EFFECTS OF OPENING TRADING MECHANISM AND INFORMATION FLOW ON RETURN VOLATILITY: ADDITIONAL EVIDENCE FROM THE ISTANBUL STOCK EXCHANGE

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ABSTRACT

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In this study, the effects of opening trading mechanism and information flow on return volatility are examined in the Istanbul Stock Exchange. The change in the morning opening mechanism from a continuous auction to a call auction on February 2, 2007 and the extension in afternoon trading hours on September 7, 2007 provide unique opportunities in this respect. First, it is found that the call auction trading mechanism has a decreasing effect on the morning open-to-open interday volatility and morning intraday volatility for low-volume stocks but it does not have an obvious effect on the same type of volatilities for high volume stocks. Second, the study provides evidence that the increased information flow towards the end of the trading day increases the afternoon close-to-close interday volatility for high volume stocks while it does not have such an effect on low-volume stocks. Third, the overnight return volatility is decreased slightly with the extension of trading hours.

Keywords: Return Volatility, Extending Trading Hours, Opening Trade Mechanism

ÖZ

AÇILIŞ ALIM SATIM MEKANİZMASI VE BİLGİ AKIŞININ GETİRİ DEĞİŞKENLİĞİ ÜZERİNDEKİ ETKİLERİ: İSTANBUL MENKUL KIYMETLER BORSASI ÖRNEĞİ

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Bu çalışmada, açılış alım-satım mekanizmasının ve bilgi akışının getiri değişkenliği üzerindeki etkileri incelenmiştir. 2 Şubat 2007'de sabah seansındaki açılış mekanizmasının sürekli müzayede sisteminden tek fiyat müzayede sistemine geçişi ile 7 Eylül 2007'de öğledensonra seansının süresinin uzatılması bu etkileri incelemek açısından önemli fırsatlar sunmaktadır. İlk olarak, tek fiyat müzayede sisteminin, düşük işlem hacimli hisselerin açılıştan açılışa olan getiri değişkenliğini düşürdüğü ancak yüksek hacimli hisselerde aynı tür değişkenlikler üzerinde bariz bir etkisinin olmadığı görülmüştür. İkinci olarak, gün sonuna doğru artan bilgi akışının, yüksek işlem hacimli hisseler için, kapanıştan kapanışa olan günlük getiri değişkenliğini arttırdığı fakat düşük işlem hacimli hisselerin üzerinde böyle bir etkisinin olmadığı gözlemlenmiştir. Üçüncü olarak, gecelik getiri değişkenliğinin, işlem saatlerinin uzamasıyla az da olsa düştüğü görülmüştür.

Anahtar Kelimeler: Getiri Değişkenliği, Seans Süresinde Uzama, Açılış Mekanizması

to my family and friends who

never withhold their love, care and patience from me

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CHAPTER 1

INTRODUCTION

One of the most interesting subjects in the market microstructure analysis is the volatility of returns. Investors, analysts, brokers, and dealers are concerned with stock return volatility not just because it is a measure of risk but also because of the noise volatility they worry about which can be defined as the excessive volatility that cannot be explained with a logical reason, such as the arrival of some important information. In order to capture real volatility at any moment, one must understand the reasons that cause high volatility. It is also necessary to decide about how to measure volatility and the type of return data to be used in calculations. In this study, the purpose is to supplement the literature on this subject by involving in the discussion through studying the reasons behind the higher values seen when daily return volatilities are calculated from opening and closing prices.

Previous empirical studies generally show evidence that opening return volatilities are higher than closing return volatilities and both opening and closing return volatilities are higher than the remaining of the day. Although these findings are generally accepted in the literature, there is still no obvious consensus on the causes of these observations.

There are three main reasons offered in the literature as a possible explanation of why opening return volatilities are higher than closing return volatilities. These are (1) the differences in price formation between the opening and closing of the market, (2) the monopoly power of the specialists in determining prices, and,

(3) the long trading halt that is introduced overnight before the market opens the next morning.

The literature has also attempted to explain why closing return volatilities are consistently observed to be high. Many studies explore this issue and document a variety of reasons such as strategic movements of investors, defensive approaches of specialists, manipulation of investors, window-dressing near the day’s closing, intensity of information that accumulates towards the end of the day and increased bid–ask spreads.

In this study, volatility of returns is analyzed for the Istanbul Stock Exchange (ISE). The inter-day return volatilities are calculated from the opening and closing prices of the morning and afternoon sessions. Additional return volatilities, such as morning, day break, afternoon, and night break return volatilities, are also calculated in order to shed additional light on the issue. These volatilities are calculated over a period of 21 months that covers two important changes that took place in ISE operations:

Shifting of opening price formation mechanism from a continuous auction system to a call auction system on February 2, 2007

Extension of trading hours until 17:00 in the afternoon on September 7, 2007.

The first change provides an opportunity to investigate the effect of the call auction trade mechanism on the volatility of opening returns. The second change enables us to explore whether the increased information flow towards the end of day affects the closing return volatility. Since the trading hours are extended until 17:00, the last half hour of trading in the ISE coincides with the first half hour of trading on the New York Stock Exchange. Such concurrent trading may allow an increase in information flow between the two markets and, therefore, may affect return volatility.

The next chapter presents the literature survey conducted regarding return volatilities. Chapter 3 explains the methodology to be used for conducting the analyses and also provides a description of the data.

CHAPTER 2

LITERATURE REVIEW

Extensive empirical work on interday return volatilities documents that open-to-open and close-to-close return volatilities in stock markets are higher in comparison to the volatilities calculated at other times during the trading day. For instance, during a morning trading session from 10.00am to 12.30pm, daily return volatilities are higher when the calculations are made with the stock prices at 10.00am or 12.30pm than when the calculation are made with the stock prices at 11.00am or 12.00 am. In the earlier studies, Wood, McInish and Ord (1985), Harris (1986), and Lockwood and Lin (1990) examine intraday stock returns and find that price volatility is higher near the opening and closing of the trading sessions. Amihud and Mendelson (1987) provide evidence that the open-to-open return volatility is even higher than the close-to-close return volatility. In the literature, there are many studies that attempt to explain why opening and closing return volatilities are higher than the rest of the day, as well as why opening return volatility is higher than the closing return volatility. In the following section, related studies are reviewed.

2.1 Why is opening return volatility higher than closing return volatility?

In the literature, there are mainly three causes that are argued to be responsible for higher return volatilities observed at the market opening:

1) Call auction trading mechanism,
2) Specialist's monopoly power,
3) The long halt of trade before the opening.

The first explanation offered focuses on the differences in the trading mechanisms between the opening and closing of the market. In their research, Amihud and Mendelson (1987) examine the effects that alternative trading methods may have on stock price behavior. Although there are different types of trading methods running in different markets around the world, it is hard to detach the differences that result from trading mechanisms from the differences that are caused by dissimilar securities and financial environments. Amihud and Mendelson run their tests in the same market and by comparing the different trading mechanisms that are used during the market opening versus the market closing. Namely, they investigate the results of differences in trading mechanisms by comparing the New York Stock Exchange stocks in the opening and closing transactions where prices at opening transactions represent the outcome of a call trading procedure and prices at closing are set or affected by the exchange's market maker. The study uses the daily opening and closing prices of 30 NYSE stocks which constituted the Dow Jones Industrials Index during the period between February 8, 1982 and February 18, 1983. Amihud and Mendelson state that since both open-to-open ($R_{o,t}$) and close-to-close ($R_{c,t}$) returns cover the same period of time, information which changes the stock prices should be equally reflected in both types of returns. This means that any observed differences in $R_{o,t}$ and $R_{c,t}$ can be attributed to the impact of different trading procedures. Amihud and Mendelson conclude in their research that the trading mechanism is a significant factor in explaining why the open-to-open returns have a larger variance compared to the variance of close-to-close returns.

Contrary to the findings of Amihud and Mendelson (1987), further studies on the subject reveal that the call auction mechanism in fact has a decreasing impact on the volatility when it is compared to the continuous trade mechanism. Amihud, Mendelson, and Murgia (1990) study the Milan Stock Exchange and find that the open-to-open volatility is higher when the market opens in a continuous fashion than when it opens in a call fashion. Similarly Choe and Shin (1993) study the Korean Stock Exchange where morning session closes in a continuous trade and afternoon session closes in a call auction and find that close-to-close return volatility in the morning session is higher than the close-to-close return volatility in the afternoon session.

The second explanation offered for explaining why opening return volatility is higher than the closing return volatility is the monopoly power of the specialist. Stoll and Whaley (1990) use the daily opening and closing prices of all NYSE stocks during the period between 1982 and 1986. They find the same result as Amihud and Mendelson (1987): open-to-open return volatility is higher than the close-to-close return volatility. Stoll and Whaley have a different explanation for this result. They argue that the specialist's presence at the market opening makes the price determination process different from a classic call auction since the specialist has the opportunity to trade for his/her own account as a dealer. The existence of liquidity trading at the opening of the market creates temporary price effects that allow suppliers of immediacy to earn revenues. This can also be interpreted to show that the suppliers of immediacy are extracting a premium for their services. Moreover, the reason for greater volatility at the opening cannot be the difference in the amount of public information released since both open-to-open and close-to-close returns span an equal time window.

Lam and Tong (1999) examine the Hong Kong stock exchange (SEHK) which is an order-driven system with no specialist and has two trading sessions separated by a two-hour midday break. They observe that open-to-open return volatility is slightly lower than the close-to-close return volatility. Lam and Tong also conclude that the main reason for the high open-to-open return volatility seen in many stock exchanges is the existence of specialists rather than the long trading halt prior to the market opening. They also mention that the existence of some dually-traded stocks in the London Stock Exchange may help to decrease the opening volatility in the SEHK but they "believe this impact to be insignificant." Moreover, contrary to other studies on the subject (French and Roll 1986, Amihud and Mendelson 1991, Güner and Önder 2002), they find that the overnight return volatility is more than twice the midday return volatility. This shows that the dually-traded stocks may have a significant impact on decreasing the opening volatility in the SEHK.

In a related study, George and Hwang (1995) analyze the stocks traded on the Tokyo Stock Exchange (TSE) and find that only the most actively traded stocks exhibit higher open-to-open return volatility. They are also able to show that most of the other stocks show no difference. The absence of a specialist in the TSE and this volatility observation both support the arguments of Stoll and Whaley (1990).

The third explanation offered for explaining why opening return volatility is higher than the closing return volatility is the long trading halt that occurs overnight before the market's open on the next day. This explanation is offered by Amihud and Mendelson (1991). In their research, Amihud and Mendelson seek answer to the question of whether the greater variance and significant negative autocorrelation at the market's opening are due to the trading mechanism or to the long period of no trading preceding the opening. They analyze the Tokyo Stock Exchange (TSE) in their study since in this market there are two times during the day that the transactions are cleared through the call auction mechanism: at the beginning of the morning session and at the beginning of the afternoon session. The difference between these two is that the morning session is preceded by an 18-hour period of no trading while the afternoon session is preceded by a two-hour period of no trading. This difference makes it possible to distinguish the effect of the clearing mechanism from the effect of a non-trading period preceding the trading session. Amihud and Mendelson use the daily TSE stock prices covering the period from July 1, 1987 to June 30, 1988 and find that the higher volatility at the daily opening is caused by the preceding long non-trading period rather than the trading mechanism itself. Moreover, for 5 of the 50 TSE stocks which are traded both in the TSE and in the US markets, the daily return variance ratio (open-to-open/close-to-close) is much lower than it is for the other 45 stocks. Amihud and Mendelson argue that since the US markets are open while the TSE is closed, the effective non-trading period for the 5 cross-listed stocks is shorter than the other 45 and price discovery at the morning open may be assisted by the presence of US trading prices during the preceding overnight period.

Gerety and Mulherin (1994) use 40 years of hourly Dow Jones Price Index data to investigate whether the reason for the high open-to-open return volatility is the trading mechanism used at the market open or the trading activity helping the investors to better process available information. They hypothesize that if the reason is the trading mechanism, then a discrete drop must be expected in return volatility following the opening hours and there must be no difference between the variances computed in any hour except for the open since volatility is generated through continuous trading during all the other hours. Gerety and Mulherin also hypothesize that if it is the trading activity itself that assists in price formation by processing the information, then a steady decrease in return volatility is expected to be observed during the day. Upon their analysis, they find that the stock return variance declines steadily during the trading day which is a result that supports their second hypothesis. In other words, similar to Amihud and Mendelson (1991), Gerety and Mulherin also find that the call auction at the market's opening does not generate a higher volatility compared to continuous trading. As a result, it can be concluded that the long trading halt preceding the morning open seems more likely to be the main source of higher volatility observed in the open-to-open returns.

In another study, Güner and Önder (2002) examine the volatility of stock returns in the Istanbul Stock Exchange (ISE). They use the daily opening and closing prices of 216 stocks for the period from February 1997 to February 1998. There are two important characteristics of the ISE during this period. First, there is no specialist on the ISE and, second, the trading mechanism for the opening and the rest of the day is the same and it is a continuous auction. In addition to these, there is a two-hour noon break in trading just like the Tokyo Stock Exchange. Güner and Önder find that the open-to-open return volatility is higher than the close-to-close return volatility. Since in ISE there is no specialist or no difference in the trading mechanisms throughout the day, this result suggests that the main source for the difference between return volatilities is the information that arrives overnight while the market is closed. Güner and Önder's results support those of Amihud and Mendelson (1991). Güner and Önder also conclude that per hour volatility of midday returns is significantly higher than the per hour volatility of overnight returns, implying that the information dissemination during midday has an increasing effect on return volatility of the stocks as well. Interestingly, Güner and Önder suggest in their paper that the absence of a specialist might be the cause of higher volatilities seen at the ISE when compared to mature markets like NYSE. Although the specialists are criticized for being the reason for high volatility (Stoll and Whaley 1990, Lam and Tong 1999), Güner and Önder argue to the contrary and state that specialists may be effective in stabilizing the prices and hence reducing the volatility.

More recently, Tian and Guo (2007) show that the high volatility at the market's open is caused by not only the information accumulated overnight during the trading halt but also the trading mechanism. They examine returns over five-minute intervals in the Shanghai Composite Stock Index between January 1, 2000 and December 31, 2002. In the Shanghai Stock Exchange, there is no market maker or specialist either. Their results are in contradiction with the Stoll and Whaley (1990) argument since there is no specialist in the SHSE. They also reject the hypothesis that the volatility is entirely caused by the opening trading mechanism. Moreover, they find the trading-hours return volatility to be higher than non-trading hours return volatility, and overnight return volatility to be greater than the midday break return volatility.

2.2 Why is return volatility at the market close higher than the rest of the day?

Even though the previous studies document that the opening return variance is higher than the closing return variance, the volatility seen at the closing of the market is still higher than the other times of the trading day (except for the openings). Many studies that are conducted by using intraday data find that the intraday return volatility pattern follows a U-shaped curve: high volatility at the open, low volatility in the middle, and relatively high volatility at the close of the market. The first comprehensive study on intraday returns and volatility is carried out by Wood, McInish and Ord (1985) and provides evidence that the intraday volatility follows a U-shaped curve.

The studies by Yadav and Pope (1992) for the UK market, Choe and Shin (1993) for the Korean market, Lam and Tong (1999) for the Hong Kong market, Andersen, Bollerslev and Cai (2000) for the Japanese market, Bildik (2001) for the Turkish market, Lowengrub and Melvin (2002) for the German market and Tian and Guo (2007) for the Chinese market all provide evidence for the existence of a U-shaped intraday volatility pattern. In addition to volatility, the studies by McInish and Wood (1990), Brock and Kleidon (1992), Foster and Viswanathan (1993), Chang, Jain and Locke (1995), and Madhavan, Richardson and Roomans (1997) all test the concentrated trading model of Admati and Pfleiderer (1988) and provide evidence that trading volume also follows a U-shaped curve during the day and exhibits a significant positive relationship with return volatility.

There are a number of studies that attempt to explain the observation that volatility and trading volume are both high at the market's close. Wood, McInish and Ord (1985) examine the behavior of returns and various trading characteristics using the minute by minute data from the NYSE for the years 1971, 1972 and 1982. They find that the return distribution differences exist during the first thirty minutes of the market open, at the market close and the rest of the day. Prices rise near the end of the day and most obviously on the last trade. They emphasize that all positive returns are earned during either the first or the last thirty minutes of trading. Excluding the first and last thirty minutes and the closing data from the sample, results in normally distributed market returns.

