}$$

$$\lambda_{\max}(r, r+1) = -T \ln(1 - \hat{\lambda}_{r+1}) \tag{11}$$

where r is the number of cointegrating vectors under the null hypothesis and $\hat{\lambda}$ is the estimated value for the ordered eigenvalue from the $\prod$ matrix (Brooks, 2002). To select optimal lag length, Schwarz Information Criteria (SIC) is considered.

Error correction mechanisms pushing deviations back towards the long run equilibrium and enable to analyze short run dynamics. Vector Error Correction Model (VECM) is used to model the long run relationship between the cointegrated variables. Based on the error correction mechanism, the disequilibrium in one period will be corrected in the next period. The cointegrating vectors show the long run equilibrium, while error correction term shows up the short run adjustment process. VECM model for this study can be described as:

$$\Delta F_t = c_1 + a_f (EC_{t-1}) + \sum_{i=1}^{k-1} a_{f,i} \Delta S_{t-i} + \sum_{i=1}^{k-1} b_{f,i} \Delta F_{t-i} + u_{f,t} \tag{12}$$

$$\Delta S_t = c_2 + a_s (EC_{t-1}) + \sum_{i=1}^{k-1} a_{s,i} \Delta S_{t-i} + \sum_{i=1}^{k-1} b_{s,i} \Delta F_{t-i} + u_{s,t} \tag{13}$$

where ΔF_t and ΔS_t represents returns of futures and spot, respectively. (EC_{t-1}) is error correction term, and $(EC_{t-1})= f_{t-1} - s_{t-1}$.Hence, $a_{s,i}$, $b_{s,i}$, $a_{f,i}$, $b_{f,i}$ reflects short-run dynamics being the short-run coefficients. $u_{f,t}$ and $u_{s,t}$ represents residuals. a_f and a_s are the coefficients on the equilibrium errors and reflects the speed of adjustment coefficients.

In the studies of the volatility spillovers between financial markets, Engle's ARCH model in 1982 and Bollerslev's GARCH model in 1986 characterize well time-varying property of volatility. Especially, GARCH models are very successful in modeling conditional volatility.

There are several different multivariate GARCH formulations in the literature. Most commonly used GARCH models are VECH model, BEKK model and Constant Conditional Correlation (CCC) model. In the literature, many studies have preferred to use the BEKK and CCC model, because of the high parameterization issue of VECH model. However, the diagonal VECH model is more flexible compared to

BEKK model because it allows the conditional variance covariance to change over time. In this study, multivariate GARCH with diagonal VECH model is used to investigate whether there is a volatility spillover in spot index and index futures. This model is chosen because the variance covariance matrix is important for the objective of this study.

Before employing M-GARCH with diagonal VECH model, ARCH LM test is applied to test whether there are ARCH effects in the variables.

A common specification of the VECH model is (Brooks,2008):

$$vech(H_t) = C + Avech(\varepsilon_{t-1}\varepsilon_{t-1}^{'}) + Bvech(H_{t-1}) \qquad (14)$$

$$\varepsilon_t \left| \psi_{t-1} \approx N(0, H_t) \right.$$

Where H_t is a 2x2 conditional variance-covariance matrix, ε_t is a 2x1 disturbance vector, ψ_{t-1} represents the information set at time (t-1), C is a 3x1 parameter vector, A and B are 3x3 parameter matrices and $vech(.)$ denotes the column stacking operator applied to the upper portion of the symmetric matrix. The model estimates 21 parameters as C has 3, A and B have 9 elements. In the VECH model, as the number of the variables increases, the estimation of the VECH model can quickly become infeasible (Brooks,2008). VECH model can be written:

$$H_t = \begin{bmatrix} h_{11t} h_{12t} \\ h_{21t} h_{22t} \end{bmatrix}, \varepsilon_t = \begin{bmatrix} u_{1t} \\ u_{2t} \end{bmatrix}, C = \begin{bmatrix} c_{11} \\ c_{21} \\ c_{31} \end{bmatrix}, A = \begin{bmatrix} a_{11} a_{12} a_{13} \\ a_{21} a_{22} a_{23} \\ a_{31} a_{32} a_{33} \end{bmatrix}, B = \begin{bmatrix} b_{11} b_{12} b_{13} \\ b_{21} b_{22} b_{23} \\ b_{31} b_{32} b_{33} \end{bmatrix}$$

