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Trader Type Effects on the Volatility-Volume Relationship. Evidence from the KOSPI 200 Index Futures Market.

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Abstract

This paper examines empirically the volatility-volume relationship implied by various market microstructure models which associate movements in prices and trading volume with information, dispersion of beliefs and trading motives. Our unique dataset allows to investigate whether different types of traders (members vs non-members, institutional vs individual) have a positive or negative effect upon volatility. Our empirical results show that surprises in non-member investors' trading volume are positively related with volatility in most of the cases. These results are more reinforcing in the case of log-volume and generally consistent with existing theoretical and empirical evidence. As regards member investors, we primarily find that unexpected volume is positively related to volatility, providing further support for the argument that informed rational speculators exacerbate volatility especially when noise traders follow positive feedback strategies. Another result of our study is that the coefficients relating the unexpected component of open interest with volatility are uniformly negative, implying that an increase in open interest during the day lessens the impact of a volume shock in volatility. Finally, when we allow for time-to-maturity effects, non-member institutional investors are not associated with any movement in volatility while surprises in open interest are associated with more volatility towards the end of the contract life.

Keywords: futures markets; range-based volatility; financial crisis; foreign investors; trading volume

JEL classification: C32, C52, G12, G15.

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1 Introduction

The process of price discovery and information assimilation under different market settings has been the key issue on market microstructure research over the years (O'Hara, 1995). Several theoretical models attempt to associate movements in prices and trading volume with information, dispersion of beliefs and trading motives. For example, a positive correlation between price changes and trading volume is found in most of the theoretical market microstructure models which involve strategically interacting traders with asymmetric information and rationally formed expectations (Shalen, 1993).[1] On the empirical side, Karpoff (1987) cites 18 separate studies that document a positive contemporaneous correlation between trading volume and price volatility in a variety of financial markets including equities, futures, currencies, and Treasury bills. This paper aims to provide additional empirical evidence on the volatility-volume relationship implied by various market microstructure models.

Bessembinder and Seguin (1993) suggest that the volatility-volume relationship might depend on the type of trader after finding that trades causing changes in open interest have a larger effect on volatility than do trades that leave the open interest intact. Moreover, Daigler and Wiley (1999) found that using trader categories is a better way to describe the link between volatility and volume than total volume. Their empirical results for the futures market show that the general public drives the positive volatility-volume relationship whereas trading by clearing members and floor traders often exhibits an inverse relationship between volatility and volume. In line with these studies we investigate whether different types of traders (members vs non-members, institutional vs individual) have a positive or negative effect upon volatility. Another contribution of our study is to assess whether the behavior of different trader types changes around the expiration of the futures contracts. Hong (2000) argues that as the futures contract rolls to its expiration date less private information is impounded into the futures price and so, all else being equal, the futures price moves less as the contract expires. Moreover, the effect of changes in open interest on futures volatility will provide some evidence on the ability of the market to absorb trading volume shocks by the different types of trader.

Our unique dataset consists of trading volume for eight different types of domestic investors, foreign investors and open interest. We distinguish trading volume into four categories based on investor type and their access to the trading system. Using open interest in conjunction with volume data should provide insights into the price effects of market activity generated by informed versus uninformed traders

[1]Shalen (1993) developed a two period noisy rational expectations model of a futures market and showed that the dispersion of beliefs measures both the excess volatility and excess volume of trade induced by the 'noisy' liquidity demand of futures hedgers. The intuition behind this is that when liquidity demand is uncertain speculators' estimates of future prices are dispersed since they cannot isolate private information, embedded in current prices, from hedging demands. Moreover, Shalen (1993) shows that the dispersion of expectations based on current information also contributes to the positive correlation between volume and absolute price changes.

(information) or hedgers versus speculators (motives). Our econometric technique (Schwert,1990, Davidian and Carroll, 1987) allows for unbiased estimation of the conditional volatility while at the same time documents partial relations between price revisions and shocks to volume and open interest in line with the Mixture of Distributions Hypothesis.[2] Additionally, the range (high, low, open, close) of daily prices for the KOSPI200 Index futures contract is available, which allows us to test the volatility-volume relationship for different and usually more efficient volatility proxies.

Our empirical results show that surprises in non-member investors' trading volume are positively related with volatility in most of the cases. These results are more reinforcing in the case of log-volume and generally consistent with the empirical findings of Daigler and Wiley (1999). Moreover, this finding is consistent with the theoretical models of Harris and Raviv (1993) and Shalen (1993), who find a positive relationship between absolute price changes and volume due to the dispersion of beliefs partly caused by different interpretation of common information and partly caused by the 'noisy' liquidity demand. As regards member investors, we primarily find that unexpected volume is positively related to volatility and this further supports the argument of Delong et al (1990b), that trading by informed rational speculators can drive prices further away from fundamentals if it triggers positive feedback strategies by noise traders.

For the entire period we report very significant relations between long-run changes in non-member investors' trading volume and volatility while after the financial crisis all these relations become insignificant. The results for the whole sample reveal a stabilizing role for non-member institutional and foreign investors while a destabilizing one for non-member individuals especially up to the period of the financial crisis. Interestingly, in the case of log volume, the moving average component of member institutional investors turns to negative, indicating a stabilizing role for these types of traders, at least up to the end of the crisis period. Further, it is worth mentioning the uniformly positive and significant relationship between volatility and the expected component of non-member individuals as well as the negative and significant relationship between volatility and the moving average component of non-member foreign investors' trading volume.

Another interesting result of our study is that the coefficients relating the unexpected component of open interest with volatility are uniformly negative, meaning that an increase in open interest during the day lessens the impact of a volume shock in volatility. This is consistent with the Bessembinder and Seguin (1993) results, who also report a negative relation between surprises in open interest and volatility. However, when we allow for time to maturity effects, surprises in open interest are associated with more volatility around the futures contract expiration probably due to the wider price range over which less

[2] Another type of theory attempting to explain the volatility-volume relationship is the Mixture of Distributions Hypothesis (MDH) in which information is used as the driving force that determines both price changes and volume (Clark, 1973, Epps and Epps, 1976, and Tauchen and Pitts, 1983).

informed investors trade as the contract rolls to its expiration and information asymmetry rises. Finally, the trading volume slope dummies reveal that non-member institutional investors are not associated with any movement in volatility towards the end of the contract life while surprises in the trading activity of non-member individual, foreign and member institutional investors are still positively associated with volatility over the same period.

Section 2 of this paper reviews the volatility-volume relation implied by market microstructure and trader behavior models and provides some empirical evidence. Section 3 summarizes the data while section 4 outlines the estimation procedure that we use. Section 5 provides the empirical results, and Section 6 presents the conclusion of this paper.

2 Information, Volatility and Trading Activity

2.1 Mixture of Distributions Hypothesis

The relation between volatility and volume has attracted a vast amount of theoretical and empirical research over the years. An early attempt to explain the volatility-volume relationship, without fully illustrating the information integration process, is due to Clark (1973), Epps and Epps (1976) and Tauchen and Pitts (1983). The mixture of distribution model posits a joint dependence of returns and volume on an underlying latent event or information flow variable such as the number of trades. Tauchen and Pitts (1983) find that the variance of the daily price change and the mean daily trading volume depend upon three factors: the average daily rate at which new information flows to the market, the extent to which traders disagree when they respond to new information and the number of active traders in the market. Their model predicts a positive volatility-volume relationship when the number of traders is fixed while a negative relation is predicted when the number of traders is growing, such as the case of T-bills futures market. Tauchen and Pitts (1983) do not consider how traders form their reservation prices or what they learn from the market price, issues subsequently explored by Hindy (1994).