Harris (1989) tries to identify the reasons that cause the high day-end price volatilities by examining every stock transaction executed on the NYSE for the 14 months between December 1, 1981 and January 31, 1983. Harris argues that the tendency of an increase in both the bid and ask prices at the day-end is not as great as the mean transaction price change. This finding suggests that the day-end effect is not primarily an information effect provided that the most recent bid and ask prices are believed to reflect the most current information. Harris also argues that this phenomenon is not caused by reasons such as inaccurately reported data, clustering of stock prices, simultaneously traded cross-listed stocks, trading volume or the day of the week effect. Although he states that his study is unable to identify the variables that cause the day-close return volatility, the finding imply that the high return volatility seen at the close appears to be due to the increase in the frequency of ask prices at the day-end.

Admati and Pfleiderer (1988) model the trading patterns throughout the day, and classify the traders into informed traders and liquidity traders. According to their concentrated trading model, informed traders are the ones that have private information that is not available to others, while liquidity traders may be the large traders such as financial institutions that need to trade strategically for reasons that are not based on the market information and are not directly related to the future earnings of the assets. For different liquidity traders in the market, there are different times that the need for liquidity arises and different durations of time are allowed before these needs are met. Therefore, if the deadline of this demand is after the close of the market, then the liquidity traders concentrate their trades at the end of the day. Moreover, Admati and Pfleiderer argue that informed traders want to trade when the market is "thick", namely when the trade volume is high, in order not to affect prices much with their trades. Hence high volume of liquidity trading at the close of the market also attracts the informed traders and as a result more information is reflected in the stock prices at the market close.

Miller (1989) argues that the high volatility seen at the close of the market is caused by specialists who want to defend their position on the upcoming non-trading period by setting relatively high prices at the last minute of the day and hence they end up increasing the index.

Brock and Kleidon (1992), Gerety and Mulherin (1992), and Hong and Wang (2000) interpret the reason for the increase in the volatility at the end of the day as the escape of investors from risk after the close of the market by decreasing their positions in the stock market. According to these studies, investors do not want to take the risk of the coming non-trading period and decrease their positions in the stock market and this, in turn, causes both the trading volume and the volatility to increase at the close of the market.

Madhavan, Richardson and Roomans (1997), on the other hand, argue that the reasons for the increase in prices at the end of the day are the announcement of new public information and the information revealed while the trading takes place.

In a later study, Cushing and Madhavan (2000) mention three reasons for the increase in prices near the close. The first reason is the fact that buy-sell orders are supported with high transaction volumes. The second reason is the excessive buy-sell orders of institutional investors and the third reason is the due time of derivative products near the closing time of the session and their impact on the closing prices.

According to Block, French and Maberly (2000), institutional investors are the reason for the high return at the start and the close of the market. Institutional investors give their orders more frequently during the 30 minutes right after the open and the 30 minutes just before the close of the market.

According to Hillion and Suominen (2001), the reason for the volatility increase near the close of the session is the increased difference between buy and sell orders and the investors benefiting from price differences who want to close their positions in order to take advantage of these benefits.

According to Küçükkocaoğlu (2008), some investors in the Istanbul Stock Exchange “try to manipulate the movement of closing prices by using brokers or through their mediation”. Moreover, he mentions that as long as the closing price is used as a performance measure, the continuation of such movements is inevitable.

To sum up, there are mainly five explanations as to why return volatility is high at the end of the day:

- Increasing trading volumes caused by increasing bid-ask spreads
- Increasing trading volumes caused by excessive buy-sell orders of institutional investors
- Manipulative behaviors of specialists who want the index to seem higher
- Manipulative behaviors of investors who want to affect performance measures
- New public information arrival intensity at the end of the day

As documented in this section, there are a variety of empirical studies on inter-day return volatilities that aim to explain the high opening and closing return volatilities. Some studies focus on explaining the reasons why opening return volatilities are higher than closing return volatilities, while some others focus on investigating the reasons why opening and closing return volatilities are higher than the rest of the day. In this study, two of these topics are examined with the purpose of contributing to the existing literature. These are namely the effect of opening trading mechanism on opening return volatility, and the effect of information flow on closing return volatility.

CHAPTER 3

DATA AND METHODOLOGY

As explained in the literature review section, the differences between different stock exchanges such as the existence of specialists, opening and closing trading mechanisms, and the existence of midday breaks make it difficult to test, analyze, and compare the effect of these characteristics on stock returns and volatility. For instance, in one study it may be possible to find high volatility in a market where a specialist exists, whereas in another study the results imply high volatility in a market where there is no specialist. In such a case, the first study concludes that what creates the high volatility is the existence of a specialist in a market, while the other study may conclude just the opposite. Empirical testing makes it necessary to keep all the variables constant while changing only one variable in order to understand the effect of this variable within the specific research context. However, conducting a controlled experiment in a dynamic environment like a stock market is impossible. Fortunately, some unique characteristics of the Istanbul Stock Exchange (ISE) together with recent changes in trading hours and trading mechanisms make it possible to investigate the effect of these by utilizing the preferred empirical methodologies.

Since its inception in 1986, ISE was an order-driven market with continuous trading mechanisms executed during the opening and closing of each trading session and also throughout the sessions. There were two trading sessions in a day with a midday break of two hours while there were no specialists in the ISE.

On February 2, 2007, ISE changed the price determination procedure at the opening of the market in the morning. The new system is a single-price system which is also known as a call auction mechanism. According to this new mechanism, all the buy and sell orders are sent to the system for a predetermined length of time and at the end of this period, an opening price is determined such that it creates the highest trading volume. Only those orders that satisfy the opening price are executed. As mentioned before, there are studies in the literature that blame the opening call auction price determination mechanism for increasing the opening return volatility, as well as many other studies that claim that the call auction mechanism decreases the volatility. The advantage of this new arrangement in the ISE is that it provides a chance to observe the effect of the call auction mechanism on opening return volatility by comparing the periods of seven months preceding February 2, 2007 against the seven months following this date. This 14-month window is chosen since there is another major change in the ISE seven months after the trading mechanism change.

The next change in the ISE is the extension of trading hours which extends the afternoon session for half an hour (the market closing moving from 16:30 to 17:00) on September 7, 2007. What makes this change important is that it creates a half an hour of concurrent trading between the New York Stock Exchange (NYSE) and the ISE. In other words, before the extension of trading hours, NYSE was opening just after the closing of ISE. However, with the extension of trading hours, the last thirty minutes of trading in the ISE is now also the first thirty minutes of trading in the NYSE. This intersection may have an impact on the stock price formation in the ISE as a result of the potential flow of new information from the NYSE trades. The public information accumulated overnight for the NYSE is quickly incorporated into the prices once the NYSE opens and this period is about thirty minutes (Chan, Chockalingam, and Lai 2000). Hence, since September 7, 2007 investors in the ISE have a chance to see what happens in the NYSE at its opening and to act accordingly before the trading day closes in Istanbul. Since the US market has the second largest effect on the Turkish market after Germany (Marashdeh, 2006), and the main source of volatility spillovers towards the ISE (Benkato and Darrat, 2003), receiving information about the NYSE before the ISE closes may have significant effects on the Turkish stock prices.

Table 3.1 Regulatory Changes in the Istanbul Stock Exchange

	Before 02.02.2007	**Between 02.02.2007 and 09.07.2007**	**After 09.07.2007**
Opening mechanism	Continuous trade	Call auction	Call auction
Concurrent trading with the NYSE	No	No	Yes

3.1 Data and Sample

The ISE consists of four markets which are namely the National, Regional, Newly Established Enterprises and Watch markets. All of these markets have different trading mechanisms and different trading hours. The analyses in this study are limited to only the National market. In order to make sure that the sample stocks have greater trading frequency and hence are affected less by non-synchronous trading (Gerety and Mulherin, 1992), the sample is restricted to only those stocks that are included in the ISE-100 index.

The sample period is from July 2006 to April 2008. The stocks whose trading was stopped by the exchange or the stocks that are dropped from the index at any time during this period are not included in the analysis. Moreover, the stocks being listed for the first time during the sample period are not included in the analyses in order to avoid the volatility caused by initial public offerings. Furthermore, in order to study the differences in return volatilities of stocks with different trading volumes, stocks in the sample are grouped into four trading volume groups from the lowest to the highest.

The opening and closing prices and volume data for each session are obtained from the databases of the Finnet Company. The opening and closing prices are adjusted for stock splits and dividends.

3.2 Methodology

This study examines the arguments documented in the literature about the factors that create high opening and closing return volatilities and examines the Istanbul Stock Exchange as an example case. The period before the shift to the call auction mechanism (02.02.2007) is analyzed as Period 1; the period from 02.02.2007 to the date that the trading hours are extended (09.07.2007) is analyzed as Period 2, and the seven months following 09.07.2007 is analyzed as Period 3.

Based on the arguments from the previous literature on the subject, a series of hypotheses is formed to be tested with the data from the Istanbul Stock Exchange. First, if the call auction trading mechanism has a decreasing effect on return volatility, then the open-to-open return volatility for the morning session should be lower during Period 2 compared to Period 1. Hence the following hypotheses are constructed accordingly:

> $H_{0,1}$: The call auction trading mechanism at the morning session opening decreases the morning session open-to-open interday return volatility.
>
> $H_{0,2}$: The call auction trading mechanism at the morning session opening decreases the morning session intraday return volatility.

Second, there could be three main reasons for the high volatilities observed at the close of the market. These could be (1) the manipulative behavior or the defensive trading activities of risk-averse investors, or (2) the institutional traders who prefer to trade at the end of the day, or (3) the intensity of information made public near the market close. If the reason for increasing closing volatility is not information intensity but the trading by individual and institutional investors, then the afternoon close-to-close and afternoon intraday return volatilities should not change during Period 2 or Period 3. Because the trading effects continue to exist in Period 3 regardless of the new information flow created with the extended trading hours. Therefore, in light of these explanations, the following hypotheses are formed:

$H_{0,3}$: Concurrent trading with the NYSE during the last thirty minutes of trading in the ISE increases ISE's afternoon session intraday return volatility

$H_{0,4}$: Concurrent trading with the NYSE during the last thirty minutes in the ISE increases the afternoon close-to-close return volatility.

Third, in Period 2, all of the information generated in the US markets reaches the Turkish market during the overnight trading break. Hence, it is plausible to assume that all this information was reflected in the prices at the opening of the ISE the next morning. It is also reasonable to assume that this may have caused the volatility to be relatively high at the market's open. During Period 3, with the extension of trading hours in the ISE, the information generated during the first thirty minutes of trading in the NYSE has a chance to be reflected in the ISE prices before the Turkish market closes. This may also mean that during the overnight break that follows the Turkish market's close, a relatively smaller amount of new information arrives from the US compared to the case before the extension of the trading hours. Therefore, if the reason for high volatility during the market opening is the accumulation of unprocessed information overnight, then a decrease in both the overnight volatility and the opening volatility should be observed for the ISE after the extension of trading hours. Hence, two additional hypotheses are formed in the following manner:

$H_{0,5}$: Concurrent trading with the NYSE during the last thirty minutes of trading in the ISE decreases ISE's overnight close-to-open return volatility.

$H_{0,6}$: Concurrent trading with the NYSE during the last thirty minutes of trading in the ISE decreases ISE's morning open-to-open return volatility.

The following 24-hour returns are calculated in order to test the six hypotheses described above:

Morning session open-to-open return: $R_{o1,t} = \ln\,(P_{o1,t}/P_{o1,t-1})$ (3.1)

Morning session close-to-close return: $R_{c1,t} = \ln\left(P_{c1,t}/P_{c1,t-1}\right)$ (3.2)

Afternoon session open-to-open return: $R_{o2,t} = \ln\left(P_{o2,t}/P_{o2,t-1}\right)$ (3.3)

Afternoon session close-to-close return: $R_{c2,t} = \ln\left(P_{c2,t}/P_{c2,t-1}\right)$ (3.4)

In order to analyze and compare trading and non-trading periods, the trading day is divided into four sub-periods:

Return during the morning session: $R_{am,t} = \ln\left(P_{c1,t}/P_{o1,t}\right)$ (3.5)

Return during the daybreak: $R_{db,t} = \ln\left(P_{o2,t}/P_{c1,t}\right)$ (3.6)

Return during the afternoon session: $R_{pm,t} = \ln\left(P_{c2,t}/P_{o2,t}\right)$ (3.7)

Return during the night break: $R_{nb,t} = \ln\left(P_{o1,t}/P_{c2,t}\right)$ (3.8)

Table 3.2 Return Calculation Periods

Morning (am)	**Day Break**	**Afternoon (pm)**	**Night Break**	**Morning (am)**	**Day Break**	**Afternoon (pm)**
o1 c1		o2 c2		o1 c1		o2 c2
Trading Day, t-1				**Trading Day, t**		

Table 3.2 presents the symbols used in the equations. In Equations 3.1 through 3.8, subscripts t and t-1 refer to the current trading day and previous trading day, respectively; o1 and o2 refer to the opening of the morning and the afternoon sessions, respectively; and c1 and c2 refer to the closing of the morning and the afternoon sessions, respectively. P is the price of the stock and R is the return during the corresponding period. Lastly, the subscripts am, pm, db and nb stand for the morning session, the afternoon session, the midday break and the overnight break, respectively. For instance, $R_{db,t}$ represents the return during the day break on day t. Similarly, $R_{c1,t}$ represents the twenty four-hour return on day t calculated from the afternoon closing prices.

After calculating the returns given in Equations 3.1 through 3.8 for each stock and for each day in the sample period, return volatilities for the corresponding stocks are calculated as the standard deviations of these returns for each period. Hence, for each stock in the sample, the following equation presents the volatility calculation:

$$\bar{R}_k^j = \frac{\sum_{t=1}^{n}\left(R_{k,t}\right)}{n} \tag{3.9}$$

$$\sigma_k^j = \sqrt{\sum_{t=1}^{n}(R_{k,t} - \bar{R}_k^j)} \tag{3.10}$$

In Equations 3.9 and 3.10, j is the month index, n is the number of trading days in period j, and k stands for one of the o1, o2, c1, c2, am, pm, db, or nb subscripts explained above. Finally, σ_k^j is the return volatility for case k in period j.

There are a variety of methods documented in the literature to test for the homogeneity of variances. For normally distributed data, classical methods such as an F-test or Bartlett test (Bartlett, 1937) can be used to test for the differences in variability. However, these tests are known to be highly sensitive to the assumption that the population distributions are normal (Box, 1953). Moreover, simulation results (Conover, Johnson and Johnson, 1981; Olejnik and Algina, 1987) show that the Brown-Forsythe (BF) test (Brown and Forsythe, 1974) seems to be the best in producing reasonably robust results while detecting variance differences and avoiding the Type-I error. Milliken and Johnson (1984) recommend the BF test unless there is confidence that the data are nearly normal or the data set is very large while Hines and Hines (2000) nominate the BF test as a “widely used and robust test.” Although the Brown-Forsythe test seems to be accepted widely in the literature, in order to be sure that the results are consistent, the homogeneity of variances across different time periods is tested by using five different tests that are proposed in the literature. Namely these tests are the following:

1) Bartlett Test

2) Brown and Forsythe Test
3) Levene Test
4) O'Brien Test
5) Cochran Test

3.2.1 Bartlett Test (B):

The Bartlett Test (Bartlett, 1937) is used to test the null hypothesis of equal variances across groups. In this study, the groups are the different sub-periods in the sample. The following null and alternative hypotheses are tested for the various variances that are calculated for the different returns presented in Table 3.2:

$$H_o: \sigma_1 = \sigma_2 \quad (3.11)$$

$$H_a: \sigma_1 \neq \sigma_2 \quad (3.12)$$

For the two sample case, with size n_i and sample variance S_i^2, the Bartlett test statistic is calculated as follows:

$$X^2 = \frac{(N-2)\ln\left(S_p^2\right) - \sum_{i=1}^{2}(n_i - 1)\ln(S_i^2)}{1 + \frac{1}{3}\left(\sum_{i=1}^{2}\left(\frac{1}{n_i - 1}\right) - \frac{1}{N-2}\right)} \quad (3.13)$$

In Equation 3.13, N equals $\sum_{i=1}^{2} n_i$ and $S_p^2 = \frac{1}{N-2}\sum_{i=1}^{2}(n_i - 1)S_i^2$ is the pooled estimate for the variance. The null hypothesis is rejected if X^2 is greater than $\chi^2_{1,\alpha}$, where $\chi^2_{1,\alpha}$ is the upper tail critical value for the χ^2_1 distribution. Like in other tests in this study, a significance level (alpha) of 0.05 is used.