The VECH operator is the upper triangular portion matrix, and stacks each element into a vector with a single column like:

$$vech(H_t) = \begin{bmatrix} h_{11t} \\ h_{22t} \\ h_{12t} \end{bmatrix} \quad (15)$$

Where h_{iit} represents the conditional variances at time t of the two-asset return series. In case of $vech(\varepsilon_{t-1}\varepsilon'_{t-1})$, the expression above can be written as:

$$vech(\varepsilon_{t-1}\varepsilon'_{t-1}) = vech(\begin{bmatrix} u_{1t} \\ u_{2t} \end{bmatrix}[u_{1t}u_{2t}]) = vech = \begin{bmatrix} (u_{1t}^2)(u_{1t}u_{2t}) \\ (u_{1t}u_{2t})(u_{2t}^2) \end{bmatrix} = vech \begin{bmatrix} u_{1t}^2 \\ u_{2t}^2 \\ u_{1t}u_{2t} \end{bmatrix} \quad (16)$$

The VECH model in full is given:

$$h_{11t} = c_{11} + \alpha_{11}u_{1t-1}^2 + \alpha_{12}u_{2t-1}^2 + \alpha_{13}u_{1t-1}u_{2t-1} + b_{11}h_{11t-1} + b_{12}h_{22t-1} + b_{13}h_{12t-1} \quad (17)$$

$$h_{22t} = c_{21} + \alpha_{21}u_{1t-1}^2 + \alpha_{22}u_{2t-1}^2 + \alpha_{23}u_{1t-1}u_{2t-1} + b_{21}h_{11t-1} + b_{22}h_{22t-1} + b_{23}h_{12t-1}$$

$$h_{12t} = c_{31} + \alpha_{31}u_{1t-1}^2 + \alpha_{32}u_{2t-1}^2 + \alpha_{33}u_{1t-1}u_{2t-1} + b_{31}h_{11t-1} + b_{32}h_{22t-1} + b_{33}h_{12t-1}$$

Bollerslev, Engle and Wooldridge (1988) have developed a restricted conditional variance-covariance matrix for VECH model, in which A and B assumed to be diagonal. By their model, the number of parameters decreases to 9, as A and B have 3 elements. The diagonal VECH model can be written as:

$$h_{ij,t} = \varpi_{ij} + \alpha_{ij}u_{i,t-1}u_{j,t-1} + \beta_{ij}h_{ij,t-1} \quad (18)$$

Where $\varpi_{ij}, \alpha_{ij}, \beta_{ij}$ are parameters.

Like other specifications of the multivariate GARCH models, Diagonal VECH model parameterization can be estimated consistently and efficiently using the maximum likelihood method. The joint log likelihood function is;

$$L(\theta) = -\frac{TN}{2}\log(2\pi) - \frac{1}{2}\sum_{t=1}^{T}(\log|H_t| + \varepsilon_t' H_t^{-1}\varepsilon_t) \qquad (19)$$

Where θ denotes the vector of parameters to be estimated, T represents the number of observations and N represents the numbers of the variables represented in the system.

5. DATA and ECONOMETRIC ANALYSIS

This study employs daily returns of ISE-30 Index as the spot index prices and Turkdex-ISE-30 Index Futures as the index futures prices to examine price discovery and volatility spillovers between spot and futures markets. The daily closing prices of ISE-30 Index are obtained from the data part of the website of Istanbul Stock Exchange. Daily settlement prices of ISE-30 Index Futures are obtained from the data part of the website of Turkdex. ISE-30 Index Futures have a maximum of 4 month trading cycle[13]. The daily settlement prices of the most liquid month are used for this study. The data covers the period between 4 February 2005 (when the futures trading first started in Turkdex) - 31 December 2010.

[13] Contract months are February, April, June, August, October and December (Contracts with three different expiration months nearest to the current month shall be traded concurrently. If December is not one of those three months, an extra contract with an expiration month of December shall be launched.)