Andersen (1996) suggested a modified version of the mixture of distribution hypothesis under a competitive market framework in which informational asymmetries and liquidity needs motivate trade in response to the arrival of new information. In Andersen's model trading volume differs from standard specifications due to microstructure effects as well as a Poisson, rather than normal, approximation to the limiting distribution of the binomial process that drives trading volume. Despite the overall satisfactory fit the simultaneous incorporation of returns and volume data results in a significant reduction in the estimated volatility persistence. The author also suggests that two or more information arrival processes may have different implications for volume and return volatility persistence. This idea was further pursued by Andersen and Bollerslev (1997) who demonstrate that by interpreting the volatility as a mixture of heterogeneous short-run information arrivals, the observed volatility process may exhibit long-run dependence. Li and Wu (2006) suggest a version of the mixture of distributions hypothesis which allows liquidity trading to affect price volatility. They find that the positive relationship between volatility and volume is primarily associated with information arrivals by informed trading. In addition controlling for the effect of informed trading, return volatility is negatively correlated with volume, which is consistent with the contention that liquidity trading increases market depth and lowers price volatility.

2.2 Information, Rational Expectations and Dispersion of Beliefs

Market microstructure theory has associated price changes and trading volume with the arrival of new information in the markets. The theoretical models that have been proposed try to explain the process of price discovery and information assimilation that occurs under a market setting that allows for different types of traders distinguished by the quality of information they hold, the dispersion of expectations they form based on this information and their trading motives. In the Glosten and Milgrom (1985) model the process over which new information integrates into prices requires an understanding of how the specialist and other uninformed investors learn from observing market information. [3] Therefore, the trading process itself generates information which might be related to information on the underlying asset value. For example a sequence of prices (Brown and Jennings , 1989, Grundy and McNichols, 1989) or trading volume (Blume, Easley and O'Hara, 1994, Schneider, 2009) can probably provide useful information to investors and hence affect the adjustment of prices to full information values

Much of the literature on how information is incorporated into prices as well as its signaling role focuses on rational expectations and dispersion of beliefs models. In rational expectations models, prices are affected both by private information and supply uncertainty (Grossman and Stiglitz, 1980).[4] Models of heterogeneous trader behavior can arise either because informed traders have different private information

[3] Glosten and Milgrom (1985) suggest a framework in which informed and uninformed investors trade sequentially a unit of the risky asset at the bid or ask prices quoted by the market maker. An important finding is that over time the sequence of trades reveals informed trader's information and the market maker's prices converge to the expected value of the asset given this information. The period over which the dynamic learning process takes place is referred to as the price discovery or information assimilation phase and is followed by a temporary market equilibrium phase when all agents agree on the price.

[4] Wang (1994) suggested a model in which the uninformed investors cannot perfectly identify the informed investors' motive behind their trade and they face the risk of trading against informed investors' private information. The risk of information based trading also dictates that volume and absolute value of excess returns are positively correlated, reflecting the price movement necessary to induce uninformed traders to take the other side of the trade. He and Wang (1995) find that volume generated by new private signals and public announcements is always accompanied by large price changes while volume generated by existing private information is not.Pfleiderer (1984) shows a positive contemporaneous relation between volume and price changes; however, this result is entirely due to non-speculative trading because the correlation between speculative trading volume and absolute price changes is zero.

(Hindy, 1994) or because they simply interpret commonly known data in a different way (Harris and Raviv, 1993). As some traders may obtain information, it is not always clear how that information relates to the ultimate value of the firm and hence not immediately apparent how unbiased or how valuable the information is. One example of this is that financial analysts often have different opinions regarding future movements of interest rates and stock prices, despite the fact that all these analysts have access to the same economic data.

Hindy (1994) suggests a model in the futures market which includes only informed traders who disagree in the interpretation of the private signals. He shows, using examples that this model is capable of producing expected volumes and price changes that are positively related, negatively related for all time periods, or have a relation that changes from positive to negative or vice versa over time. Holthaussen and Verrecchia (1988) propose a partially revealing rational expectations model of competitive trading in which a heterogeneous interpretation of a public information release results in price and volume reactions. The extent to which the information content (informedness) of an information signal makes investors revise their beliefs in the same (consensus) or opposite direction gives rise to different volatility-volume relationships. More specifically, the variance of price changes and trading volume tend to be positively related when the informedness effect dominates the consensus effect and tend to be negatively related when the consensus effect dominates the informdness effect.

The models reviewed above provide a wealth of volatility-volume relationships. If investors have an information advantage (informed) due to access to market economic data it is relatively likely to form homogenous expectations about the market movements as well as the fundamental characteristics of an asset. In such cases we would expect informed traders to buy and sell within a small range of prices around the fair value of the asset. Certainly this is not always true, as in the case of public news announcements expectations can be quite dispersed even among investors who have access to market economic data as well as in the case of informed investors' trading when noise traders follow positive feedback strategies (see next section). Moreover, investors who do not have access to order flow data (less informed) cannot interpret with precision the noisy signals from volume and price changes, resulting in a wider dispersion of beliefs. Consequently, less informed investors are likely to react to all changes in volume and price as it is difficult to differentiate short term liquidity (hedging) demand from changes in overall fundamental supply and demand. Despite this information asymmetry that arises, we will argue in the next section that less informed traders not only survive the market but they can also dominate it. Additionally uninformed investors' frequent revision of their beliefs can also cause the price fluctuations resulting from their trading to persist more than those of informed investors after the new information is revealed.

2.3 Noise Trading and Information

In this study, the member financial institutions characterized as securities companies represent the informed traders due to their direct access to the trading system. By comparison we define the non-member financial institutions, individual and foreign investors as uninformed or less informed as their orders are channeled through members' trading pits. Clearing members of the exchange enjoy lower trading costs and information advantages. Their direct access to the trading system provides them with short term information about pit dynamics such as trading activity at specific prices and price trends. In addition they have specific information about their own customers' supply and demand in the cash and futures markets. Furthermore, they benefit from increased information in the cash markets because of their access to trading screens and in house knowledge in these markets. As Daigler and Wiley (1999) argue this access to private information allows clearing members to better distinguish liquidity demand from fundamental information and to estimate current value more precisely, which translates into smaller dispersion of beliefs and less price volatility. The non-member investors do not enjoy such information advantages as member investors since they do not have direct access to the trading system. If they receive some information this happens on a delayed or a second hand basis. Since the non-member investors hold less information, we would expect them to have a greater dispersion of beliefs and to trade over a wider range of prices around the fair value of the futures contract.

The trading behavior associated with non-member investors is consistent with the noise literature (Black, 1986, DeLong, Shleifer, Summers and Waldman, 1990, 1991). Black (1986) argues that noise trading increases liquidity in the markets and also puts noise into the prices as they reflect both information and noise induced trading. DeLong et al. (1990a) show that the unpredictability of noise traders' beliefs creates excess risk and significantly reduces the attractiveness of arbitrage. In cases where arbitrageurs have short horizons noise trading can lead to a large divergence between market prices and fundamental values. DeLong et al. (1991) find that noise traders who form incorrect expectations about asset price variance can not only earn higher returns than do rational investors but also survive and dominate the market in terms of wealth in the long-run. DeLong et al (1990b) argue, despite the fact that rational speculation stabilizes prices, that trading by informed rational speculators can drive prices further away from fundamentals if it triggers positive feedback strategies by noise traders. The key point is that, although part of the price rise is rational, part of it results from rational speculators' anticipatory trades and from positive feedback traders' reaction to such trades. In such cases we would expect to find a positive relationship between informed investors' trading volume and volatility.