3.2.2 The Brown and Forsythe Test (BF):

The BF method also tests for the null hypothesis of equal variances across groups. In this study, the groups are the different sub-periods in the sample. The following null and alternative hypotheses are tested for the various variances that are calculated for the different returns presented in Table 3.2:

$$H_o: \sigma_1 = \sigma_2 \quad (3.14)$$

$$H_a: \sigma_1 \neq \sigma_2 \quad (3.15)$$

The Brown-Forsythe test statistic for comparison of two periods is calculated as follows:

$$W = \frac{(N-2)\sum_{i=1}^{2} N_i(\bar{Z}_{i.} - \bar{Z}_{..})^2}{\sum_{i=1}^{2}\sum_{j=1}^{N_i}(Z_{i,j} - \bar{Z}_{i.})^2} \quad (3.16)$$

In Equation 3.16, N_i is the sample size for the i^{th} period, N is the total sample size for all periods, $\bar{Z}_{i.}$ is the group means of $Z_{i,j}$, and $\bar{Z}_{..}$ is the overall mean of $Z_{i,j}$. Up to this point, Equation 3.13 is nothing but an F-test for two groups if $Z_{i,j}$ is taken as the dependent variable itself, without any transformation. However, the transformation of the dependent variable ($R_{i,j}$) to $Z_{i,j} = |R_{i,j} - \tilde{R}_{i.}|$ where $\tilde{R}_{i.}$ is the median of the i^{th} period makes the BF test different from a typical F-test.

3.2.3 Levene Test (L):

Similar to the BF test, Levene test (Levene, 1960) also uses Equation 3.16 in testing the homoscedasticity of two groups. However, in the Levene test, the transformation is performed as $Z_{i,j} = |R_{i,j} - \bar{R}_{i.}|$, where $\bar{R}_{i.}$ is the mean of the i^{th} period.

3.2.4 O'Brien Test (O):

Similar to the BF and Levene tests, the O'Brien test (O'Brien 1979, 1981) also uses the F-distribution performing a one-way ANOVA. Equation 3.16 represents a one-way ANOVA for the two-group special case. However, rather than using the raw $R_{i,j}$ data, O'Brien proposes the following transformation:

$$Z_{i,j} = \frac{N_i(N_i - 1.5)(R_{i,j} - \bar{R}_{i.})^2 - 0.5var(R_i)(N_i - 1)}{(N_i - 1)(N_i - 2)} \quad (3.17)$$

In Equation 3.17, N_i is the sample size for the i^{th} period, $R_{i,j}$ is the j^{th} return of the i^{th} period, $\bar{R}_{i.}$ is the mean return of the i^{th} period, and $var(R_i)$ is the variance of the returns in the i^{th} period.

The choice of $Z_{i,j}$ depends on the distribution of the sample and this choice enhances the robustness and power of the test according to Brown and Forsythe (1974). Therefore, if the data follow a Cauchy distribution (i.e. the probability distribution has a heavy tail), then $Z_{i,j} = \left|R_{i,j} - \bar{R}'_{i.}\right|$, where $\bar{R}'_{i.}$ is the 10% trimmed mean of the i^{th} period. Alternatively, if the data follow a χ^2_4 distribution (i.e. the probability distribution is skewed), then $Z_{i,j} = \left|R_{i,j} - \tilde{R}_{i.}\right|$, where $\tilde{R}_{i.}$ is the median of the i^{th} period. If the distribution is symmetric and moderate-tailed, then $Z_{i,j} = \left|R_{i,j} - \bar{R}_{i.}\right|$, where $\bar{R}_{i.}$ is the mean of the i^{th} period.

3.2.5 Cochran Test (C):

Cochran's C statistic (Cochran 1941, 1951) is calculated as follows:

$$C = \frac{s^2_{largest}}{\sum s^2_j} \tag{3.18}$$

In Equation 3.18, s^2_j is the sample variance of group j, i.e. period j in this study. This test statistic is then compared against the critical values originally tabulated and provided by Eisenhart et al. (1947). In this study, a MATLAB file which is coded by Trujillo and Ortiz (2003) and formulates the related table is used in computing the critical values for the Cochran test in order to obtain accurate numerical results for the critical values. This critical value is obtained by inputting number of groups (k), and degrees of freedom (υ). Here the degrees of freedom are defined as follows:

$$\upsilon = \max\,(n_j - 1) \tag{3.19}$$

In Equation 3.19, n_j is the number of observations in group j.

In the next step of the analysis, the calculated volatilities are compared across the three sample periods defined at the beginning of the methodology section, and the results are presented.

CHAPTER 4

RESULTS

The results from the empirical tests are investigated under two main headings:

1) The effect of the change in the opening mechanism on stock volatilities, i.e. changes between Period 1 and Period 2

2) The effect of extending trading hours on stock volatilities, i.e. changes between Period 2 and Period 3.

Stocks in the sample are divided into four groups in terms of their total trading volume within the three periods. The trading volume intervals are 0-25%, 25-50%, 50-75%, and 75-100% and they are named VI-1, VI-2, VI-3, and VI-4, respectively. Each interval's volatility change between the periods is presented for each of the five Homogeneity of Variance (HOV) tests mentioned above. The results of the tests are presented in Tables 4.3.1 through 4.8.4 at the Appendix. Also, Figures 4.1.1 through 4.7.4 tracks the return volatilities for interday and intraday returns. It is important to note that in calculating the hourly volatilities, average number of hours which also take non-working days into account, are used. The non-working days cover both weekends and official holidays. Hence the average number of hours used in the calculations differs from period to period since different periods may have a different number of official holidays coinciding with the calculation period. Therefore, for instance, the average number of trading hours for interday returns is 35.13 hours for Period 1, whereas it is 34.04 for Period 2. Similarly, in calculating the overnight break return hourly volatilities for Period 1, the averages are taken by dividing the overnight break volatilities by 28.13 rather than 18 (from 4pm to 10am) since weekends and official holidays increase the number of hours that the overnight break period covers.

4.1 The effect of the change in the opening mechanism on stock volatilities (Change from Period 1 to Period 2)

The trading mechanism used during the market opening is argued to be one of the main reasons for high volatility observed during the market's opening. The shifting of the opening price formation mechanism from a continuous auction system to a call auction system on February 2, 2007 in the Istanbul Stock Exchange makes it possible to investigate the effect of the trading mechanism on various return volatilities.

The volatility effects are investigated under the sub-headings of interday and intraday volatilities. Interday volatilities are the volatilities of the 24-hour periods calculated from morning opening (O1), morning closing (C1), afternoon opening (O2), and afternoon closing (C2). Intraday volatilities are the volatilities of the morning return (morning opening to morning closing), daybreak return (morning closing to afternoon opening), afternoon return (afternoon opening to afternoon closing), and night break return (afternoon closing to next day's morning opening).

4.1.1 The Interday Return Volatilities

Upon testing the volatility changes between Period 1 and Period 2 with five different HOV tests, the results are summarized in Tables 4.3.1 through 4.3.4. In these tables, the first four rows are the interday volatilities. O1 represents the morning open-to-open volatility, C2 represents the morning close-to-close volatility, O2 represents the afternoon open-to-open volatility, and C2 represents the afternoon close-to-close volatility. The results are divided, investigated, and presented for four trading volume intervals. In these tables, the figures represent the percentage of stocks whose volatilities increase, do not change, or decrease in the related volume interval. For instance, according to Table 4.3.1, the BF test result shows that among the stocks with the lowest trading volume interval (VI-1, volume interval 0-25% of all stocks analyzed), the C1 volatility increases for 5% of the stocks, and it does not change for 90% of the stocks. Moreover, in Tables 4.4.1 through 4.4.4, results for different volume intervals are compared for each of the interday return volatilities. For instance, according to Table 4.4.1, the Bartlett test results show that 16% of the stocks in volume interval 1 (lowest volume interval) has an increase in their O1 volatility, while this proportion is 33% for volume interval 2.

Although the results differ from test to test, there are some common trends that all tests agree on. One of these common results is that the O1 volatility mainly decreases for the lowest volume interval stocks, while for stocks in the higher volume groups, there is a general tendency for the O1 volatility to increase. Similar effects are observed for other interday return volatilities. C1, O2, and C2 return hourly volatilities mainly increase for high-volume stocks while there is no apparent increase or decrease trend for stocks in the lowest volume interval.

The effect of the opening mechanism shift can be better observed by examining Figures 4.1.1 to 4.1.4 for each volume interval. In these figures, mean volatilities of interday returns throughout the day are graphed for each volatility interval. Comparing these figures side by side, one can easily observe that except for the lowest volume interval stocks there is an obvious increase in all other stocks' interday volatilities. This is a somewhat surprising result since a change in morning opening mechanism is expected to affect only the opening interday return volatility. Moreover, the graphs of Period 1 and Period 2 are almost parallel for higher volume stocks. Hence, this constant increase seen in volume intervals 2, 3, and 4 can be attributed to the more volatile characteristics of Period 2. So, it is plausible to argue that the opening mechanism shift does not have any effect on high volume stocks while it considerably decreases open-to-open return volatility for low volume stocks. This makes sense since it is known (Barclay and Hendershott, 2003) that the price discovery process takes longer for low volume stocks, and this in turn causes higher volatility. At this point, it can be concluded that the call auction opening mechanism helps low volume stocks to reach their expected price easier and faster and, as a result, the morning opening return volatilities of these stocks decline. Hence, the first hypothesis ($H_{0,1}$) which states that the call auction trading mechanism used during the morning session opening decreases the morning open-to-open interday volatility is failed to be rejected for low volume stocks but rejected for high volume stocks between Period 1 and Period 2.

Another interesting observation becomes more obvious when the interday return volatilities of different volume intervals are merged into a single graph for each period in Figures 4.2.1 and 4.2.2. As seen in these figures, interday return volatilities exhibit a more regular trend in Period 2 compared to Period 1. The typical high volume-high volatility characteristic of many stock markets is once again seen clearly in Period 2. On the other hand, in Period 1, there is a disorder in the volume-volatility relationship as the lowest volume quartile stocks experience very high volatilities especially in the morning openings. This observation provides additional evidence about how effective the call auction opening mechanism is for regulating the return volatilities of low volume stocks.

4.1.2 The Intraday Return Volatilities

The homogeneity of variance test results for intraday return hourly volatilities are presented in the last four rows of Tables 4.3.1 through 4.3.4. These are namely night-break (NB), morning (MO), daybreak (DB), and afternoon (AN) return hourly volatilities. The numbers in these tables represent the percentage of stocks in the related volume interval that have an increase, decrease, or no change in their volatilities. For instance, for the low volume interval stocks (VI-1), according to the Levene Test, 42% of the stocks have an increase in morning return hourly volatility, while 58% percent of them have no change. Also these test results are reordered in Tables 4.5.1 through 4.5.4 for a better comparison of volume interval differences for each of the intraday return hourly volatilities. The test results differ from each other, but still there are some common trends that all the tests agree on.

First, the night break (NB) volatility mostly increases and this increase is more noticeable for higher volume intervals. For instance, according to the Cochran Test, 89% of the highest volume stocks experience an increase in volatility following the shift from the continuous auction to the call auction at the opening of the market. Although this proportion is only 28% according to the O’Brien test, other tests generate a proportion around 70%. Similarly, the morning (MO) hourly volatility mostly decreases for all volume intervals, but this decrease is more noticeable for lower volume intervals. Examining Table 4.4.1, it can be seen that the morning session volatility decreases in Period 2 according to the Bartlett Test for 69% of the lowest volume interval stocks. This proportion is 37%, 42%, 32%, and 63% according to the Brown and Forsythe Test, Levene Test, O’Brien Test, and Cochran Test, respectively.

The graphs for the intraday return volatilities are presented in Figures 4.3.1 through 4.3.4. As seen in these figures, trading time hourly volatilities (morning and afternoon) are significantly higher than non-trading time hourly volatilities (night break and daybreak). This finding is consistent with other studies in the literature, such as studies by French and Roll (1986), Barclay et al. (1990), and Stoll and Whaley (1990). Also, daybreak per hour volatility is higher than the night break per hour volatility. This finding is in line with the conclusions of Amihud and Mendelson (1991) but in contrast with Lam and Tong (1999). It is reasonable to argue that this large difference between daybreak and night break return hourly volatilities are mostly attributable to the higher intensity of information that arrives during the business hours.

The most important result that can be captured from Figures 4.3.1 through 4.3.4 is the decrease in the morning return hourly volatility for the lowest volume quartile stocks following the shift from the continuous auction to the call auction. This result supports the previous result that open-to-open interday return hourly volatility is decreased between Period 1 and Period 2. The lowest volume quartile stocks experience a decrease of an average of 21% in the morning intraday return volatility. This result also shows that the call auction opening mechanism has a significant effect on low volume stocks in terms of assisting their price discovery process during morning opening and in turn decreasing their return volatilities. Morning return volatilities decrease on average for other volume quartiles also, but the decline is less significant. The average decrease in morning return volatility is 11% for VI-2 stocks, 6% for VI-3 stocks, and 9% for VI-4 stocks. Hence, the second hypothesis ($H_{0,2}$) which states that the call auction trading mechanism used during the morning session opening decreases the morning session intraday return volatility is failed to be rejected for low volume stocks but rejected for high volume stocks between Period 1 and Period 2.

4.2 The effect of extended trading hours (until 17:00) on stock volatilities (Change from Period 2 to Period 3)

On September 7, 2007, the trading hours in Istanbul Stock Exchange were extended by half an hour. Morning trading hours did not change while the afternoon closing is extended from 4.30pm to 5pm. Although this extension of 30 minutes may not seem long enough to be significant, it is important since it creates concurrent trading minutes with the NYSE. This concurrent trading is expected to create an additional information flow during the closing of the day.

Information flow is discussed in the literature to be one of the main sources of high return volatility. This change in trading hours in the ISE, therefore, makes it possible to measure the effect of increased information flow by examining the return volatilities through the end of day. The seven months preceding the change occurs (September 7, 2007) is defined as Period 2, while the seven months following the change is defined as Period 3. The return volatilities of both periods are calculated for interday and intraday returns. Moreover, the stocks are classified into four trading volume quartiles like before in order to see whether there is a difference in volatility effects for different volume classes. The differences in volatilities between periods are investigated by the use of the previous five HOV (homogeneity of variances) tests: Bartlett Test, Brown and Forsythe Test, Levene Test, O'Brien Test, and Cochran Test. The results of these tests are tabulated in Tables 4.6.1 through 4.8.4. The numbers in these tables represent the percentage of stocks in the corresponding volume interval that experience an increase, decrease or no change in their volatilities.

The results are presented separately for interday and intraday return volatilities.

4.2.1 The Interday Return Volatilities

The first four rows of the Tables from 4.6.1 to 4.6.4 present the interday return volatility changes according to the HOV tests. The test results show that for most of the subgroups volatility did not change upon the extension of trading hours. However, these test results do not present a complete picture since they only compare the deviations of two data sets of certain interday returns and do not take the volatility trend into account. Therefore, it is better to draw conclusions by examining both the tables of the HOV test results and the figures graphing the volatility trends.