5.1. DESCRIPTIVE STATISTICS

Descriptive statistics for the returns of the variables used in this study are reported in Table 5. The first central moment is called “mean” or “expectation of the random variable”. Mean measures the central location of the distribution. The second central moment is “variance of the random variable” which measures variability of the random variable. The square root of the variance is “standard deviation”. Mean and standard deviations are very similar for the returns of spot index and futures index, while there are some differences in median, maximum and minimum values. Third and fourth central moments are named respectively skewness and kurtosis. They summarize the extent of asymmetry and tail thickness. A Gaussian distribution (normal distribution) has kurtosis equal to three. The distribution of the concerned variables in this study is not Gaussian, because the kurtosis is higher than 3. The kurtosis values shows that spot index returns and index futures returns have heavy tails implying that the distribution puts more mass on the tails of its support than a normal distribution does. So this means that returns of spot and futures index have distribution which tends to contain more extreme values. It can be said that they are leptokurtic. Both two series negatively skewed, indicating nonsymmetrical distribution. The Jarque-Bera statistic rejects the hypothesis of normal distribution for two series.

Table 5 Descriptive Statistics

	Spot Index Returns	Index Futures Returns
Mean	0.000560	0.000564
Median	0.000748	0.000449
Maximum	0.127255	0.096570
Minimum	-0.097398	-0.099722
Std. Dev.	0.020499	0.020434
Skewness	-0.020845	-0.073411
Kurtosis	5.646330	5.736159
Jarque-Bera	433.4221	464.5652
Probability	0.000000	0.000000
Observations	1485	1485

Additionally correlograms of spot index and index futures at their level and first difference are given at Figure 5 and Figure 6 respectively. Based on visual inspection, it is clearly seen that there is no autocorrelation between the return series.

Figure 7 Correlograms of Spot Index

	Correlograms of Spot Index	
Level (log prices)		**First Difference (returns)**

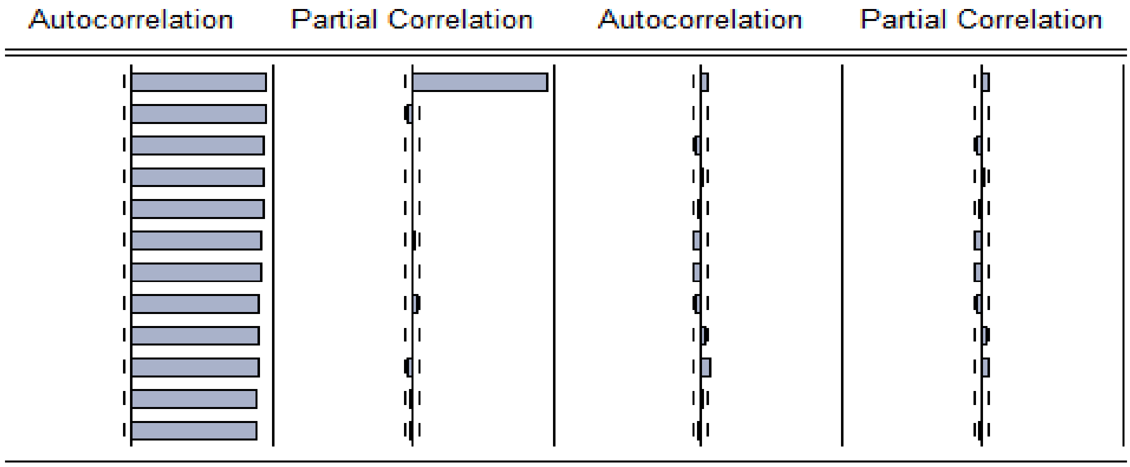
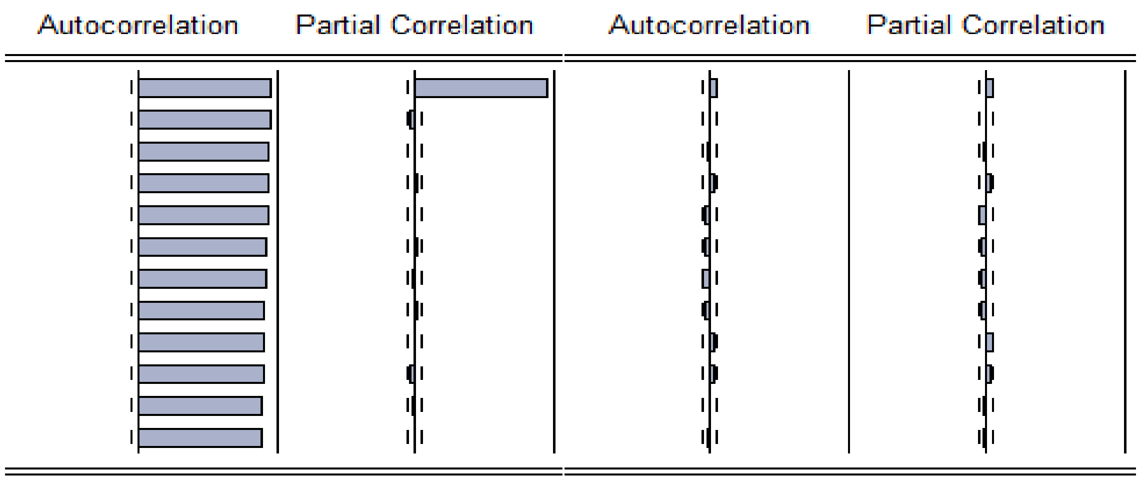