2.4 Empirical Evidence

A plethora of empirical studies have examined the relationship between volatility and volume in cash and futures markets and a positive contemporaneous relationship between the two variables is often documented (Karpoff, 1987). Gallant, Rossi and Tauchen (1992) find a positive contemporaneous volatility-volume relationship robust to non-normalities, stochastic volatility, and other forms of conditional heterogeneity. Bessembinder and Seguin (1992) find that equity volatility covaries positively with spot equity and futures equity trading volume with the unexpected component of spot trading volume being more effective. In a similar way, Bessembinder and Seguin (1993) examine the relationship between trading activity and volatility in eight futures markets. They find a strong positive relationship between contemporaneous volume (expected and unexpected) and volatility and that the impact of an unexpected volume shock is between 2 and 13 times greater than the effect of changes in expected volume. Moreover, they find that the expected open interest is negatively related to volatility in all markets, a result consistent with the belief that variations in open interest reflect changes in market depth.

Bessembinder and Seguin (1993) suggest that the volatility-volume relationship might also depend on the class of traders after finding that trades resulting in changes in open interest appear to have a larger impact on prices than do trades that leave the open interest unaltered. Daigler and Wiley (1999), in line with Bessembinder and Seguin's (1993) suggestion, try to investigate the impact of trader type on the futures volatility-volume relationship. They find that the positive volatility-volume relationship is driven by the general public, a group of traders distant from the trading floor, less informed and with greater dispersion of beliefs. On the other hand clearing members and floor traders often decrease volatility and this is attributed mainly to the informational advantage from holding a seat in the futures market. Moreover, Avramov, Chordia and Goyal (2006) show that informed (or contrarian) trades lead to a reduction in volatility while non-informational (or herding) trades lead to an increase in volatility. Bjonnes et al (2007) also find that the volume-volatility relation depends on the group of market participants trading. Specifically, institutional investors' trading volume has the highest correlation with volatility while trading by non-financial investors is not correlated with volatility at all when controlling for trading by other market participants.

3 Data description

Our database consists of daily data on high, low, open and closing prices of the KOSPI 200 Futures Index of the Korean stock exchange from the 3rd of May 1996 to 30th of September 2005 (2308 observations). Furthermore, for the same period, daily trading volume of futures contracts bought and sold by eight different types of domestic investors and total open interest is available. The different types of domestic investors consist of Securities, Insurance, Investment, Bank, Merchant and Mutual Fund, Pension Fund, Others and Individuals. Finally, daily trading volume data is also available for foreign investors not members of the Korean stock exchange.

3.1 Index futures volatility

The returns for the futures contracts traded on the KOSPI200 index are defined as $R_{F,t} = 100 * Ln(F_t/F_{t-1})$. The most widely used proxies for daily volatility using close to close prices are squared and absolute returns. Other volatility measures utilising range-based data have been suggested in the academic literature due to their higher efficiency compared to the aforementioned ones. The intuition behind range-based volatility estimators is that in case, just by chance, the open and closing prices are close to each other when the security price has fluctuated substantially throughout the day, then the absolute or squared return will indicate low volatility. Parkinson (1980) proposed the use of the range for estimating volatility while Garman and Klass (1980) combine the range with opening and closing prices to produce highly efficient volatility estimators. Further studies that try to improve the range-based volatility estimators include Beckers (1983), Rogers and Satchell (1991), Yang and Zhang (2000). Garman-Klass (1980) show that their volatility estimator is about eight times more efficient than using the close-to-close prices to measure volatility. The Garman-Klass estimator that we use in this study is defined as

$$\hat{\sigma}_t^{gk} = \frac{1}{2}\left[\mathrm{Ln}(High) - \mathrm{Ln}(Low)\right]^2 - 2\left[2Ln(2) - 1\right]\left[\mathrm{Ln}(Open) - \mathrm{Ln}(Close)\right]^2$$

where $\hat{\sigma}_t^{gk}$ is the Garman-Klass volatility, Ln is the natural logarithm and *High*, *Low*, *Open*, *Close* are the high, low, open and closing prices of the KOSPI200 Futures Index in the interval of a trading day. Brown (1990) argues that the opening and closing prices are highly influenced by microstructure effects and opposes their inclusion in estimators of volatility. Moreover, Alizadeh (1998) reveals little theoretical efficiency gain from combining the range with the opening and closing prices. For this reason, we estimate the range as

$$\hat{\sigma}_t^{range} = \max\ln(F_\tau) - \min\ln(F_\tau)$$

where $\tau = t-1, t-1+\frac{1}{n}, t-1+\frac{2}{n}, ..., t$ and n denotes the number trades within a single trading day. The properties of the range-based estimator depend on the level of trading activity. This means that the smaller the sampling interval of the price path is, the more accurate the range-based volatility estimator will be. Alizadeh et al (2002) argue in favor of using the range as volatility estimator as the return interval shrinks and discuss the very good performance of range-based volatility in the presence of microstructure noise. Shu and Zhang (2006) find that the range estimators are fairly robust toward microstructure effects and quite close to the daily integrated variance.[5] Andersen and Bollerslev (1998) show that the daily range is about as efficient a volatility proxy as the realized volatility based on returns sampled every three-four hours. Upon availability of high frequency data for the Korean Stock spot/futures market and to provide more robustness to our results, we aim to estimate realized volatility proxies either using minute-by-minute squared returns (Andersen et al 2001) or squared ranges (Martens and vanDijk, 2007, Christensen and Podolskij, 2007). Various measures of range-based volatility have been employed in empirical finance research (Daigler and Wiley,1999, Kawaller et al., 2001, Wang, 2002, Chen and Daigler, 2008).[6]

3.2 Trading volume

In this study we use total trading volume as well as disaggregated data of four different types of investors, namely member institutional (securities companies), non-member institutional (non securities), non-member individual and non-member foreign investors. We select these trader type volume categories according to their proximity and access to the trading system. Daigler and Wiley (1999) argue that clearing members trade to benefit from mispricing of the futures contracts as well as for long term hedging and arbitrage purposes. Securities companies are members of the Korean Stock Exchange and they have direct access to the trading system. This gives an information advantage to this type of investors as they have up to the minute information about the supply and demand orders of the futures and cash markets. Additionally, Kodres and Pritsker (1997) show that many smaller insurance companies and pension funds are not members of the exchange they trade in, as their trading activity is insufficient to justify a seat. We form a volume category matching closely this type of institutional investors and this is an aggregation of the trading volume generated by Insurance, Investment, Bank, Merchant banks and Mutual Fund, Pension Fund and Other non-member institutional investors. Their share of trading volume is small compared to member institutional investors and mainly they intend to trade for hedging and speculative purposes. The amount of information available for non-member investors in the Korean futures market is limited as anyone wishing to place an order is required to open an account for futures and options trading with a member firm. Non-member institutional, foreign and individual traders are those least likely to have access to temporary private information such as trader's risk aversion, trading constraints and the supply and distribution of the underlying asset which affect prices in these markets

[5] Realized volatility is estimated as the sum of squared high-frequency returns over a given sampling period (e.g., five-minute returns) and is subject to microstructure biases due to uneven trading times, bid-ask bounces and stale prices (Andersen et al, 2001).