In examining Figures 4.4.1, 4.4.2, 4.4.3, and 4.4.4 it is seen that the general trend of the interday return volatilities is very similar for all volume intervals. Moreover, it is seen that Period 2 and Period 3 return volatilities are very close to each other in terms of their levels. This is most likely the reason why HOV tests give the result of "no change" for the majority of the stocks. Since the differences between Period 2 and Period 3 volatilities are not large enough, the tests regard them as nearly the same. Furthermore, Period 3 return volatilities are always higher than Period 2 return volatilities in all interday returns and for all volume intervals, except for the afternoon closing interday return volatility case (C2) of the highest volume interval stocks (VI-4). The Period 3 to Period 2 variance ratios of O1 returns are 0.88, 0.87, 0.88, and 0.91 for the lowest volume quartile to highest volume quartile, respectively. Similarly, these ratios are 0.95, 0.95, 0.95, and 0.96 for C1 returns; 0.90, 0.94, 0.93, and 0.93 for O2 returns; and 0.91, 0.90, 0.97, and 1.02 for C2 returns. It is important to note that although the variance ratios are very close to each other for the O1, C1, and O2 returns, they differ dramatically in C2 return volatilities for high volume stocks and especially for the highest volume interval stocks since it is even larger than 1. This observation provides evidence that the increased information flow through the end of the day has an increasing effect on the interday volatility for higher volume stocks. Hence, the third hypothesis ($H_{0,4}$) which states that the concurrent trading with the NYSE during the last thirty minutes in the ISE increases the afternoon close-to-close return volatility is failed to be rejected for high volume stocks between Period 2 and Period 3. Similarly, in examining the same Figures (4.4.1 through 4.4.4), it is seen that O1 return volatility experiences a more dramatic decrease when compared with the trend in other interday volatilities. However this is not verified by the Period 3 to Period 2 variance ratios for O1 return volatility which are 0.88, 0.87, 0.88, and 0.91 for VI-1, VI-2, VI-3, and VI-4 respectively. These variance ratios are not found to be small enough to name them a decrease according to the HOV test results as can be seen in table 4.7.1. So it can be concluded that the slight decrease in morning open-to-open interday volatility between Period 2 and Period 3 is not significant. Therefore the sixth hypothesis ($H_{0,6}$) which states that the concurrent trading with the NYSE during the last thirty minutes in the ISE decreases the morning open-to-open return volatility is rejected between Period 2 and Period 3.

4.2.2 The Intraday Return Volatilities

Upon examining the Figures 4.6.1 through 4.6.4, it is observed that there is an increase in daybreak return hourly volatility, and a decrease in afternoon return hourly volatility. The increase in daybreak return hourly volatility is also supported by the results of HOV tests as can be seen in Tables 4.6.1 through 4.6.4, or more specifically in Table 4.8.3 which shows the results for only the daybreak return volatilities. All tests agree that there is an increase in daybreak return hourly volatility. For instance, according to the O'Brien test, 42% of the stocks in the 3rd volume quartile experience an increase in daybreak volatility; or according to Cochran test, 26% of the stocks in the 1st volume quartile experience an increase in daybreak volatility. However the decrease in afternoon volatility seen in these figures is not supported by the HOV test results. This is because of the fact that in Period 3, the length of the afternoon session is increased from 2 hours to 2.5 hours. Hence, the decrease in afternoon session return hourly volatility is attributed to the increase in the number of trading hours. This is also verified by comparing the (non per hour) variance ratios of Period 3 to Period 2. These ratios are 1.13, 0.98, 1.09, and 1.12 for VI-1, VI-2, VI-3, and VI-4, respectively. As evidenced by these ratios, the afternoon session volatility is not decreased; on the contrary, it almost does not change or slightly increased from Period 2 to Period 3. Also the Figures 4.7.1 through 4.7.4 compare the intraday volatilities (not per hour) graphically and provide additional information on the finding that there is no extreme change in afternoon volatility during Period 3. Therefore, it is possible to argue that the decrease in afternoon hourly volatility is due to the increase in the number of trading hours. As a result, the 3rd null hypothesis ($H_{0,3}$) which states that concurrent trading with the NYSE during the last thirty minutes in the ISE increases the ISE's afternoon session intraday return volatility is rejected between Period 2 and Period 3.

For the night break intraday return volatility, only the Bartlett and Cochran tests report high decreases for all volume intervals, whereas the other three HOV tests generally give a "no change" result. Furthermore, examining Figures 4.6.1 through 4.6.4 which graph the intraday return hourly volatilities, it is not possible to observe any discernible trends of volatility change since the per hour volatility values are very small for the night break returns and it is very difficult to detect the changes in these graphs. On the other hand, Figures 4.7.1, 4.7.2, 4.7.3, and 4.7.4 which plot the intraday return volatilities (not per hour) reveal the decrease in the night break return volatility a lot more clearly. Also, this decrease becomes more important since the other intraday return volatilities in Period 3 are mostly parallel to their equivalents in Period 2. The volatilities in Period 3 are also observed to be generally higher than the ones in Period 2. In order to provide additional evidence for these trends observed in Figures 4.7.1 through 4.7.4, it is a good idea to compare the variance ratios. Period 3 to Period 2 average variance ratios of the intraday returns are 0.78, 1.04, 1.46, and 1.08 for night break, morning, daybreak, and afternoon session returns, respectively. These numbers suggest that night break volatility decreases while all other intraday return volatilities mostly do not change or even increase. This result is in line with what was expected in Hypothesis $H_{0,5}$ which states that concurrent trading with the NYSE during the last thirty minutes of trading in the ISE decreases ISE's overnight close-to-open return volatility in Period 3 compared to Period 2, and, therefore, this hypothesis is failed to be rejected.

CHAPTER 5

CONCLUSION

Three main causes that are held responsible in the literature for the high return volatilities are the trading mechanism, information flow, and the specialists' monopoly power in a market. In this study, the effects of opening trading mechanism and information flow on return volatility are examined. The non-existence of a specialist in the Istanbul Stock Exchange and two important regulatory changes that took place on February 2, 2007 and September 7, 2007 provide unique opportunities to investigate the effects of trading mechanism and information flow on return volatility. First, on February 2, 2007, the morning session opening mechanism was changed from a continuous auction to a call auction system. This change makes it possible to examine the isolated effect of a call auction trading mechanism on stock return volatility since there are no other structural or regulatory changes in the ISE during the 14-month window surrounding this change. Second, on September 7, 2007, the afternoon session trading hours are extended by half an hour and this change created a concurrent trading period of thirty minutes with the New York Stock Exchange. This extension makes it possible to investigate the effects of information flow on stock return volatility since the concurrent trading with the NYSE is expected to increase the information flow density right before the closing of the afternoon session.

The study uses data on the daily morning and afternoon session opening and closing prices and trading volumes during the July 2006 and April 2008 period. In order to make sure that the sample stocks have greater trading frequency and hence are affected less by non-synchronous trading, the sample is restricted to only those stocks that are included in the ISE-100 index without interruption during the same period. The analyses are carried out by using five different "homogeneity of variance" tests: Bartlett Test, Brown and Forsythe Test, Levene Test, O'Brien Test, and Cochran Test.

The results show that the call auction trading mechanism has a decreasing effect on the morning open-to-open interday volatility and morning intraday volatility for low-volume stocks but it does not have an obvious effect on the same type of volatilities for high volume stocks. It is known in the literature that the price discovery process takes much longer for low volume stocks and this creates high volatility for these stocks. Therefore, it is plausible to interpret the findings as evidence of the call auction trading mechanism helping to create a more efficient price discovery process for especially the low-volume stocks and thereby helping to reduce their periodic volatility.

Another finding of this study provides evidence that the increased information flow caused by concurrent trading with the NYSE towards the end of the trading day increases the afternoon close-to-close interday volatility for high volume stocks while it does not have such an effect on low-volume stocks. There may be two explanations for this finding:

1) High volume stocks have a greater proportion of foreign investors who have internationally diversified portfolios and, therefore, their trading decisions are more dependent on international financial dynamics.

2) The companies whose stocks have a high trading volume have closer commercial relationships and financial dependencies with the US firms and markets.

Although the testing of these explanations is beyond the scope of this study, it certainly provides an excellent opportunity for further research.

Despite the increase in afternoon close-to-close return volatility for high volume stocks, afternoon session intraday return volatility is not affected by the information flow. Neither the HOV tests nor the graphical observations or the variance ratios do not reveal any change in the intraday afternoon volatilities.

Finally, the overnight return volatility is decreased slightly with the extension of trading hours. Since some of the information that used to arrive during the overnight trading break now reaches the market before the close of trading, the density of information flow overnight is decreased. As expected, this decrease in information flow results in decreased overnight volatility.

Further research may analyze the effects of concurrent trading with the NYSE on interday return volatilities by examining the minute by minute price data for the ISE stocks. The last thirty minutes of the afternoon session before and after the extension on February 2, 2007 may provide detailed information on the subject when the tests are conducted with high frequency return data. More importantly, the recent change on October 19, 2009 that extends the afternoon trading hours by another thirty minutes, and the change on November 13, 2009 that changes the afternoon session opening from a continuous auction system to a call auction system are good opportunities that may be investigated in order to shed additional light on the subject and to verify the results of this study.

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APPENDICES

APPENDIX

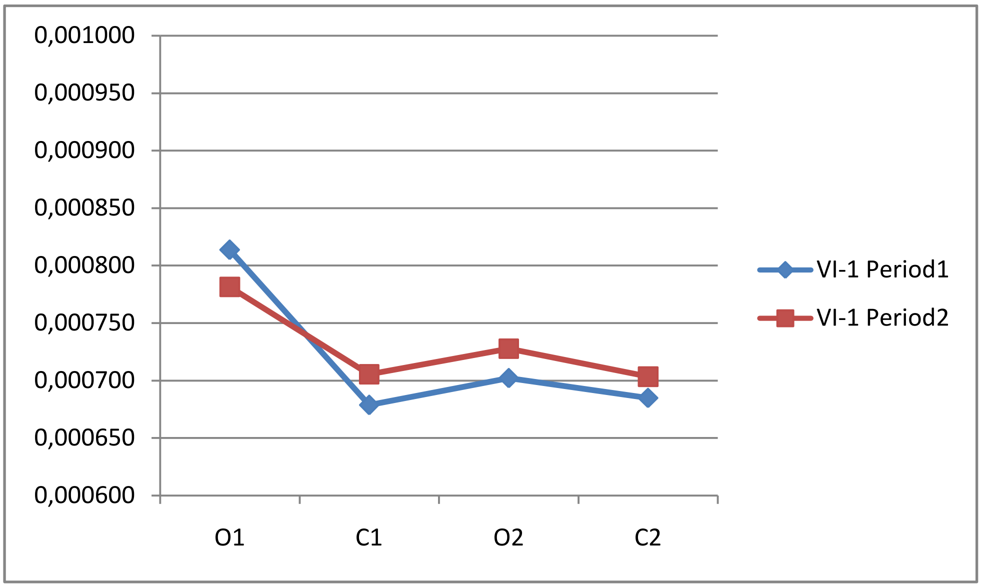

Figure 4.1.1 – Comparison of Period 2 against Period 1 in terms of interday return hourly volatilities for the 1st volume quartile.

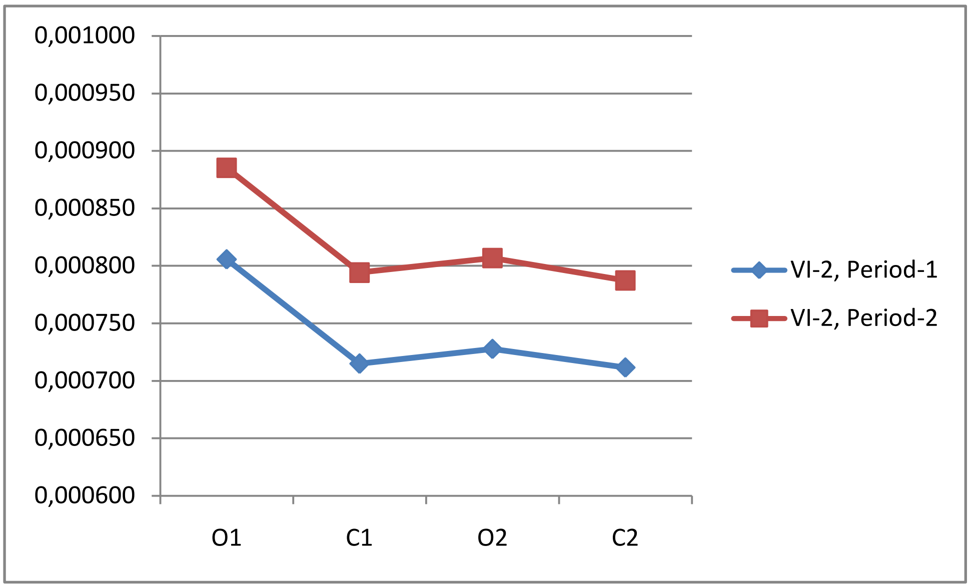

Figure 4.1.2 – Comparison of Period 2 against Period 1 in terms of interday return hourly volatilities for the 2nd volume quartile.

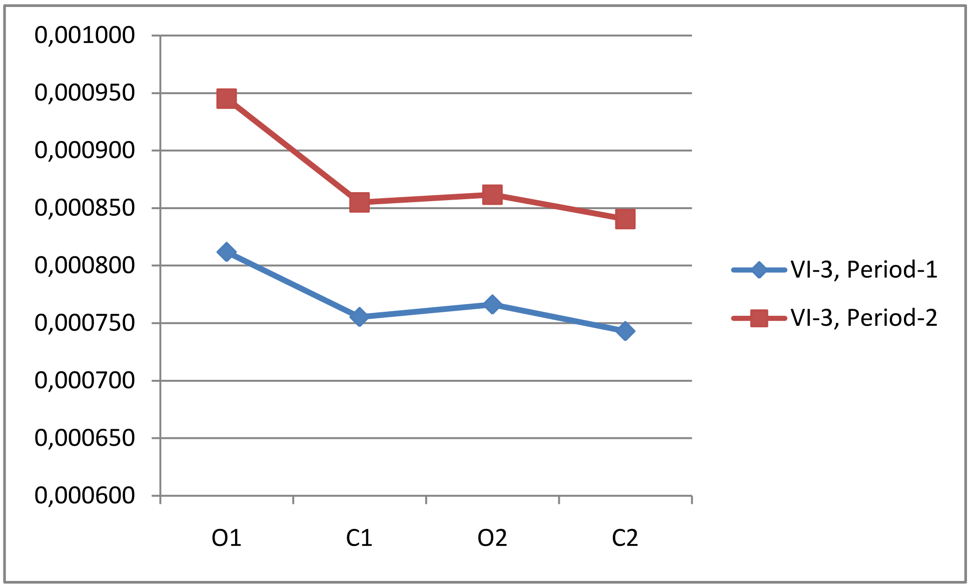

Figure 4.1.3 – Comparison of Period 2 against Period 1 in terms of interday return hourly volatilities for the 3rd volume quartile.

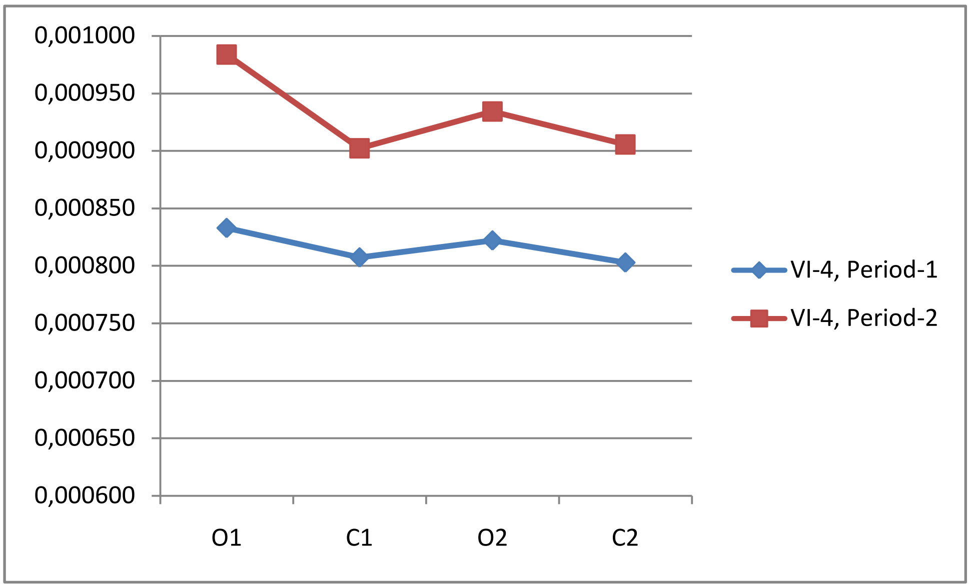

Figure 4.1.4 – Comparison of Period 2 against Period 1 in terms of interday return hourly volatilities for the 4th volume quartile.