Figure 8 Correlograms of Index Futures

Correlograms of Index Futures	
Level (log prices)	**First Difference (returns)**



5.2. UNIT ROOT TESTS and COINTEGRATION BY ENGLE-GRANGER TEST

To determine whether the variables are stationary is necessary for investigating the cointegration relationship. In this study, log prices of the raw price series are tested whether they are stationary or not. Augmented Dickey Fuller (ADF) test and Phillips-Perron (P-P) test has been performed in EViews 6. An I (1) time series has unit root and any shock to the series is permanent.

In Table 6, the ADF statistics for the level and the first differences are shown for the log prices series and the return series of spot and futures indices.

Table 6 ADF Unit Root Test for Spot Index and Index Futures

ADF Unit Root Test ♦	**Level (Log Prices)**		**First Difference (Returns)**	
	Intercept	*Intercept and Trend*	*Intercept*	*Intercept and Trend*
Spot Index	- 1.271292 (- 2.863280)	- 1.620569 (-3.412839)	- 36.41571* (- 2.863282)	- 36.40466* (-3.412841)
Index Futures	- 1.251052 (- 2.863280)	- 1.611665 (-3.412839)	- 36.63601* (- 2.863282)	- 36.62505* (-3.412841)

♦ Numbers in parentheses are critical values at the %5 significance level. Probabilities are based on MacKinnon (1996).
* Statistical significance at %5 level.

In Table 7, the P-P statistics for the level and the first differences are shown for the log prices series and the return series of spot and futures indices.

Table 7 Phillips-Perron Unit Root Test for Spot Index and Index Futures

P-P ***Unit Root Test***♦	**Level (Log Prices)**		**First Difference (Returns)**	
	Intercept	*Intercept and Trend*	*Intercept*	*Intercept and Trend*
Spot Index	- 1.321604 (- 2.863280)	- 1.675005 (-3.412839)	- 36.37703* (- 2.863282)	- 36.36543* (-3.412841)
Index Futures	- 1.280822 (- 2.863280)	- 1.644287 (-3.412839)	- 36.60278* (- 2.863282)	- 36.59136* (-3.412841)

♦ Numbers in parentheses are critical values at the %5 significance level. Probabilities are based on MacKinnon (1996).
* Statistical significance at %5 level.

As it is seen in Table 6 and Table 7, the null hypothesis that log price series of spot and futures indices have a unit root cannot be rejected at their levels. Both spot and futures log prices are non-stationary. The first differences of the log price series are the returns. Then, ADF and P-P unit root tests are conducted for the first differences of spot and futures log prices. Log price series for both spot and futures become stationary after being differenced 1 times.

Consequently, two log price series are non-stationary at their level values I(0), while return series for both spot and futures indices are the stationary at the first difference I(1).

After testing the orders of integration of these variables by employing unit roots tests, a cointegrating regression should be estimated by using OLS. As expected, in this study, the log form of the prices in both spot and futures markets are integrated order one (I (1)). As mentioned in the econometric methodology part, Equation 7 is employed to investigate cointegration. After estimating the cointegrating regression, residuals are saved. Then the orders of integration are tested for residuals. Residuals are found to be I (0), so there is cointegration between the variables based on Engle Granger cointegration test. The unit root tests of residuals are presented in Table 8.