[6] Chou (2005) propose a Conditional Autoregressive Range (CARR) model for the range (defined as the difference between the high and low prices). In order to be in line with previous research (Daigler and Wiley, 1999, Kawaller et al., 2001, and Wang, 2007) in what follows we model Garman-Klass volatility as an autoregressive type of process taking into account bidirectional feedback between volume and volatility, long memory characteristics and GARCH effects.

(Ito, Lyons and Melvin, 1998, Philips and Weiner, 1994). Based on the information available as well as the different trading motives we would expect to find volatility-volume relationships that are not uniform over the different type of investors trading in the KSE futures market.

Several studies in the volume-volatility literature suggest detrending trading volume into expected and unexpected components (see Appendix for more details). This separation allows us to examine the extent to which surprises versus trend activity affect the volatility-volume relationship. A number of detrending methods have been suggested in the literature depending on whether the underlying process is trend or stochastic stationary. As is evident from Table 1, the assumption of a constant growth rate for trader type volume seems quite restrictive. For this reason we employ a detrending procedure that allows for a stochastic trend component in volume as well as an autocorrelated disturbance term (Andersen, 1996). In other words, we filter out the trend in volume while at the same time retaining the correlated deviations around this trend, which are often associated with increased information arrival intensity in market microstructure theory. Open interest is also partitioned into expected and unexpected components once we first deduct the moving average component.

In Table 1 we report descriptive statistics regarding the percentage breakdown of total volume into the four trader categories underlined above and the cross correlations between the identified trader categories.[7] Average total trading volume was 0.62 trillion Korean won for the two years ending in 1997 and increased to 23.41 trillion won for the two years ending in 2005. This immense increase in trading volume over the years is not shared evenly across the different type of traders. Member institutional investors' average percentage of trading was 69.60 percent for the two years ending in 1997 and thereafter decreases gradually to 23.97 percent for the two years ending in 2005. As regards non-member investors, individuals' percentage of trading volume doubled after the financial crisis and remains almost at the same levels over the end of 2005. The presence of foreign investors in the index futures market almost doubles every two year period after the Asian financial crisis to match the performance of member institutional investors from the beginning of 2004. As regards non-member institutional investors' trading, their participation gradually increases until the end of 2001, reaching a level of 10 percent, while towards the end of the sample their participation fell to 6.37 percent.

[7] Wiley and Daigler (1998) examine the characteristics and relations among four categories of traders. They find that after scalpers, the general public trades most frequently and there are strong coincident correlations between pairs of groups such as scalpers, clearing members and the general public. Furthermore, they find that any information about prior days trading volume, both within and across trader categories, is useful for only a few days

Table 1. Descriptive Statistics

This table presents daily volume descriptive statistics for four categories of investors. The categories are: Member Institutional Investors (MFI), Non-member Institutional (NMFI), Non-member Individual Investors (NMI) and Non-member Foreign Investors (NMF). Panel A shows the breakdown in percent of volume by category of traders and the total daily volume (in trillion Korean won). Percentages sum to 100 over each period.Panel B provides the cross correlations between each pair of volume variables. An ARIMA(0,0,10) model calculates the expected (predicted) value using the 10-day moving average of the change in volume The unexpected volume is detrended volume minus expected volume.

Panel A: Average Trader Category Volume as a percentage of Total Volume

Investor Type	MFI	NMFI	NMI	NMF	Total
Period					
1996-97	69.60%	4.33%	23.19%	2.88%	0.6158
1998-99	41.63%	7.13%	48.59%	2.65%	4.8226
2000-01	33.49%	10.09%	49.76%	6.66%	8.1794
2002-03	24.42%	8.39%	53.69%	13.5%	19.0362
2004-05	23.97%	6.37%	47.11%	22.55%	23.4083

Panel B: Cross - Correlations between Trader Categories

Series	MFI - NMFI	MFI - NMI	MFI - NMF	NMFI - NMI	NMFI - NMF	NMI-NMF
Total	0.828	0.858	0.769	0.821	0.739	0.804
Moving Av.	0.935	0.925	0.873	0.933	0.793	0.898
Expected	0.521	0.656	0.388	0.414	0.579	0.320
Unexpected	0.502	0.608	0.458	0.380	0.593	0.397

As regards cross correlations between traders, amongst the non-member investors, individuals show the highest correlation with member investors over all trading volume components. Moreover, the pair correlations between non-member investors reveal that the total and moving average components of institutional and individual investors are highly correlated but the correlations concerning the expected and unexpected components are the highest among institutional and foreigner investors.

4 Estimation procedures

The econometric techniques that we use in this paper are mainly parametric and consistent with previous studies that investigate the impact of trading volume on volatility (see Daigler and Wiley,1999, Bessembinder and Seguin, 1992, 1993 and Schwert, 1990). This procedure allows for unbiased estimation of the conditional daily return volatility while at the same time accounting for effects such as the day of the week, the persistence of volatility, and lagged returns. In this model equation (1) estimates the conditional return based on lagged returns, the day of the week and lagged volatility. Equation (2) estimates conditional volatility using transformations of past volatility, day of the week, and trading activity variables. Equation (3) transforms the lagged unexpected returns. The equations are:

$$R_t = a + \sum_{i=1}^{4} \rho_j d_i + \sum_{j=1}^{n} \gamma_j R_{t-j} + \sum_{j=1}^{n} \pi_j \hat{\sigma}_{t-j} + U_t \tag{1}$$

$$\hat{\sigma}_t = \delta + \sum_{i=1}^{4} \eta_j d_i + \sum_{j=1}^{n} \beta_j \hat{\sigma}_{t-j} + \sum_{j=1}^{n} \omega_j \hat{U}_{t-j} + \sum_{k=1}^{m} \mu_k A_k + e_t \tag{2}$$

$$\hat{\sigma}_t = \left|\hat{U}_t\right| \sqrt{\pi/2} \tag{3}$$

where R_t is the percent change in the futures price on day t; d_i represent the four dummy variables for the days of the week; $\hat{\sigma}_t$ is the volatility on day t and A_k are the activity variables of volume and change in open interest. The residual U_t represents unexpected returns. The transformed variable, $\left|\hat{U}_t\right| \sqrt{\pi/2}$, has an expected value equal to the standard deviation of unexpected returns when they follow a normal distribution with a constant mean and time-varying standard deviation $(E(\left|\hat{U}_t\right|) = \sigma_t(2/\pi)^{1/2})$.[8]

In order to estimate the conditional volatility of the Korean Index futures market, equations (1) and (2) are estimated using an iterative procedure.[9] First, we use the series of close to close returns on KOSPI200 index futures contract to estimate equation (1) without lagged volatility estimates. Second, the volatility transformation defined in equation (3) is applied to the residuals of equation (1) and using these transformed values we estimate equation (2). Third, the fitted volatility values from equation (2) are used to re-estimate equation (1). Finally, we re-estimate equation (2) with the residuals from the consistent estimation obtained from the second pass of equation (1).

Lags of the estimated standard deviation series are included in equation (2) in order to measure the effect of volatility persistence over time. Additionally, lagged raw residuals from (1) are included

[8]Evidence in Seguin (1991) indicates that the effect of changes in higher moments on inferences made using this class of volatility estimate are negligible for equity returns.

[9]Results reported are based on OLS estimation. A weighted least squares procedure suggested by Davidian and Carroll (1987), with fitted values from (2) used as weights for estimation of (1) was also estimated and conclusions remain the same.

in equation (2) as it is evident from previous studies (Karpoff, 1987, Schwert, 1990) that they have explanatory power and they also allow for possible effects of recent realized returns on volatility. To be consistent with previous studies and incorporate the range of significant lags for each variable we set the number of lags n equal to 10 in both equations. Further examination of different lag structures using information criteria leaves the results unaltered.