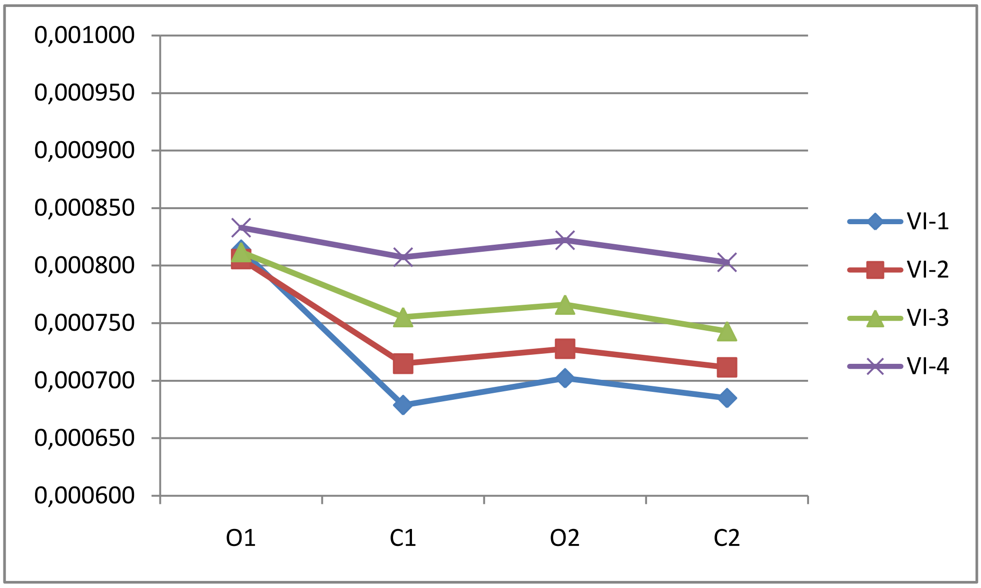

Figure 4.2.1 – Comparison of all volume quartiles in terms of interday return hourly volatilities for Period 1.

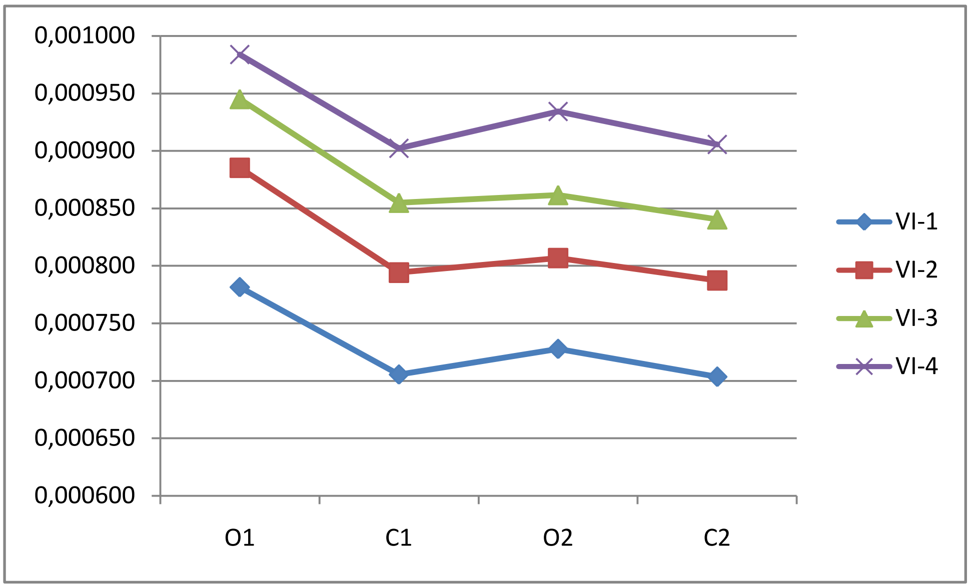

Figure 4.2.2 – Comparison of all volume quartiles in terms of interday return hourly volatilities for Period 2.

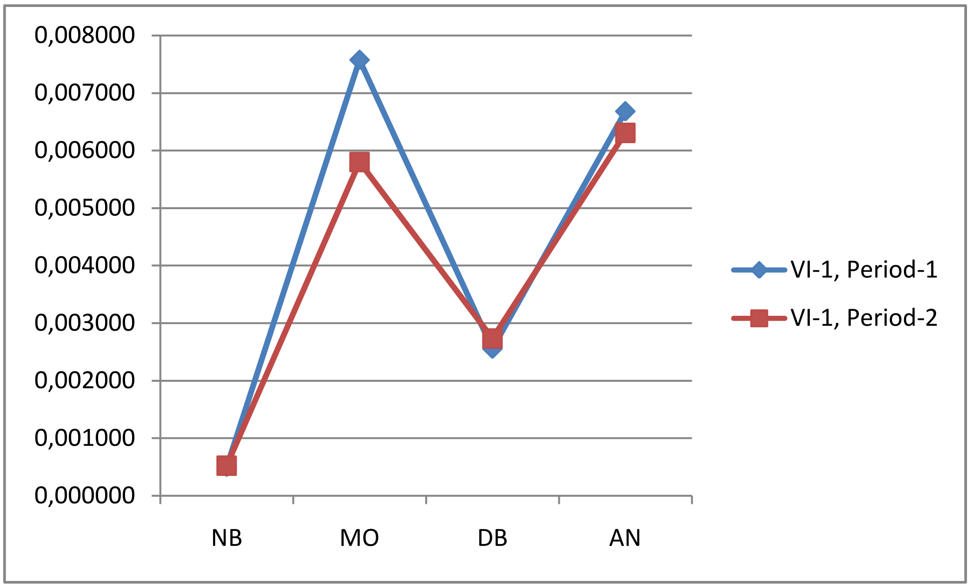

Figure 4.3.1 – Comparison of Period 2 against Period 1 in terms of intraday return hourly volatilities for the 1st volume quartile (VI-1).

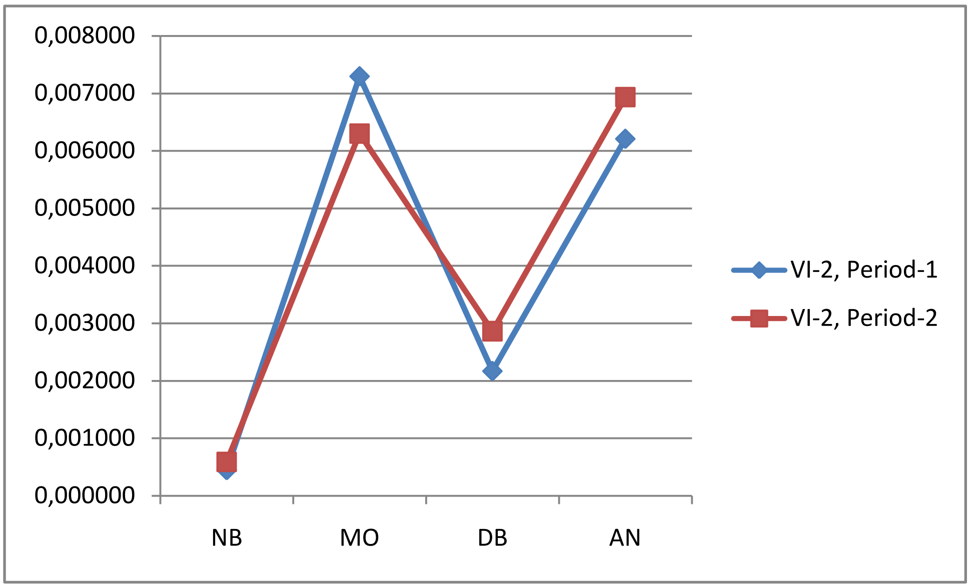

Figure 4.3.2 – Comparison of Period 2 against Period 1 in terms of intraday return hourly volatilities for the 2nd volume quartile (VI-2).

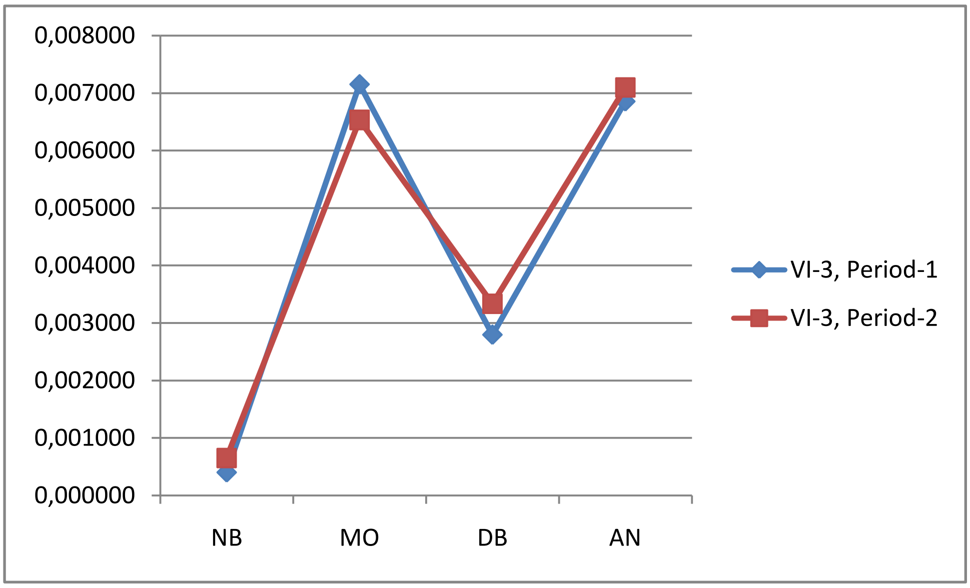

Figure 4.3.3 – Comparison of Period 2 against Period 1 in terms of intraday return hourly volatilities for the 3rd volume quartile (VI-3).

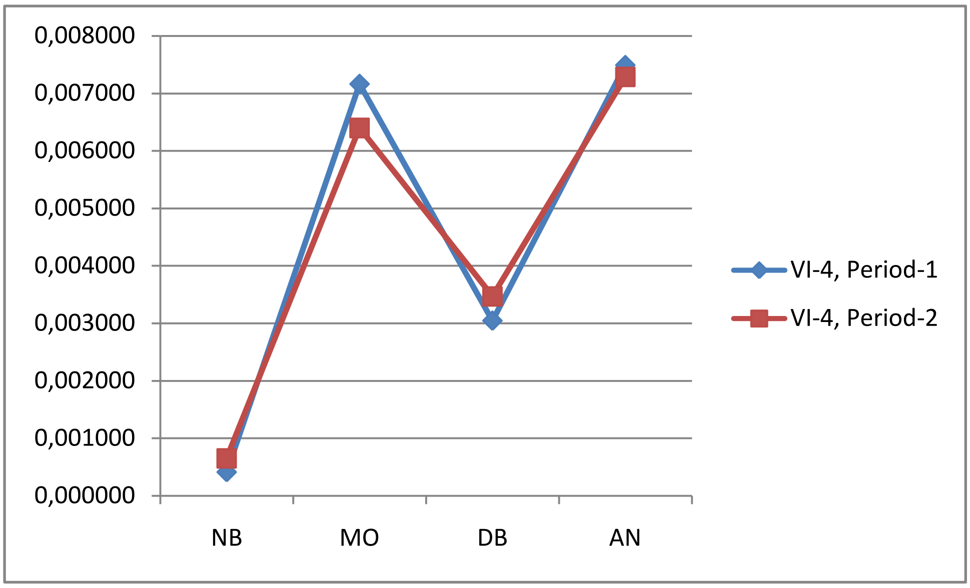

Figure 4.3.4 – Comparison of Period 2 against Period 1 in terms of intraday return hourly volatilities for the 4th volume quartile (VI-4).

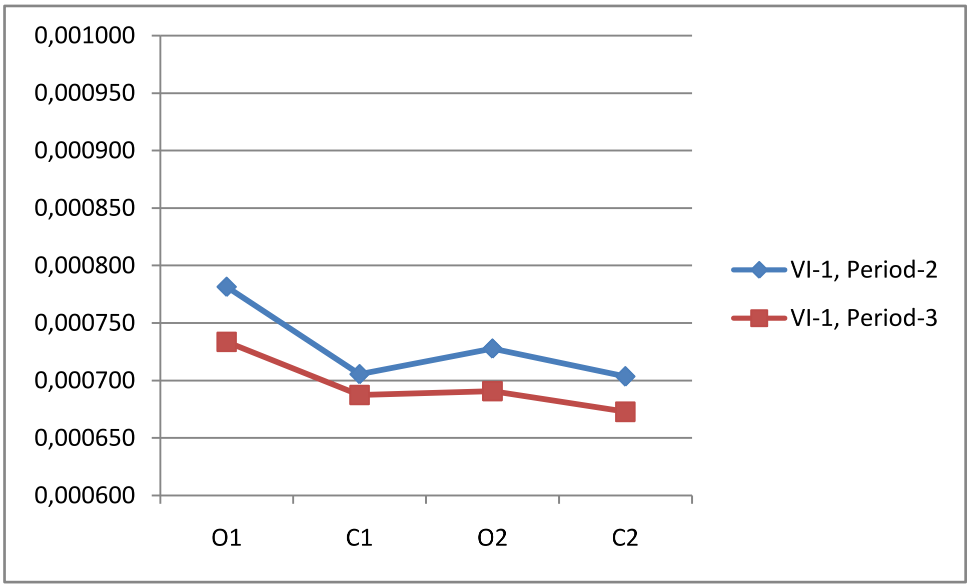

Figure 4.4.1 – Comparison of Period 3 against Period 2 in terms of interday return hourly volatilities for the 1st volume quartile.

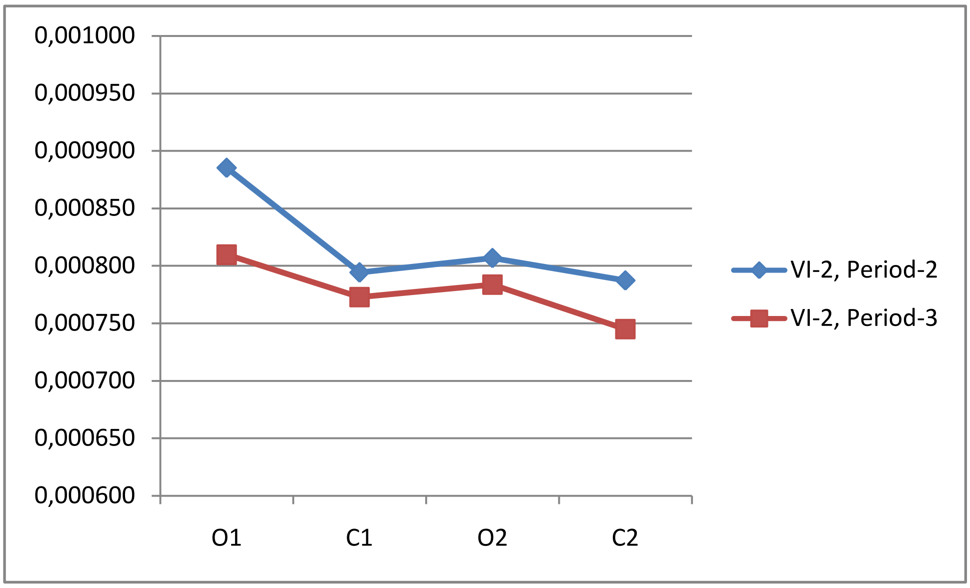

Figure 4.4.2 – Comparison of Period 3 against Period 2 in terms of interday return hourly volatilities for the 2nd volume quartile.