Table 8 Unit Root Tests of Residuals

Unit Root Tests ♦	**ADF Unit Root Test**		**P-P Unit Root Test**	
	Intercept	*Intercept and Trend*	*Intercept*	*Intercept and Trend*
Residuals	- 8.218555* (- 2.863287)	- 8.443982* (-3.412849)	- 17.15984* (- 2.863282)	- 17.66693* (-3.412841)

♦ Numbers in parentheses are critical values at the %5 significance level. Probabilities are based on MacKinnon (1996).
* Statistical significance at %5 level.

5.3. COINTEGRATION TEST BY JOHANSEN VAR METHOD and VECTOR ERROR CORRECTION

Before testing cointegration by employing Johansen VAR method, the optimal lag length will be selected. In Table 9, VAR lag order selection criteria are presented.

Table 9 VAR Lag Order Selection Criteria

Lag	LogL	LR	Final Prediction Error	Akaike Information criterion	Schwarz Information Criteria	Hannan-Quinn Information criterion
0	4219.993	NA	1.10e-05	-5.738767	-5.731565	-5.736081
1	8731.384	9004.367	2.40e-08	-11.87127	-11.84967	-11.86321
2	8795.705	128.2039	2.21e-08	-11.95334	-11.91733	-11.93991
3	8814.226	36.86730*	2.16e-08	-11.97310	**-11.92269***	-11.95430*
4	8818.352	8.201118	2.16e-08*	-11.97327*	-11.90846	-11.94910
5	8822.242	7.722056	2.16e-08	-11.97312	-11.89390	-11.94358
6	8824.920	5.307802	2.17e-08	-11.97132	-11.87770	-11.93641
7	8827.898	5.895696	2.17e-08	-11.96993	-11.86191	-11.92965
8	8831.784	7.680976	2.17e-08	-11.96977	-11.84735	-11.92412

"*" indicates lag order selected by the criterion.
LR: sequential modified LR test statistic (each test at 5% level)

In this study, Schwarz Information Criteria (SIC) is considered to select the optimal leg length. As the minimum SIC is lag 3, 3 lag is selected for the application of Johansen VAR method. The results of Johansen Cointegration Tests are given in Table 10 and Table 11.

Table 10 Johansen Cointegration Tests (Trace)

Unrestricted Cointegration Rank Test (Trace)				
Hypothesized No. of CE(s)	**Eigenvalue**	**Trace Statistic**	**0.05 Critical Value**	**Prob.****
None *	0.041677	65.74454	20.26184	0.0000
At most 1	0.001910	2.825863	9.164546	0.6138

* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Trace test indicates 1 cointegrating equation at the 0.05 level as the null hypothesis that there is no cointegrating vector is rejected at the 0.05 significance level.

Table 11 Johansen Cointegration Tests (Maximum Eigenvalue)

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)				
Hypothesized No. of CE(s)	**Eigenvalue**	**Trace Statistic**	**0.05 Critical Value**	**Prob.****
None *	0.041677	62.91867	15.89210	0.0000
At most 1	0.001910	2.825863	9.164546	0.6138

* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Max-Eigenvalue indicates 1 cointegrating equation at the 0.05 level as the null hypothesis that there is no cointegrating vector is rejected at the 0.05 significance level. Both Trace and Max-Eigenvalue Tests show that two log price series are cointegrated with one cointegrating vector.

In Table 12, the results of Vector Error Correction Model (VECM) are given. In the VECM, 2 lags are used for both spot and futures log prices as the VECM takes differences of the series.

Table 12 Vector Error Correction Estimates

Cointegrating Eq:	CointEq1	
LNVOB(-1)	1.000000	
LNIMKB(-1)	-1.010996	
	(0.00473)	
	[-213.577]	
C	7.027395	
	(0.05135)	
	[136.849]	
Error Correction:	D(LNVOB)	D(LNIMKB)
CointEq1	-0.170149	-0.028218
	(0.04695)	(0.04750)
	[-3.62398]	[-0.59411]
D(LNVOB(-1))	-0.159782	0.192440
	(0.07555)	(0.07643)
	[-2.11486]	[2.51791]
D(LNVOB(-2))	-0.061718	0.093612
	(0.07149)	(0.07232)
	[-0.86325]	[1.29435]
D(LNIMKB(-1))	0.223343	-0.124847
	(0.07593)	(0.07681)
	[2.94154]	[-1.62544]
D(LNIMKB(-2))	0.057926	-0.098497
	(0.07208)	(0.07292)
	[0.80361]	[-1.35080]

Notes: t-statistics are in parenthesis, Standard errors are in brackets.