The trading activity variables A_k in equation (2) are the expected and unexpected values of both the trader type volumes and the change in the contract's open interest. Trading activity variables are partitioned so we can investigate whether surprises in trading volume pass on more information and, therefore, have a larger effect on futures prices than forecastable volumes. Further, including expected and unexpected components of open interest in equation (2) allows us to measure the sensitivity of volatility on a volume shock especially when a change in open interest occurs at the same time. For example, if the unexpected component of volume and open interest are positive and negative respectively, a trade that increases both volume and open interest has a smaller effect on volatility than a trade that increases volume but decreases open interest or leaves it unchanged. Table 1, panel B, shows that the various volume measures (across trader types) are highly correlated and this may make it difficult to disentangle between the volume effects of different traders. For this reason we repeat the analysis including only one trader type at a time and our conclusions remain the same in most of the cases.

The inclusion of unexpected open interest and unexpected volume (not predetermined variables) in Equation (2) does not imply that volume shocks and changes in positions necessarily induce or cause (in either an economic or statistical sense) changes in prices. This paper is in accord with Clark (1973), Epps and Epps (1976), and Tauchen and Pitts (1983), who argue that volume and volatility are jointly endogenous variables that covary in response to external order or information shocks. The main econometric objective of this paper is to report partial relations between price revisions and shocks to volume and open interest while conditioning on levels of recent activity.[10] The specification (2) allows for this investigation.

Moreover, we re-examine the volatility-volume relationship by individually substituting the Garman-Klass (1980) and High-Low range-based measures of volatility for $\hat{\sigma}_t$ in equations (1) and (2). Since these measures calculate volatility independent of the return equation, we generate one pass estimation of equations (1) and (2) to fit the volatility-volume relation using these intraday estimators or proxies of volatility. This is in line with previous research (Daigler and Wiley, 1999, Kawaller et al., 2001, and Wang, 2007, Kartsaklas and karanasos, 2009) where Garman-Klass volatility is modelled as an autoregressive

[10] The expected component of trading volume reflects activity that is forecastable (but variable across days and roughly equal to the prior day level of the detrended series) while slower adjusting changes of this forecastable activity are captured by the moving average component.

type process taking into account bidirectional feedback between volume and volatility, long memory characteristics and GARCH effects.[11]

5 Empirical Results

5.1 Volatility-volume relationship by trader category

5.1.1 Raw volume results

Table 2 shows the results of regressing different measures of Index futures volatility on the volume for member institutional and non-member institutional, individuals and foreign investors as well as open interest. We also include variables such as lagged returns, lagged volatility and days of the week. The first column of Table 2 reports the results of running a regression of the daily return standard deviation on each trader type volume. The results indicate that unanticipated trading volume generated by member institutional, non-member institutional and individual investors are positively related with range-based volatility with the largest effect shared between member institutional and non-member individual investors. Interestingly, surprises in non-member foreign investors trading volume exert a stabilizing effect on futures daily price range although they are insignificant for High-Low volatility. As regards return standard deviation, the positive effect over volatility is shared between member institutional, non-member institutional and foreign investors with member institutional investors' coefficient being the highest. On the other hand, it is the non-member individuals' unexpected component which affects return volatility negatively. The expected component of trading activity is insignificant over all trader types as well as over all volatility estimators and for this reason we do not analyze further the corresponding results.

The moving average component of non-member institutional and foreign investors is significant and negatively related to return volatility, indicating a stabilization effect over the long-run for these trader types. In addition, the low-frequency component of non-member individual investors trading volume is significant and positively associated with return volatility, exhibiting a destabilization force on volatility over the long-run. These results are robust over all volatility estimators as can be seen in Table 2. The inclusion of open interest as an activity variable in the volatility regressions is supported by significant coefficients on the moving average and unexpected components. The low-frequency component of open interest is positively associated with volatility while surprises in open interest are often associated with lower volatility (negative relation). It is interesting to note here that unexpected changes in open interest reduce the sensitivity of volatility to volume, especially when a trade increases both trading volume and

[11] Chou (2005) propose a Conditional Autoregressive Range (CARR) model for the range (defined as the difference between the high and low prices).

open interest. These results also are robust across the different volatility proxies that we have used. However, their significance changes slightly as we move from one volatility estimator to the other.

An interesting exercise in our analysis is to check whether our results are robust to the Asian Financial Crisis that hit the major Asian economies in the summer of 1997 and lasted over the end of the same year. Another reason for investigating the period after the financial crisis is that non-member investors significantly increased their participation in futures trading with non-member individual investors almost doubling their trading in the two year period following the Asian Financial Crisis (see descriptive statistics in Table 1). Table 3 reports the results of regressing volatility on volume excluding the period from the start of the sample until the end of 1997 (388 observations).

As is evident in Table 3 the unexpected components of trading volume remain highly significant and of the same sign as for the whole sample. More specifically surprises in trading activity are positively associated with range-based volatility in the case of member institutional, non-member institutional and individual investors with the non-member individual being the most dominant traders. Surprises in non-member foreign investors' volume no longer affect range-based volatility. Results for the return standard deviation regression remain the same with member institutional investors being the most dominant among those who share a positive effect over return volatility and non-member individuals affecting volatility negatively, although somewhat less significantly. The expected components of trading volume and open interest remain insignificant.

Table 2. Regressions of Volatility on Expected and Unexpected Volume by Trader Type

Volumes are detrended by subtracting the 200-day centered moving average from each series, prior to partitioning into expected and unexpected components using an ARMA (0,10) model. Values in brackets are t-statistics for the hypothesis that the coefficient is zero using White (1980) heteroscedasticity consistent standard errors. Test statistics for 10 lagged coefficients are F-statistics for the hypothesis that the sum of the 10 coefficients is zero. Coefficients on raw volumes are scaled so the underlying unit is one trillion of Korean Won. Time series means are deducted from each volume series. VLT stands for volatility. ENTIRE PERIOD RESULTS.

	Volatility measures		
Regression coefficients	Return VLT	Garman-Klass VLT	High-Low VLT
Intercept	0.6912 (4.21)***	0.0858 (2.71)***	0.0711 (6.55)***
KOSPI200 futures volume			
Member Institutional Inv.			
Moving average	0.1244 (0.60)	0.0393 (1.08)	0.0161 (1.33)
Expected	0.1259 (0.64)	0.0305 (0.67)	0.0075 (0.48)
Unexpected	0.4495 (2.12)***	0.1775 (4.75)***	0.0886 (7.07)***
Non-member Institutional Inv.			
Moving average	-0.5486 (-1.83)**	-0.1247 (-2.30)***	-0.0371 (-2.32)***
Expected	0.378 (1.23)	0.0021 (0.04)	0.0161 (0.94)
Unexpected	0.3124 (2.10)***	0.0496 (2.01)***	0.0309 (3.39)***
Non-member Individuals Inv.			
Moving average	0.3425 (1.44)*	0.0656 (1.62)**	0.0250 (1.91)***
Expected	-0.2363 (-0.68)	0.0111 (0.18)	-0.0071 (-0.38)
Unexpected	-0.4176 (-1.92)***	0.2705 (7.04)***	0.0859 (6.35)***
Non-member Foreign Inv.			
Moving average	-0.4247 (-2.24)***	-0.0892 (-2.18)***	-0.0401 (-3.62)***
Expected	-0.0475 (-0.43)	-0.0133 (-0.64)	-0.0086 (-1.23)
Unexpected	0.2333 (2.44)***	-0.0334 (-1.79)**	-0.0014 (-0.22)
KOSPI200 open interest			
Moving average	0.4305 (1.45)*	0.1163 (1.89)***	0.0397 (2.29)***
Expected	0.1666 (0.41)	0.0848 (0.99)	0.0046 (0.19)
Unexpected	-0.3690 (-0.69)	-0.2140 (-1.75)**	-0.0789 (-2.27)***
Sum of 10 lagged volatilities	0.6938 (128)***	0.7397 (84.2)***	0.7609 (427.5)***
Sum of 10 lagged unex. returns	-0.1919 (6.89)***	-0.0444 (5.75)***	-0.0088 (3.83)***
Regression $\bar{R}^2$	0.239	0.347	0.463

*,**,*** Denotes statistical significance at 0.15, 0.10, 0.05 level.