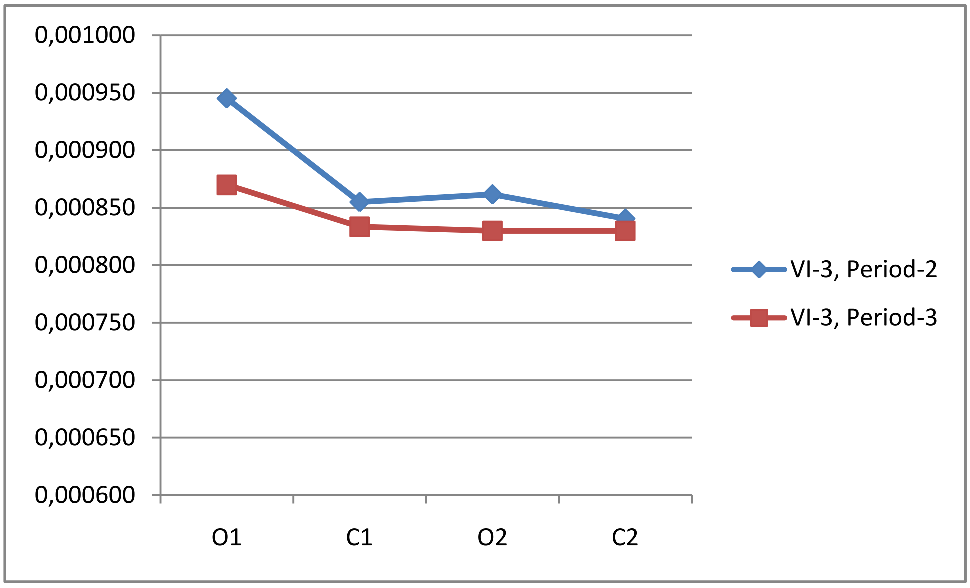

Figure 4.4.3 – Comparison of Period 3 against Period 2 in terms of interday return hourly volatilities for the 3rd volume quartile.

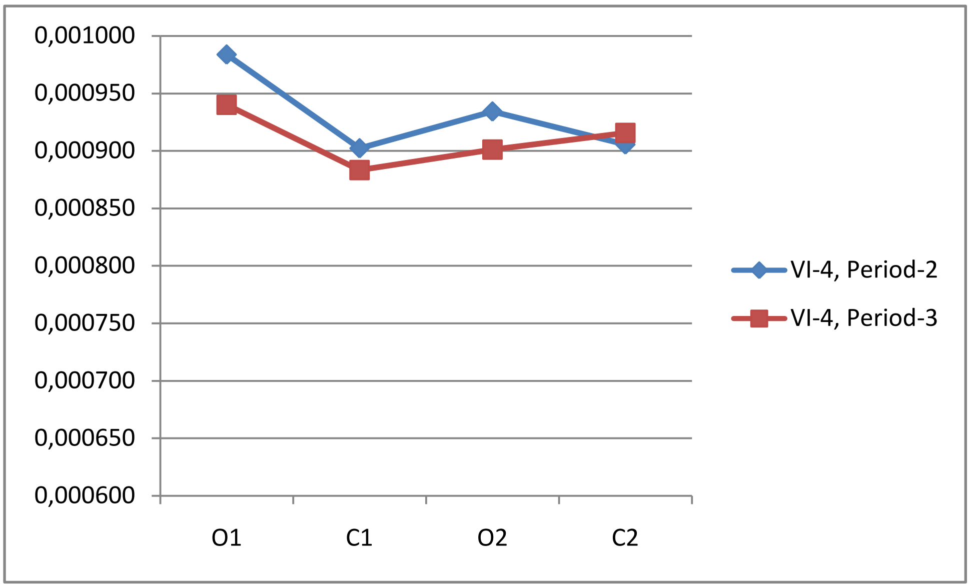

Figure 4.4.4 – Comparison of Period 3 against Period 2 in terms of interday return hourly volatilities for the 4th volume quartile.

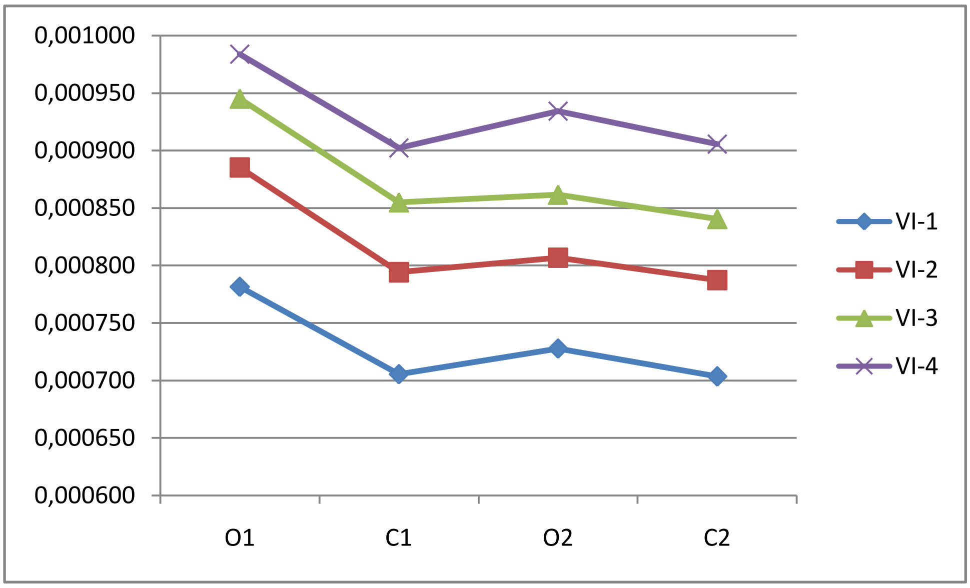

Figure 4.5.1 – Comparison of all volume quartiles in terms of interday return hourly volatilities for Period 2.

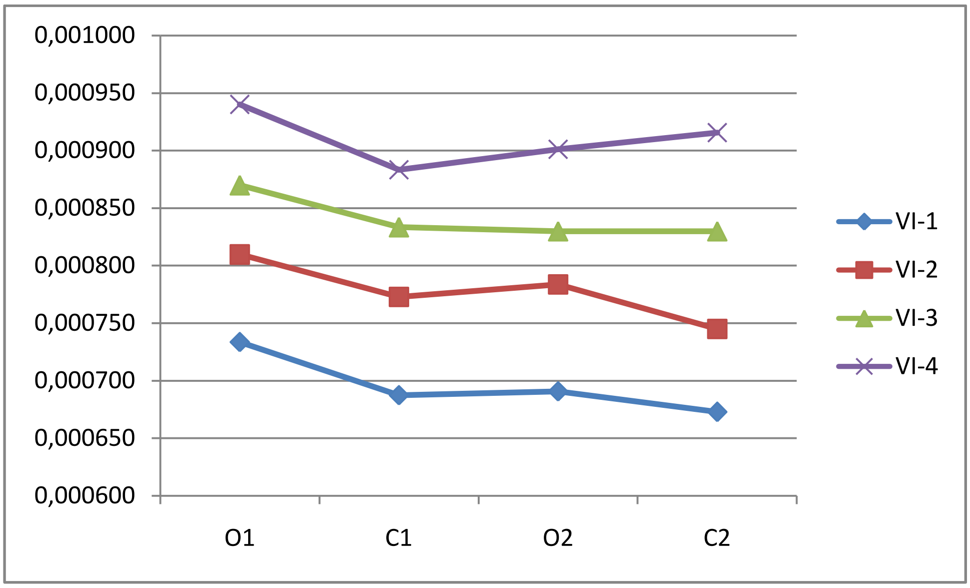

Figure 4.5.2 – Comparison of all volume quartiles in terms of interday return hourly volatilities for Period 3.

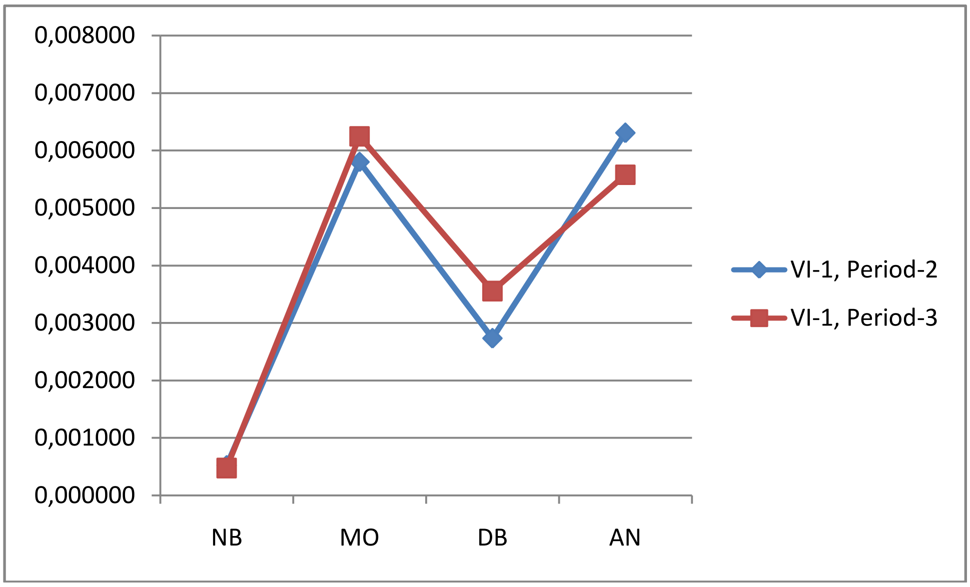

Figure 4.6.1 – Comparison of Period 3 against Period 2 in terms of intraday return hourly volatilities for the 1st volume quartile (VI-1).

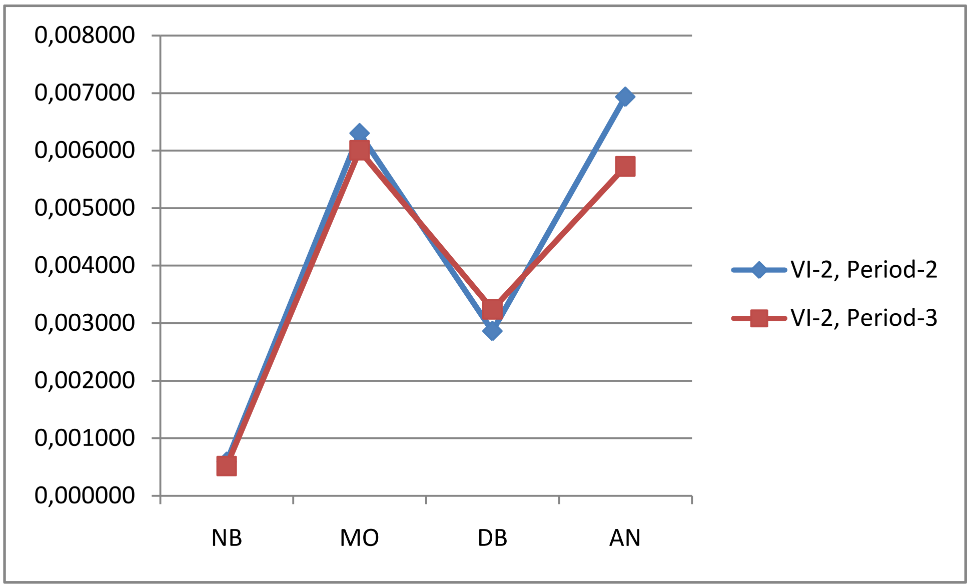

Figure 4.6.2 – Comparison of Period 3 against Period 2 in terms of intraday return hourly volatilities for the 2nd volume quartile (VI-2).

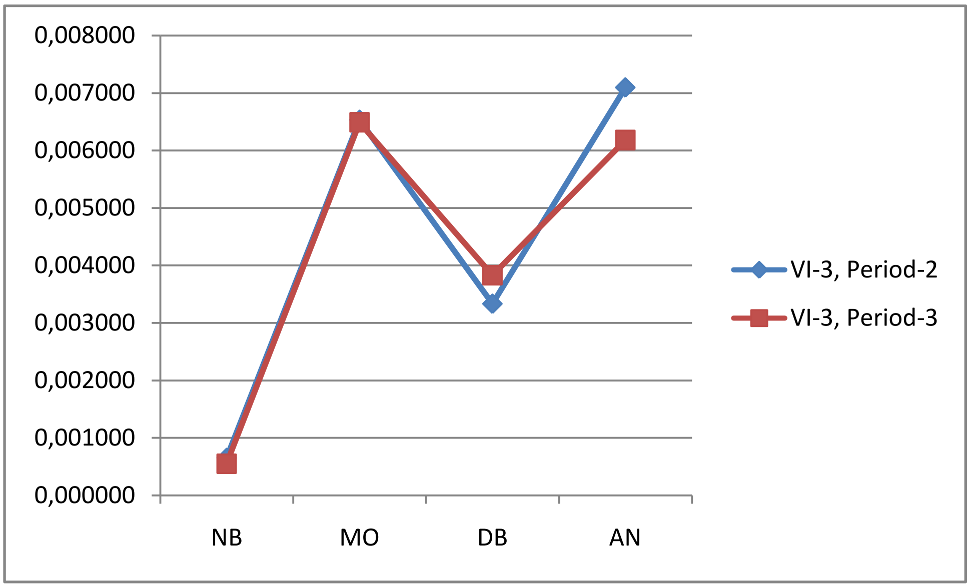

Figure 4.6.3 – Comparison of Period 3 against Period 2 in terms of intraday return hourly volatilities for the 3rd volume quartile (VI-3).

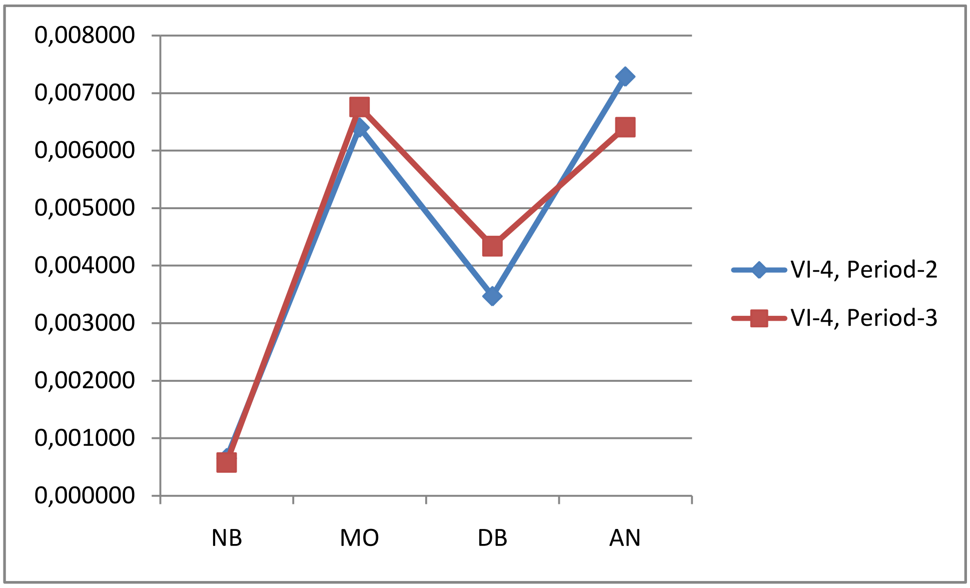

Figure 4.6.4 – Comparison of Period 3 against Period 2 in terms of intraday return hourly volatilities for the 4th volume quartile (VI-4).

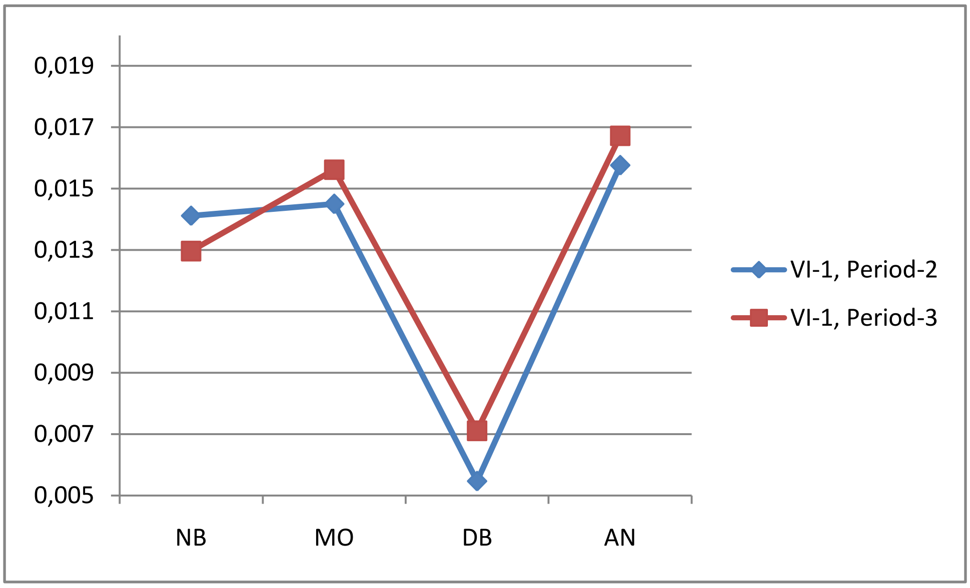

Figure 4.7.1 – Comparison of Period 3 against Period 2 in terms of intraday return volatilities for the 1st volume quartile (VI-1).