In this framework, the cointegrating vectors show the long run equilibrium, while error correction terms show the short run adjustment process. The magnitude and direction of the short run adjustment of the return series are represented by the coefficients of the error correction terms.

Cointegrating vectors reflect the long run relationship between spot index and index futures. When the cointegrating vector is equal to (1,-1), this is an essential condition for long-run market efficiency. In this study, the cointegration vector is found (1, -1.010996) so there is a stable long-run relationship between two series.

In most studies employing VECM model to investigate price discovery process, the error correction coefficients of futures are negative and the error correction coefficients of spot are positive and futures markets lead spot markets. (For example; Tse 1999; Karmakar 2009)

In the VECM framework, it is generally expected that error correction coefficient of futures will be negative and error correction coefficient of spot will be positive. However it is possible that the error correction coefficient of the spot market has the same sign as the error correction coefficient of the futures markets. The index is not a traded asset itself but rather a weighted average of individual assets. In fact, some consisting stocks may depreciate even more due to short term momentum. In this case, the index may deviate even further from equilibrium. Thus, the momentum effect implies that the sign on the error correction term in the spot equation can be negative. (Bohl at al. 2010)

In the results of this study, the negative coefficients mean that deviations in one period would be corrected in next period. If the null hypothesis is that the error correction coefficients are equal to zero, the null is rejected at the %5 level and both coefficients are significant at %5 level of significance. This means that deviations in short run are adjusted by variables and there is long-run equilibrium between spot and futures. Spot and futures markets have adjustment towards each others in the long run and they have error correction. Spot index have error correction by shifting 0.028%, while index futures have error correction by shifting 0.170%. Hence, spot index leads index futures as the adjustment of spot index is less than the adjustment of index futures. This means, spot market plays price discovery role in Turkey.

As an example of the VECM results for developed countries, the study of Tse (1999) can be analyzed. In the study of Tse (1999), error correction coefficient of futures is -2.84e-3 and error correction coefficient of spot is 4.67e-3. The results indicate that spot market makes the greater adjustment in order to reestablish the equilibrium. So, the futures price leads the cash price in price discovery.

Moreover, in some studies the error correction coefficients of spot market are insignificant and only futures prices respond to correct the deviations from the long run equilibrium (For example; Kavussanos at al. 2008).

5.4. MULTIVARIATE GARCH WITH DIAGONAL VECH

Before employing multivariate GARCH with diagonal VECH, residuals have been tested with ARCH-LM test and ARCH effects are observed.

Then multivariate GARCH with diagonal VECH is employed to investigate the volatility spillover among spot index and index futures. In Table 13, the results are given.

Table 13 Multivariate GARCH with diagonal VECH

	Coefficient	Std. Error	z-Statistic	Prob.
C(1)	0.000864	0.000426	2.030284	0.0423
C(2)	0.000921	0.000428	2.152596	0.0314
	Variance Equation Coefficients			
C(3)	4.53E-06	8.17E-07	5.551772	0.0000
C(4)	4.09E-06	8.00E-07	5.108052	0.0000
C(5)	3.91E-06	8.76E-07	4.464725	0.0000
C(6)	0.054204	0.004861	11.14970	0.0000
C(7)	0.055525	0.004766	11.65124	0.0000
C(8)	0.059094	0.004974	11.88132	0.0000
C(9)	0.936935	0.005012	186.9449	0.0000
C(10)	0.936870	0.004941	189.6024	0.0000
C(11)	0.934888	0.005151	181.5087	0.0000
Log likelihood	9259.296	**Schwarz criterion**		-12.45831
Avg. log likelihood	3.128141	**Hannan-Quinn criter.**		-12.48301
Akaike info criterion	-12.49770			
Equation: RESID01 = C(1)				
R-squared	-0.000461	Mean dependent var		0.000431
Adjusted R-squared	-0.000461	S.D. dependent var		0.020158
S.E. of regression	0.020162	Sum squared resid		0.601246
Prob(F-statistic)	1.997238			
Equation: RESID02 = C(2)				
R-squared	-0.000470	Mean dependent var		0.000479
Adjusted R-squared	-0.000470	S.D. dependent var		0.020391
S.E. of regression	0.020395	Sum squared resid		0.615221
Prob(F-statistic)	1.994859			