An significant change is evident on the moving average component of all investors trading activity after the Asian Financial Crisis. All the coefficients become insignificant showing no relation between long-run changes in trader type volume and volatility. Another change is reported for the moving average component of open interest where the effect turns from positive to negative. Unexpected changes in open interest remain negative and significant.

The results after the financial crisis leave the unexpected and expected components of trading volume and open interest intact across different types of investors and volatility estimators. The moving average component of all non-member investors becomes insignificant after the financial crisis while being significant for the whole period. Moreover, the moving average component of open interest turns to negative and is still significant, indicating that long-run changes in open interest are often associated with increased informativeness and lower volatility.

Overall we find that unexpected levels of volume and open interest are more important in explaining volatility than expected and moving average components. This property is quite robust across the different trader types, volatility estimators as well as across different sample periods (whole sample and after crisis period). In particular we find that surprises in non-member investors' trading volume are positively associated with volatility in most of the cases. This result is consistent with Daigler and Wiley's (1999) finding that the positive volatility-volume relationship is driven by the general public or less informed investors. In this study we consider non-member investors as less informed due to the fact that they do not have direct access to the trading system. Moreover, we find that member investors' unexpected trading volume also exhibits a positive relation with volatility, a result consistent with Delong et al (1990b), who argue that trading by informed rational speculators can drive prices further away from fundamentals if it triggers positive feedback strategies by noise traders. The coefficients relating the unexpected component of open interest with volatility are uniformly negative, implying that an increase in open interest during the day lessens the impact of a volume shock in volatility. This is consistent with the Bessembinder and Seguin (1993) results, who also find a negative relation between surprises in open interest and volatility. Furthermore, the after crisis period has a significant impact on the low-frequency components of non-member investors and open interest. Although non-member institutional and foreign investors trading activity seems to have a stabilizing effect upon volatility over the long-run, when we exclude the Asian Financial Crisis period all moving average coefficients become insignificant.

As regards the other variables that we include in the volatility regressions, lagged volatilities are significant and range from 0.69 to 0.76 for the whole sample and from 0.41 to 0.61 for the after crisis period. Lagged unexpected returns are negative and significant in four out of six cases. Finally, the explanatory power of the volatility-volume regressions is substantially higher for the High-Low (0.46, 0.49) and Garman-Klass volatility (0.34, 0.39) estimators than the return volatility ones (0.24, 0.20).

Table 3. Regressions of Volatility on Expected and Unexpected Volume by Trader Type

Volumes are detrended by subtracting the 200-day centered moving average from each series, prior to partitioning into expected and unexpected components using an ARMA (0,10) model. Values in brackets are t-statistics for the hypothesis that the coefficient is zero using White (1980) heteroscedasticity consistent standard errors. Test statistics for 10 lagged coefficients are F-statistics for the hypothesis that the sum of the 10 coefficients is zero. Coefficients on raw volumes are scaled so the underlying unit is one trillion of Korean Won. Time series means are deducted from each volume series. VLT stands for volatility. AFTER CRISIS RESULTS.

	Volatility measures		
Regression coefficients	Return VLT	Garman-Klass VLT	High-Low VLT
Intercept	1.6087 (7.19)***	0.1905 (6.04)***	0.1285 (8.59)***
KOSPI200 futures volume			
Member Institutional Inv.			
Moving average	-0.1267 (-0.59)	-0.0033 (-0.09)	0.0018 (0.15)
Expected	0.2338 (0.89)	0.0304 (0.71)	0.0125 (0.81)
Unexpected	0.4795 (2.29)***	0.1486 (4.30)***	0.0792 (6.51)***
Non-member Institutional Inv.			
Moving average	-0.2311 (-0.81)	-0.0542 (-1.17)	-0.0132 (-0.85)
Expected	0.4402 (1.45)*	0.0093 (0.19)	0.0191 (1.13)
Unexpected	0.3133 (2.10)***	0.0666 (2.89)***	0.0332 (3.66)***
Non-member Individuals Inv.			
Moving average	-0.1569 (-0.65)	-0.0469 (-1.26)	-0.0149 (-1.08)
Expected	0.1316 (0.38)	0.0484 (0.91)	0.0155 (0.84)
Unexpected	-0.3145 (-1.43)*	0.2523 (6.91)***	0.0864 (6.52)***
Non-member Foreign Inv.			
Moving average	0.1536 (0.75)	0.0298 (0.84)	0.0041 (0.34)
Expected	-0.0704 (-0.64)	-0.0219 (-1.06)	-0.0115 (-1.67)**
Unexpected	0.2491 (2.64)***	-0.0177 (-0.99)	0.0013 (0.23)
KOSPI200 open interest			
Moving average	-0.5886 (-1.85)**	-0.0871 (-1.67)**	-0.0344 (-1.81)**
Expected	-0.1321 (-0.33)	0.0407 (0.55)	-0.0041(-0.17)
Unexpected	-0.4723 (-0.92)	-0.2848 (-2.61)***	-0.0896 (-2.67)***
Sum of 10 lagged volatilities	0.4072 (28.2)***	0.5910 (82.9)***	0.6142 (183.3)***
Sum of 10 lagged unex. returns	-0.0918 (1.55)	-0.0209 (1.79)	-0.0081 (3.36)**
Regression $\bar{R}^2$	0.202	0.393	0.492

*,**,*** Denotes statistical significance at 0.15, 0.10, 0.05 level.

Further, we have investigated the effect of the number of active value motivated traders by considering the natural logarithm of trader type volume (see Appendix). This alternative specification of trading volume helps interpret surprises in trading activity in terms of percentage deviations from trend so that the unexpected log volume series is unaffected by trend growth in volume. The positive relationship between volatility and surprises in non-member investors' trading volume is further reinforced, with individuals being the most active in the case of range-based volatility and foreigners in the case of return volatility. These results are also consistent with those of Jones, Kaul, and Lipson (1994a), who find that public, rather than private, information is the major source of short-term volatility. Interestingly, the effect of member investors becomes much less significant and of changing sign over the different volatility estimators. Moreover, it is worth mentioning the uniformly positive and significant relationship between volatility and the expected component of non-member individuals as well as the negative and significant relationship between volatility and the moving average component of non-member of foreign investors trading volume. Interestingly, the slowly changing components of non-member individual and member institutional investors exert a strong destabilizing and stabilizing effect, respectively, over volatility up to the period of the financial crisis. As regards the unexpected component of open interest its effect on volatility remains negative and significant. Finally, the explanatory power of the volatility-volume regressions does not seem to improve in the log-volume case as we get smaller $\bar{R}^2$ values.