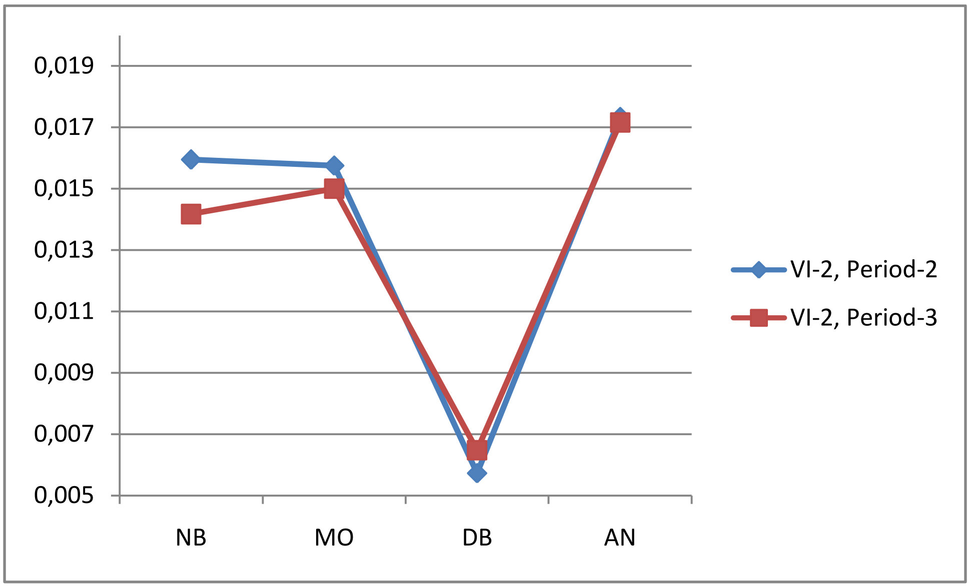

Figure 4.7.2 – Comparison of Period 3 against Period 2 in terms of intraday return volatilities for the 2nd volume quartile (VI-2).

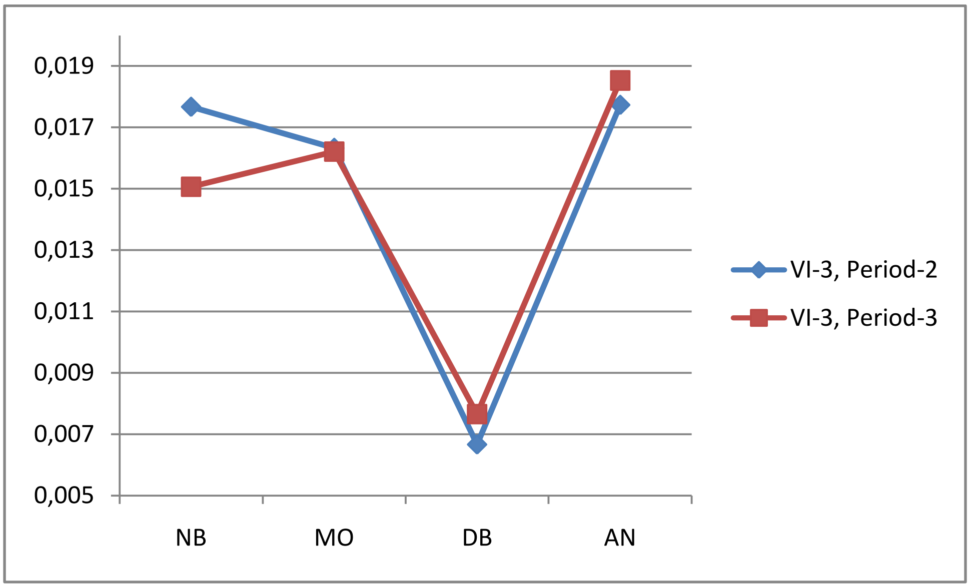

Figure 4.7.3 – Comparison of Period 3 against Period 2 in terms of intraday return volatilities for the 3rd volume quartile (VI-3).

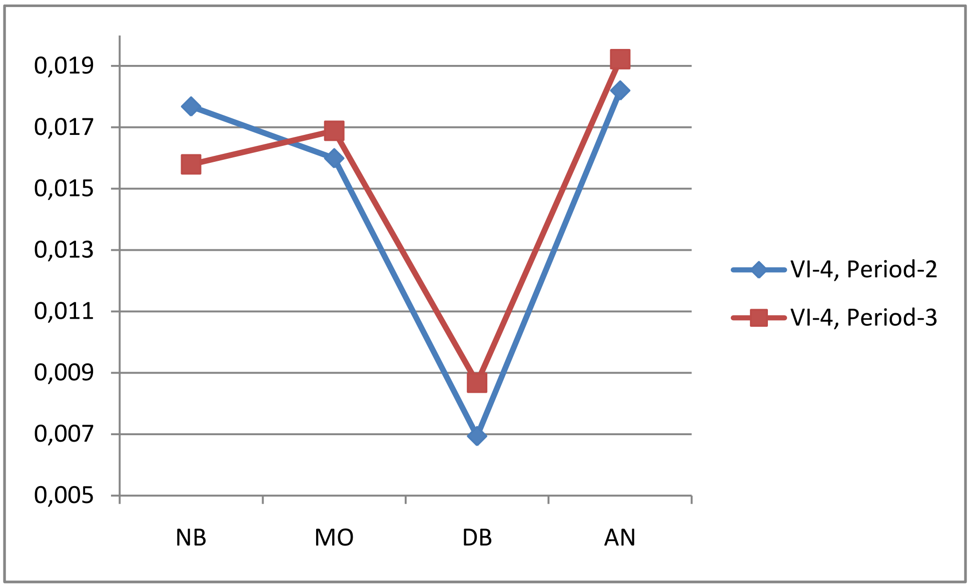

Figure 4.7.4 – Comparison of Period 3 against Period 2 in terms of intraday return volatilities for the 4th volume quartile (VI-4).

Table 4.3.1 Change in Return Volatility Following the Opening Mechanism Change from Continuous Auction to Call Auction

Subsample: Stocks in Volume Interval 0-25% (V.I.-1).

Numbers in the table represent the percentage of statistically significant changes from Period 1 to Period 2 in the direction indicated by the column heading. Each test-type/return-type subgroup is represented by three consecutive cells in a row and the percentages in these cells add up to 100. Significance level is 5 percent.

	Bartlett			**B&F**			**Levene**			**O'Brien**			**Cochran**		
	+	**0**	**-**	**+**	**0**	**-**	**+**	**0**	**-**	**+**	**0**	**-**	**+**	**0**	**-**
O1	16	58	26	5	84	11	5	79	16	5	84	11	16	53	32
C1	16	79	5	5	89	5	5	89	5	5	95	0	26	63	11
O2	21	68	11	5	89	5	5	89	5	5	95	0	21	58	21
C2	26	53	21	11	84	5	5	89	5	5	89	5	26	53	21
NB	37	32	32	21	74	5	16	84	0	5	95	0	47	21	32
MO	0	37	63	0	63	37	0	58	42	0	68	32	5	32	63
DB	21	63	16	32	42	26	26	74	0	11	79	11	32	47	21
AN	11	68	21	5	84	11	0	95	5	5	95	0	11	53	37

Table 4.3.2 Change in Return Volatility Following the Opening Mechanism Change from Continuous Auction to Call Auction

Subsample: Stocks in Volume Interval 25-50% (V.I.-2).

Numbers in the table represent the percentage of statistically significant changes from Period 1 to Period 2 in the direction indicated by the column heading. Each test-type/return-type subgroup is represented by three consecutive cells in a row and the percentages in these cells add up to 100. Significance level is 5 percent.

	Bartlett			**B&F**			**Levene**			**O'Brien**			**Cochran**		
	+	**0**	**-**	**+**	**0**	**-**	**+**	**0**	**-**	**+**	**0**	**-**	**+**	**0**	**-**
O1	33	56	11	28	72	0	28	72	0	17	83	0	39	50	11
C1	44	50	6	28	67	6	22	72	6	6	94	0	44	50	6
O2	33	61	6	11	83	6	11	83	6	0	99	0	39	56	6
C2	33	56	11	33	61	6	22	72	6	0	99	0	44	44	11
NB	72	11	17	50	39	11	56	39	6	28	67	6	72	11	17
MO	11	44	44	11	61	28	11	61	28	6	67	28	17	33	50
DB	61	28	11	61	22	17	61	28	11	50	39	11	72	17	11
AN	33	61	6	33	56	11	33	56	11	17	83	0	39	44	17

Table 4.3.3 Change in Return Volatility Following the Opening Mechanism Change from Continuous Auction to Call Auction

Subsample: Stocks in Volume Interval 50-75% (V.I.-3).

Numbers in the table represent the percentage of statistically significant changes from Period 1 to Period 2 in the direction indicated by the column heading. Each test-type/return-type subgroup is represented by three consecutive cells in a row and the percentages in these cells add up to 100. Significance level is 5 percent.

	Bartlett			**B&F**			**Levene**			**O'Brien**			**Cochran**		
	+	**0**	**-**	**+**	**0**	**-**	**+**	**0**	**-**	**+**	**0**	**-**	**+**	**0**	**-**
O1	37	53	11	21	74	5	21	74	5	21	68	11	37	53	11
C1	53	26	21	21	68	11	21	68	11	21	68	11	53	21	26
O2	47	26	26	32	58	11	32	58	11	21	74	5	47	21	32
C2	47	37	16	26	58	16	26	58	16	21	63	16	47	37	16
NB	79	21	0	68	32	0	47	53	0	21	79	0	79	21	0
MO	21	37	42	21	58	21	21	58	21	11	68	21	21	26	53
DB	37	42	21	32	37	32	26	63	11	32	53	16	37	42	21
AN	21	53	26	21	63	16	21	68	11	16	79	5	32	37	32

Table 4.3.4 Change in Return Volatility Following the Opening Mechanism Change from Continuous Auction to Call Auction

Subsample: Stocks in Volume Interval 75-100% (V.I.-4).

Numbers in the table represent the percentage of statistically significant changes from Period 1 to Period 2 in the direction indicated by the column heading. Each test-type/return-type subgroup is represented by three consecutive cells in a row and the percentages in these cells add up to 100. Significance level is 5 percent.

	Bartlett			**B&F**			**Levene**			**O'Brien**			**Cochran**		
	+	**0**	**-**	**+**	**0**	**-**	**+**	**0**	**-**	**+**	**0**	**-**	**+**	**0**	**-**
O1	50	39	11	28	72	0	28	72	0	28	72	0	61	28	11
C1	33	61	6	0	99	0	11	89	0	0	99	0	33	56	11
O2	39	50	11	17	83	0	17	83	0	11	89	0	39	50	11
C2	44	50	6	6	89	6	6	89	6	6	89	6	50	33	17
NB	78	11	11	50	44	6	67	28	6	33	61	6	83	6	11
MO	6	61	33	0	72	28	0	67	33	0	72	28	6	56	39
DB	33	33	33	39	22	39	33	44	22	22	50	28	33	33	33
AN	6	78	17	6	89	6	6	83	11	6	94	0	6	72	22

Table 4.4.1 Comparison of Period 1 and Period 2 Volatilities Following the Opening Mechanism Change from Continuous Auction to Call Auction

Subsample: Morning Open-to-Open Volatilities (O1).

Numbers in the table represent the percentage of statistically significant changes from Period 1 to Period 2 in the direction indicated by the column heading. Each test-type/volume-interval subgroup is represented by three consecutive cells in a row and the percentages in these cells add up to 100. Significance level is 5 percent.

	Bartlett			**B&F**			**Levene**			**O'Brien**			**Cochran**		
V.I.	**+**	**0**	**-**	**+**	**0**	**-**	**+**	**0**	**-**	**+**	**0**	**-**	**+**	**0**	**-**
1	16	58	26	5	84	11	5	79	16	5	84	11	16	53	32
2	33	56	11	28	72	0	28	72	0	17	83	0	39	50	11
3	37	53	11	21	74	5	21	74	5	21	68	11	37	53	11
4	50	39	11	28	72	0	28	72	0	28	72	0	61	28	11

Table 4.4.2 Comparison of Period 1 and Period 2 Volatilities Following the Opening Mechanism Change from Continuous Auction to Call Auction

Subsample: Morning Close-to-Close Volatilities (C1)

Numbers in the table represent the percentage of statistically significant changes from Period 1 to Period 2 in the direction indicated by the column heading. Each test-type/volume-interval subgroup is represented by three consecutive cells in a row and the percentages in these cells add up to 100. Significance level is 5 percent.

	Bartlett			**B&F**			**Levene**			**O'Brien**			**Cochran**		
V.I.	**+**	**0**	**-**	**+**	**0**	**-**	**+**	**0**	**-**	**+**	**0**	**-**	**+**	**0**	**-**
1	16	79	5	5	89	5	5	89	5	5	95	0	26	63	11
2	44	50	6	28	67	6	22	72	6	6	94	0	44	50	6
3	53	26	21	21	68	11	21	68	11	21	68	11	53	21	26
4	33	61	6	0	99	0	11	89	0	0	99	0	33	56	11

Table 4.4.3 Comparison of Period 1 and Period 2 Volatilities Following the Opening Mechanism Change from Continuous Auction to Call Auction

Subsample: Afternoon Open-to-Open Volatilities (O2)

Numbers in the table represent the percentage of statistically significant changes from Period 1 to Period 2 in the direction indicated by the column heading. Each test-type/volume-interval subgroup is represented by three consecutive cells in a row and the percentages in these cells add up to 100. Significance level is 5 percent.

	Bartlett			**B&F**			**Levene**			**O'Brien**			**Cochran**		
V.I.	**+**	**0**	**-**	**+**	**0**	**-**	**+**	**0**	**-**	**+**	**0**	**-**	**+**	**0**	**-**
1	21	68	11	5	89	5	5	89	5	5	95	0	21	58	21
2	33	61	6	11	83	6	11	83	6	0	99	0	39	56	6
3	47	26	26	32	58	11	32	58	11	21	74	5	47	21	32
4	39	50	11	17	83	0	17	83	0	11	89	0	39	50	11

Table 4.4.4 Comparison of Period 1 and Period 2 Volatilities Following the Opening Mechanism Change from Continuous Auction to Call Auction

Subsample: Afternoon Close-to-Close Volatilities (C2)

Numbers in the table represent the percentage of statistically significant changes from Period 1 to Period 2 in the direction indicated by the column heading. Each test-type/volume-interval subgroup is represented by three consecutive cells in a row and the percentages in these cells add up to 100. Significance level is 5 percent.

	Bartlett			**B&F**			**Levene**			**O'Brien**			**Cochran**		
V.I.	**+**	**0**	**-**	**+**	**0**	**-**	**+**	**0**	**-**	**+**	**0**	**-**	**+**	**0**	**-**
1	26	53	21	11	84	5	5	89	5	5	89	5	26	53	21
2	33	56	11	33	61	6	22	72	6	0	99	0	44	44	11
3	47	37	16	26	58	16	26	58	16	21	63	16	47	37	16
4	44	50	6	6	89	6	6	89	6	6	89	6	50	33	17

Table 4.5.1 Comparison of Period 1 and Period 2 Volatilities Following the Opening Mechanism Change from Continuous Auction to Call Auction

Subsample: Overnight Break Volatilities (NB)

Numbers in the table represent the percentage of statistically significant changes from Period 1 to Period 2 in the direction indicated by the column heading. Each test-type/volume-interval subgroup is represented by three consecutive cells in a row and the percentages in these cells add up to 100. Significance level is 5 percent.