Covariance specification: Diagonal VECH				
GARCH = M + A1.*RESID(-1)*RESID(-1)' + B1.*GARCH(-1)				
M is an indefinite matrix				
A1 is an indefinite matrix				
B1 is an indefinite matrix				
	Tranformed Variance Coefficients			
	Coefficient	Std. Error	z-Statistic	Prob.
M(1,1)	4.53E-06	8.17E-07	5.551772	0.0000
M(1,2)	4.09E-06	8.00E-07	5.108052	0.0000
M(2,2)	3.91E-06	8.76E-07	4.464725	0.0000
A1(1,1)	0.054204	0.004861	11.14970	0.0000
A1(1,2)	**0.055525**	**0.004766**	**11.65124**	**0.0000**
A1(2,2)	0.059094	0.004974	11.88132	0.0000
B1(1,1)	0.936935	0.005012	186.9449	0.0000
B1(1,2)	**0.936870**	**0.004941**	**189.6024**	**0.0000**
B1(2,2)	0.934888	0.005151	181.5087	0.0000

Based on the magnitudes of the estimated cross-volatility coefficient which is represented by A1(1,2), innovations in one market influence the volatility of the other market.

Cross volatility spillovers are represented by B1(1,2) and the volatility spillover is found to be significant between spot and futures markets. Consequently, it is found that there is a volatility spillover between spot index and index futures. The evidence of this study suggests that there exists a strong intermarket dependency in the volatility of their price changes.

6. CONCLUSION

The interactions of stock market returns and futures market returns have been considered an important area of research for many years. In general, several studies have found that futures market leads the spot market due to the market frictions and futures market has been described as a price discovery vehicle for the spot market. Generally, one of the most important roles of the futures is their price discovery role for future.

This thesis examines the lead-lag relationship and volatility spillover between spot index and index futures using daily closing prices of ISE-30 Index and daily settlement prices of Turkdex-ISE-30 Index Futures for period February 2005-December 2010. According to the results of the Johansen VAR method based on Vector Error Correction, a long run and a cointegrating relationship are found between the prices of spot index and index futures. Error correction coefficients suggest that index futures prices adjust more to the discrepancy from the long run equilibrium compared to the spot prices. Consequently, the empirical results of this study indicate that spot markets lead futures markets in Turkey and information disseminates first in spot markets before than the futures markets.

The result of this thesis is contrary to the general claim of the lead-lag relationship but is in the line with the study Kasman and Kasman (2008), which suggests the price discovery role of spot markets in Turkey. Especially, in developed countries futures markets are well developed and matured during the years. The trading volume of the derivative exchanges in developed countries (namely U.S and European countries) are very high compared to the emerging countries. So the futures contracts in the developed countries play dominant role in the price discovery process, while there are not sufficient empirical studies to generalize the lead-lag relationship for the emerging countries.

In Turkey, TurkDEX is relatively new compared to the Istanbul Stock Exchange. However, trading volume of TurkDEX reached 68 percent of the trading volume of ISE in 2010. It is clear that TurkDEX is developing rapidly despite of its short history and its trading volume will overtake that of the ISE in the near future, thus enhancing the futures trading mechanism.

However, for the data period of this study, the conventional behavior of the investors and the insufficient knowledge on derivatives in Turkey may have caused this inverse relationship in which spot market leads futures market.

Understanding the way of information flows between spot and futures markets in Turkey, will provide valuable information for both foreign and domestic individual investors, institutional investors and fund managers when they are building their portfolios. Also, this inverse relationship is important for hedgers and arbitrage seekers to take some advantageous positions in the Turkish futures and spot market.

Moreover, using multivariate GARCH with Diagonal VECH model, the volatility spillover is investigated in this thesis for spot index and index futures markets in Turkey. Based on the empirical results, a volatility spillover is observed between spot index and index futures. The evidence of this study suggests that spot index has dominant role in price discovery process in Turkey leading the index futures. Moreover, a strong intermarket dependency in the volatility of the price changes of spot index and index futures is suggested based on the multivariate GARCH with Diagonal VECH model.

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