5.1.2 Time-to-maturity effects

In this section we try to investigate whether the trader type behavior around the expiration of the futures contracts has a different impact on the volatility-volume relationship evidenced over the whole sample. For this reason we perform the same regression analysis as in the previous section while we introduce a constant and trading volume slope dummies around the expiration of the futures contracts.[12] The constant dummy in the volatility regression would allow us to test whether a pattern known as the 'Samuelson' effect is evident. Samuelson (1965) shows that the return volatility of a futures contract monotonically rises as the contract expires. This is mainly a price elasticity effect because when the futures contract approaches its expiration, its price elasticity to market shocks increases and, therefore, its volatility rises. In contrast to the 'Samuelson effect' alternative theories such as the state variable effect (Richard and Sundaresan, 1981, Andersen and Danthine, 1983) and the speculative effect (Hong, 2000) allow for more rich time-to-maturity patterns in futures return volatility. Hong (2000), allowing for differently informed investors and nonmarketed risks, argues that as the futures contract rolls to its expiration date, its sensitivity to the non marketed risks increases and uninformed investors can learn less about the fundamental, so information asymmetry rises. Therefore, less private information is impounded into the futures price and so, all else being equal, the futures price moves less as the contract expires. In line with Hong's (2000) argument it is interesting to investigate if uninformed investor's trading volume is less associated with volatility changes, especially near the futures contract expiration.

Moreover, the variation in information asymmetry that affects the term structure of futures return volatility is also an important determinant of open interest according to Hong (2000). The author shows that open interest can take on rich time-to-maturity patterns based on the fact that the higher the adverse selection cost taken by uninformed investors, when they trade with informed investors, the lower the open interest will be. Additionally, Milonas (1986) examines the time-to-maturity pattern of open interest for

[12] The dummy variables take the value of 1 near (two weeks before the expiration week as well as the weekdays until the expiration of the contract) the expiration of the futures contract and the value of zero otherwise.

different futures markets with the very distant and the nearest contracts having the least open interest, probably due to their high illiquidity. Further, he finds that for the liquid contracts of intermediate maturities, different time-to-maturity patterns can also arise, with more distant contracts having more or less open interest than those nearer to the expiration. So, the effect of changes in open interest, near the contract expiration, on futures volatility will provide some evidence of the ability of the market to absorb trading volume shocks by the different types of trader.

As we see from Table 4 and in comparison with the results from Table 2, the qualitative relations between volatility and volume remain almost the same over all types of trader and volatility estimators for the whole period. Among the most notable differences, in terms of significance, is that for non-member institutional investors' unexpected trading volume. The t-statistics become much more significant when we add the trading volume dummy variables in the volatility regression. The same effect is evident for non-member individuals and foreigners in the case of return volatility while their effect diminishes slightly in the case of range-based volatilities. In the case of member institutional investors, the volatility-volume relationship continues to be highly significant and positive. Finally the unexpected component of open interest continues to affect volatility negatively over the sample. Moreover, the expected component of trading volume is insignificant in most of the cases, a result consistent with evidence from Table 2. However, there are some significant values in the case of return volatility for non-member investors trading volume. Additionally, the moving average component of member investors is still insignificant despite adding the trading volume slope dummies. As regards non-member investors' significance it reduces a little rendering the effect of non-member investors still influential over all volatility estimators. The same result does not hold for the moving average component of the open interest, which, although still positive, becomes insignificant.

It is now worth looking at Table 5 in order to compare the behavior of member and non-member investors near the expiration of the futures contracts with that over the whole sample. As regards non-member investors, the estimated coefficient for the slope dummy on institutional investors' unexpected volume is negative and significant, implying a reduction in the magnitude of the relation between volume and volatility towards the end of the contract life. In other words, the combined effect reveals a less significant role for non-member institutional investors as the futures contract rolls to its expiration. Moreover, the slope dummy coefficient for non-member individual and foreign investors' unexpected volume is insignificant, thus indicating no change in the behavior of these trader types near contract expiration. The same result is evident for member institutional investors. The term structure of stock index futures prices is mainly driven by interest rate and dividend levels, and hence the information sets of investors across the different maturities should be very similar. Heterogeneous trader behavior though can arise even when traders simply interpret commonly known data in a different way, especially near contract expiration.

Table 4. Regressions of Volatility on Expected and Unexpected Total Volume

Volumes are detrended by subtracting the 200-day centered moving average from each series, prior to partitioning into expected and unexpected components using an ARMA (0,10) model. Values in brackets are t-statistics for the hypothesis that the coefficient is zero using White (1980) heteroscedasticity consistent standard errors. Test statistics for 10 lagged coefficients are F-statistics for the hypothesis that the sum of the 10 coefficients is zero. Coefficients on raw volumes are scaled so the underlying unit is one trillion of Korean Won. Time series means are deducted from each volume series. VLT stands for volatility. ENTIRE PERIOD RESULTS.

	Volatility measures		
Regression coefficients	Return VLT	Garman-Klass VLT	High-Low VLT
Intercept	0.7175 (4.36)***	0.0883 (2.91)***	0.0724 (6.62)***
KOSPI200 futures volume			
Member Institutional Inv.			
Moving average	0.1242 (0.52)	0.0553 (1.21)	0.0238 (1.63)**
Expected	-0.1511 (-0.53)	-0.0207 (-0.42)	-0.0158 (-0.93)
Unexpected	0.4708 (2.02)***	0.1679 (3.79)***	0.0864 (6.13)***
Non-member Institutional Inv.			
Moving average	-0.4433 (-1.28)	-0.1026 (-1.67)**	-0.0326 (-1.76)**
Expected	0.8186 (2.31)**	0.0338 (0.59)	0.0380 (1.96)***
Unexpected	0.9105 (4.37)***	0.1110 (3.43)***	0.0604 (5.24)***
Non-member Individuals Inv.			
Moving average	0.3595 (1.26)	0.0363 (0.76)	0.0205 (1.36)
Expected	-0.6399 (-1.67)**	0.0059 (0.09)	-0.0168 (-0.81)
Unexpected	-0.8209 (-3.18)***	0.2544 (5.74)***	0.0709 (4.74)***
Non-member Foreign Inv.			
Moving average	-0.2919 (-1.29)	-0.0741 (-1.41)*	-0.0319 (-2.43)***
Expected	0.2486 (1.75)**	0.0276 (0.85)	0.0098 (0.99)
Unexpected	0.2930 (2.43)***	-0.0229 (-0.82)	0.0021 (0.25)
KOSPI200 open interest			
Moving average	0.2319 (0.64)	0.0839 (1.12)	0.0265 (1.23)
Expected	0.0877 (0.17)	0.0575 (0.51)	0.0010 (0.03)
Unexpected	-0.5032 (-0.84)	-0.2791 (-1.82)**	-0.0945 (-2.33)***
Sum of 10 lagged volatilities	0.6959 (127.1)***	0.7403 (83.3)***	0.7618 (423.1)***
Sum of 10 lagged unex. returns	-0.1884 (6.67)***	-0.0449 (5.83)***	-0.0087 (3.78)***
Regression $\bar{R}^2$	0.249	0.352	0.472

*,**,*** Denotes statistical significance at 0.15, 0.10, 0.05 level.

Further, an interesting result of this analysis is that the slope coefficient associated with unanticipated open interest is positive and highly significant, showing that open interest shocks are associated with bigger price movements towards the end of the contract life. The slope dummy on expected volume becomes significant and negative for non-member institutional and foreign investors but significant and positive for member institutional investors. This result indicates that trading volume forecastable across days, for these types of traders, is very much associated with volatility as the contract rolls to its expiration. Finally, the estimated coefficient for the shift in the regression intercept near the futures expiration is negative and significant, showing reduced futures volatility near contract expiration.