	Bartlett			**B&F**			**Levene**			**O'Brien**			**Cochran**		
V.I.	**+**	**0**	**-**	**+**	**0**	**-**	**+**	**0**	**-**	**+**	**0**	**-**	**+**	**0**	**-**
1	37	32	32	21	74	5	16	84	0	5	95	0	47	21	32
2	72	11	17	50	39	11	56	39	6	28	67	6	72	11	17
3	79	21	0	68	32	0	47	53	0	21	79	0	79	21	0
4	78	11	11	50	44	6	67	28	6	33	61	6	83	6	11

Table 4.5.2 Comparison of Period 1 and Period 2 Volatilities Following the Opening Mechanism Change from Continuous Auction to Call Auction

Subsample: Morning Session Volatilities (MO)

Numbers in the table represent the percentage of statistically significant changes from Period 1 to Period 2 in the direction indicated by the column heading. Each test-type/volume-interval subgroup is represented by three consecutive cells in a row and the percentages in these cells add up to 100. Significance level is 5 percent.

	Bartlett			**B&F**			**Levene**			**O'Brien**			**Cochran**		
V.I.	**+**	**0**	**-**	**+**	**0**	**-**	**+**	**0**	**-**	**+**	**0**	**-**	**+**	**0**	**-**
1	0	37	63	0	63	37	0	58	42	0	68	32	5	32	63
2	11	44	44	11	61	28	11	61	28	6	67	28	17	33	50
3	21	37	42	21	58	21	21	58	21	11	68	21	21	26	53
4	6	61	33	0	72	28	0	67	33	0	72	28	6	56	39

Table 4.5.3 Comparison of Period 1 and Period 2 Volatilities Following the Opening Mechanism Change from Continuous Auction to Call Auction

Subsample: Day Break Volatilities (DB)

Numbers in the table represent the percentage of statistically significant changes from Period 1 to Period 2 in the direction indicated by the column heading. Each test-type/volume-interval subgroup is represented by three consecutive cells in a row and the percentages in these cells add up to 100. Significance level is 5 percent.

	Bartlett			**B&F**			**Levene**			**O'Brien**			**Cochran**		
V.I.	**+**	**0**	**-**	**+**	**0**	**-**	**+**	**0**	**-**	**+**	**0**	**-**	**+**	**0**	**-**
1	21	63	16	32	42	26	26	74	0	11	79	11	32	47	21
2	61	28	11	61	22	17	61	28	11	50	39	11	72	17	11
3	37	42	21	32	37	32	26	63	11	32	53	16	37	42	21
4	33	33	33	39	22	39	33	44	22	22	50	28	33	33	33

Table 4.5.4 Comparison of Period 1 and Period 2 Volatilities Following the Opening Mechanism Change from Continuous Auction to Call Auction

Subsample: Afternoon Session Volatilities (AN)

Numbers in the table represent the percentage of statistically significant changes from Period 1 to Period 2 in the direction indicated by the column heading. Each test-type/volume-interval subgroup is represented by three consecutive cells in a row and the percentages in these cells add up to 100. Significance level is 5 percent.

	Bartlett			**B&F**			**Levene**			**O'Brien**			**Cochran**		
V.I.	**+**	**0**	**-**	**+**	**0**	**-**	**+**	**0**	**-**	**+**	**0**	**-**	**+**	**0**	**-**
1	11	68	21	5	84	11	0	95	5	5	95	0	11	53	37
2	33	61	6	33	56	11	33	56	11	17	83	0	39	44	17
3	21	53	26	21	63	16	21	68	11	16	79	5	32	37	32
4	6	78	17	6	89	6	6	83	11	6	94	0	6	72	22

Table 4.6.1 Change in Return Volatility Following the Extension of Afternoon Trading Hours by Thirty Minutes

Subsample: Stocks in Volume Interval 0-25% (V.I.-1).

Numbers in the table represent the percentage of statistically significant changes from Period 2 to Period 3 in the direction indicated by the column heading. Each test-type/return-type subgroup is represented by three consecutive cells in a row and the percentages in these cells add up to 100. Significance level is 5 percent.

	Bartlett			**B&F**			**Levene**			**O'Brien**			**Cochran**		
	+	**0**	**-**	**+**	**0**	**-**	**+**	**0**	**-**	**+**	**0**	**-**	**+**	**0**	**-**
O1	16	63	21	0	89	11	0	89	11	0	95	5	16	58	26
C1	16	63	21	0	95	5	0	95	5	0	95	5	21	58	21
O2	16	58	26	5	89	5	5	89	5	0	95	5	16	58	26
C2	16	58	26	11	84	5	16	79	5	5	89	5	26	37	37
NB	5	63	32	16	74	11	5	84	11	0	95	5	16	47	37
MO	42	47	11	16	79	5	37	53	11	16	74	11	42	47	11
DB	58	26	16	32	53	16	37	58	5	37	58	5	68	16	16
AN	21	79	0	16	79	5	16	79	5	11	89	0	26	68	5

Table 4.6.2 Change in Return Volatility Following the Extension of Afternoon Trading Hours by Thirty Minutes

Subsample: Stocks in Volume Interval 25-50% (V.I.-2).

Numbers in the table represent the percentage of statistically significant changes from Period 2 to Period 3 in the direction indicated by the column heading. Each test-type/return-type subgroup is represented by three consecutive cells in a row and the percentages in these cells add up to 100. Significance level is 5 percent.

	Bartlett			**B&F**			**Levene**			**O'Brien**			**Cochran**		
	+	**0**	**-**	**+**	**0**	**-**	**+**	**0**	**-**	**+**	**0**	**-**	**+**	**0**	**-**
O1	11	61	28	11	72	17	11	72	17	0	89	11	11	50	39
C1	22	50	28	0	83	17	0	83	17	0	89	11	28	44	28
O2	22	44	33	0	89	11	0	83	17	0	94	6	33	33	33
C2	6	67	28	6	83	11	0	83	17	0	94	6	11	61	28
NB	11	44	44	6	89	6	6	94	0	0	94	6	11	44	44
MO	28	33	39	17	72	11	17	67	17	11	72	17	33	28	39
DB	33	44	22	33	50	17	17	78	6	11	89	0	44	33	22
AN	17	61	22	11	78	11	11	78	11	6	83	11	22	56	22

Table 4.6.3 Change in Return Volatility Following the Extension of Afternoon Trading Hours by Thirty Minutes

Subsample: Stocks in Volume Interval 50-75% (V.I.-3).

Numbers in the table represent the percentage of statistically significant changes from Period 2 to Period 3 in the direction indicated by the column heading. Each test-type/return-type subgroup is represented by three consecutive cells in a row and the percentages in these cells add up to 100. Significance level is 5 percent.

	Bartlett			**B&F**			**Levene**			**O'Brien**			**Cochran**		
	+	**0**	**-**	**+**	**0**	**-**	**+**	**0**	**-**	**+**	**0**	**-**	**+**	**0**	**-**
O1	21	58	21	11	84	5	11	84	5	5	89	5	21	53	26
C1	26	42	32	16	79	5	21	74	5	11	84	5	32	37	32
O2	26	42	32	21	68	11	21	68	11	11	79	11	26	37	37
C2	32	47	21	16	74	11	16	74	11	21	68	11	37	37	26
NB	16	42	42	11	79	11	11	79	11	11	89	0	16	42	42
MO	32	42	26	21	68	11	21	63	16	11	74	16	37	37	26
DB	63	21	16	58	37	5	37	47	16	42	53	5	63	21	16
AN	32	58	11	32	58	11	21	68	11	11	79	11	32	53	16

Table 4.6.4 Change in Return Volatility Following the Extension of Afternoon Trading Hours by Thirty Minutes

Subsample: Stocks in Volume Interval 75-100% (V.I.-4).

Numbers in the table represent the percentage of statistically significant changes from Period 2 to Period 3 in the direction indicated by the column heading. Each test-type/return-type subgroup is represented by three consecutive cells in a row and the percentages in these cells add up to 100. Significance level is 5 percent.

	Bartlett			**B&F**			**Levene**			**O'Brien**			**Cochran**		
	+	**0**	**-**	**+**	**0**	**-**	**+**	**0**	**-**	**+**	**0**	**-**	**+**	**0**	**-**
O1	11	67	22	0	94	6	0	99	0	6	94	0	11	61	28
C1	11	67	22	6	94	0	6	94	0	11	89	0	17	61	22
O2	11	61	28	6	94	0	6	94	0	11	89	0	11	61	28
C2	22	56	22	6	94	0	11	89	0	11	89	0	33	33	33
NB	22	44	33	0	89	11	0	94	6	0	94	6	22	44	33
MO	33	50	17	17	67	17	11	78	11	17	72	11	33	44	22
DB	56	39	6	44	39	17	28	67	6	28	72	0	61	33	6
AN	22	67	11	11	72	17	11	83	6	6	94	0	28	56	17

Table 4.7.1 Comparison of Period 2 and Period 3 Volatilities Following the Extension of Afternoon Trading Hours by Thirty Minutes

Subsample: Morning Open-to-Open Volatilities (O1)

Numbers in the table represent the percentage of statistically significant changes from Period 2 to Period 3 in the direction indicated by the column heading. Each test-type/volume-interval subgroup is represented by three consecutive cells in a row and the percentages in these cells add up to 100. Significance level is 5 percent.

	Bartlett			**B&F**			**Levene**			**O'Brien**			**Cochran**		
V.I.	**+**	**0**	**-**	**+**	**0**	**-**	**+**	**0**	**-**	**+**	**0**	**-**	**+**	**0**	**-**
1	16	63	21	0	89	11	0	89	11	0	95	5	16	58	26
2	11	61	28	11	72	17	11	72	17	0	89	11	11	50	39
3	21	58	21	11	84	5	11	84	5	5	89	5	21	53	26
4	11	67	22	0	94	6	0	99	0	6	94	0	11	61	28

Table 4.7.2 Comparison of Period 2 and Period 3 Volatilities Following the Extension of Afternoon Trading Hours by Thirty Minutes

Subsample: Morning Close-to-Close Volatilities (C1)

Numbers in the table represent the percentage of statistically significant changes from Period 2 to Period 3 in the direction indicated by the column heading. Each test-type/volume-interval subgroup is represented by three consecutive cells in a row and the percentages in these cells add up to 100. Significance level is 5 percent.

	Bartlett			**B&F**			**Levene**			**O'Brien**			**Cochran**		
V.I.	**+**	**0**	**-**	**+**	**0**	**-**	**+**	**0**	**-**	**+**	**0**	**-**	**+**	**0**	**-**
1	16	63	21	0	95	5	0	95	5	0	95	5	21	58	21
2	22	50	28	0	83	17	0	83	17	0	89	11	28	44	28
3	26	42	32	16	79	5	21	74	5	11	84	5	32	37	32
4	11	67	22	6	94	0	6	94	0	11	89	0	17	61	22

Table 4.7.3 Comparison of Period 2 and Period 3 Volatilities Following the Extension of Afternoon Trading Hours by Thirty Minutes

Subsample: Afternoon Open-to-Open Volatilities (O2)

Numbers in the table represent the percentage of statistically significant changes from Period 2 to Period 3 in the direction indicated by the column heading. Each test-type/volume-interval subgroup is represented by three consecutive cells in a row and the percentages in these cells add up to 100. Significance level is 5 percent.

	Bartlett			**B&F**			**Levene**			**O'Brien**			**Cochran**		
V.I.	**+**	**0**	**-**	**+**	**0**	**-**	**+**	**0**	**-**	**+**	**0**	**-**	**+**	**0**	**-**
1	16	58	26	5	89	5	5	89	5	0	95	5	16	58	26
2	22	44	33	0	89	11	0	83	17	0	94	6	33	33	33
3	26	42	32	21	68	11	21	68	11	11	79	11	26	37	37
4	11	61	28	6	94	0	6	94	0	11	89	0	11	61	28

Table 4.7.4 Comparison of Period 2 and Period 3 Volatilities Following the Extension of Afternoon Trading Hours by Thirty Minutes

Subsample: Afternoon Close-to-Close Volatilities (C2)

Numbers in the table represent the percentage of statistically significant changes from Period 2 to Period 3 in the direction indicated by the column heading. Each test-type/volume-interval subgroup is represented by three consecutive cells in a row and the percentages in these cells add up to 100. Significance level is 5 percent.

	Bartlett			**B&F**			**Levene**			**O'Brien**			**Cochran**		
V.I.	+	**0**	**-**	+	**0**	**-**	+	**0**	**-**	+	**0**	**-**	+	**0**	**-**
1	16	58	26	11	84	5	16	79	5	5	89	5	26	37	37
2	6	67	28	6	83	11	0	83	17	0	94	6	11	61	28
3	32	47	21	16	74	11	16	74	11	21	68	11	37	37	26
4	22	56	22	6	94	0	11	89	0	11	89	0	33	33	33

Table 4.8.1 Comparison of Period 2 and Period 3 Volatilities Following the Extension of Afternoon Trading Hours by Thirty Minutes

Subsample: Overnight Break Volatilities (NB)

Numbers in the table represent the percentage of statistically significant changes from Period 2 to Period 3 in the direction indicated by the column heading. Each test-type/volume-interval subgroup is represented by three consecutive cells in a row and the percentages in these cells add up to 100. Significance level is 5 percent.

	Bartlett			**B&F**			**Levene**			**O'Brien**			**Cochran**		
V.I.	**+**	**0**	**-**	**+**	**0**	**-**	**+**	**0**	**-**	**+**	**0**	**-**	**+**	**0**	**-**
1	5	63	32	16	74	11	5	84	11	0	95	5	16	47	37
2	11	44	44	6	89	6	6	94	0	0	94	6	11	44	44
3	16	42	42	11	79	11	11	79	11	11	89	0	16	42	42
4	22	44	33	0	89	11	0	94	6	0	94	6	22	44	33

Table 4.8.2 Comparison of Period 2 and Period 3 Volatilities Following the Extension of Afternoon Trading Hours by Thirty Minutes

Subsample: Morning Session Volatilities (MO)

Numbers in the table represent the percentage of statistically significant changes from Period 2 to Period 3 in the direction indicated by the column heading. Each test-type/volume-interval subgroup is represented by three consecutive cells in a row and the percentages in these cells add up to 100. Significance level is 5 percent.

	Bartlett			**B&F**			**Levene**			**O'Brien**			**Cochran**		
V.I.	**+**	**0**	**-**	**+**	**0**	**-**	**+**	**0**	**-**	**+**	**0**	**-**	**+**	**0**	**-**
1	42	47	11	16	79	5	37	53	11	16	74	11	42	47	11
2	28	33	39	17	72	11	17	67	17	11	72	17	33	28	39
3	32	42	26	21	68	11	21	63	16	11	74	16	37	37	26
4	33	50	17	17	67	17	11	78	11	17	72	11	33	44	22

Table 4.8.3 Comparison of Period 2 and Period 3 Volatilities Following the Extension of Afternoon Trading Hours by Thirty Minutes

Subsample: Day Break Volatilities (DB)

Numbers in the table represent the percentage of statistically significant changes from Period 2 to Period 3 in the direction indicated by the column heading. Each test-type/volume-interval subgroup is represented by three consecutive cells in a row and the percentages in these cells add up to 100. Significance level is 5 percent.

	Bartlett			**B&F**			**Levene**			**O'Brien**			**Cochran**		
V.I.	**+**	**0**	**-**	**+**	**0**	**-**	**+**	**0**	**-**	**+**	**0**	**-**	**+**	**0**	**-**
1	58	26	16	32	53	16	37	58	5	37	58	5	68	16	16
2	33	44	22	33	50	17	17	78	6	11	89	0	44	33	22
3	63	21	16	58	37	5	37	47	16	42	53	5	63	21	16
4	56	39	6	44	39	17	28	67	6	28	72	0	61	33	6

Table 4.8.4 Comparison of Period 2 and Period 3 Volatilities Following the Extension of Afternoon Trading Hours by Thirty Minutes

Subsample: Afternoon Session Volatilities (AN)

Numbers in the table represent the percentage of statistically significant changes from Period 2 to Period 3 in the direction indicated by the column heading. Each test-type/volume-interval subgroup is represented by three consecutive cells in a row and the percentages in these cells add up to 100. Significance level is 5 percent.

	Bartlett			**B&F**			**Levene**			**O'Brien**			**Cochran**		
V.I.	**+**	**0**	**-**	**+**	**0**	**-**	**+**	**0**	**-**	**+**	**0**	**-**	**+**	**0**	**-**
1	21	79	0	16	79	5	16	79	5	11	89	0	26	68	5
2	17	61	22	11	78	11	11	78	11	6	83	11	22	56	22
3	32	58	11	32	58	11	21	68	11	11	79	11	32	53	16
4	22	67	11	11	72	17	11	83	6	6	94	0	28	56	17