Table 5.

Time-to-maturity effects			
	Volatility measures		
Regression coefficients	Return VLT	Garman-Klass VLT	High-Low VLT
Intercept	-0.1647 (-1.23)	-0.0371 (-1.62)**	-0.0122 (-1.61)**
KOSPI200 futures volume			
Member Institutional Inv.			
Moving average	0.2265 (0.47)	-0.0132 (-0.19)	-0.0134 (-0.52)
Expected	1.1051(1.53)*	0.2767 (2.48)***	0.1141 (2.87)***
Unexpected	-0.1111 (-0.22)	0.0632 (0.81)	0.0138 (0.47)
Non-member Institutional Inv.			
Moving average	-0.6337 (-0.90)	-0.1266 (-0.99)	-0.0274 (-0.72)
Expected	-1.3453 (-1.74)*	-0.1129 (0.98)	-0.0987 (-2.27)***
Unexpected	-0.9509 (-3.25)***	-0.1150 (-2.44)***	-0.0438 (-2.58)***
Non-member Individuals Inv.			
Moving average	0.1648 (0.29)	0.1313 (-1.25)	0.0211 (0.63)
Expected	0.7464 (0.90)	-0.0679 (-0.54)	0.0059 (0.12)
Unexpected	0.4643 (0.91)	-0.0657 (0.65)	-0.0045 (-0.12)
Non-member Foreign Inv.			
Moving average	-0.3517 (-0.92)	-0.0519 (-0.82)	-0.0163 (-0.78)
Expected	-0.5367 (-2.07)***	-0.1079 (-2.38)***	-0.0446 (-2.79)***
Unexpected	0.0628 (0.35)	-0.0007 (-0.01)	0.0051 (0.42)
KOSPI200 open interest			
Moving average	0.3614 (0.58)	0.0423 (0.43)	0.0211 (0.58)
Expected	0.0089 (0.01)	0.0519 (0.25)	-0.0238 (-0.35)
Unexpected	3.7989 (2.68)***	0.7545 (2.96)***	0.3161 (3.82)***

*,**,*** Denotes statistical significance at 0.15, 0.10, 0.05 level.

When we include the trading volume dummies, in order to capture time to maturity effects, the volatility-volume relationships across trader categories do not change sign while their significance in most cases changes a little. We conclude that, despite adding the slope dummies on trading activity, there is no evidence that trading activity across different types of traders affects volatility in a different way apart from the case of non-member institutional investors. In general we find small changes in significance among different trader types. The most apparent change concerns the non-member institutional trading, which becomes much less associated with volatility as the contract rolls to its expiration. Surprises in open interest during the day are associated with much bigger price movements near the expiration of the contract, meaning that volatility becomes more sensitive to volume shocks especially when trades result in an increase on open interest as well. Moreover, the expected component of investors' volume becomes more significant near contract expiration while the level of volatility decreases slightly for the same period. The other variables included in the volatility regressions such as lagged volatilities and lagged unexpected returns are also very significant and of the same sign and magnitude compared to the values in Table 2. Finally, when the slope dummies on trading activity are added, the explanatory power of the trading activity and other variables in the volatility regressions is almost the same and consistent with the evidence in Table 2.

6 Conclusions

This study provides empirical evidence on the volatility-volume relationship for different trader types of the Korean index futures market. The different types of traders have been selected according to the information they possess and their access to the trading system. Moreover, the trading activity variables are partitioned into expected and unexpected components and the econometric techniques that we use allow for an unbiased estimation of daily standard deviations conditional on the trading activity variables, day of the week, lagged volatilities and lagged unexpected returns.

A key finding of this study is that surprises in volume and open interest are more important in explaining volatility than expected and moving average components. This result is robust across different types of traders, volatility estimators and sample periods. Also this result is consistent with the studies of Bessembinder and Seguin (1993), Daigler and Wiley (1999) and provides further support for the hypothesis that traders who lack information about the order flow and pit dynamics are unable to distinguish the liquidity demand of large hedgers from the volume associated with change in fundamental value.

In the case of raw volume we find, among the non-member investors, that institutional and individuals affect range-based volatility positively while the same effect is shared between institutional and foreigners in the case of return volatility. When we consider the after crisis period we only find one significant case out of nine where non-member investors affect volatility negatively. In general we find that surprises in non-member investors' trading volume are positively associated with volatility in most of the cases. This result is consistent with Daigler and Wiley's (1999) finding that the positive volatility-volume relationship is driven by the general public or less informed investors. Moreover, we find that member investors' unexpected trading volume also exhibits a positive relation with volatility, a result consistent with Delong et al. (1990b), who argue that trading by informed rational speculators can drive prices further away from fundamentals if it triggers positive feedback strategies by noise traders. The coefficients relating the unexpected component of open interest with volatility are uniformly negative implying that an increase in open interest during the day lessens the impact of a volume shock in volatility. This is consistent with the Bessembider and Seguin (1993) results, who also report a negative relation between surprises in open interest and volatility.

Although for the whole sample we report very significant relations between long-run changes in non-member investors' trading volume and volatility, after the financial crisis, all these relations become insignificant. Surprisingly, the results for the whole sample reveal a stabilizing role for non-member institutional and foreign investors but a destabilizing one for non-member individuals, especially up to the period of the financial crisis.

We also investigated the volatility-volume relationship as the futures contract roll to its expiration by adding trading volume slope dummies near the expiration date. Our results reveal a less significant role for non-member institutional investors as the futures contract moves towards expiration while we do not experience any change in trading behavior for the remaining trader types. Another result of this exercise is that surprises in open interest during the day are associated with much bigger price movements near the expiration of the contract, indicating that volatility becomes more sensitive to volume shocks especially when trades result in an increase on open interest as well. This result is consistent with the argument of Hong (2000) that as the futures contract rolls to its expiration date, its sensitivity to nonmarketed risk shocks increases and uninformed investors can learn less about the fundamental by looking at prices. Therefore, information asymmetry rises and less informed investors face a higher adverse selection cost in trading with informed investors near the futures contract expiration. As a result those uninformed traders who choose to trade with informed investors near the futures contract expiration will probably cause wider price movements so as to induce them to take the other side of the trade.

The inclusion of variables such as lagged volatilities and unexpected returns in the volatility regressions are significant in most of the cases, with the effect of lagged unexpected returns being consistently negative. Further, we find that when the high-low volatility measure is used, models that incorporate trader type volume, lagged volatilities and unexpected returns can explain up to 59 percent of the variability in volatility. In future work we aim to investigate the trader type effect on volatility using alternative detrending methods for trading volume, such as the band pass filtering and non parametric regressions. Finally, an interesting exercise is to use nonparametric and semi-parametric techniques for analysing the trader type effect on volatility as we could capture simultaneously the long memory characteristics often evidenced in trading volume and volatility.

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7 Appendix

7.1 Trading Volume and Detrending Procedures

As regards trading volume of the KOSPI 200 futures index, the Korean Stock Exchange publishes the daily amount of contracts traded by eight types of domestic investors and the total amount by foreign Investors. Domestic investors are categorized as institutional and individual investors. Moreover, domestic institutional investors consist of securities and non securities companies. The latter are divided into Insurance, Investment, Bank, Merchant and Mutual Fund, Pension Fund and Others. Membership is granted only to the securities companies licensed by the Financial Supervisory Commission to conduct securities business. Moreover, no individual members are accepted. Members of the Korean Stock Exchange have the right to trade and the responsibility of clearing the trade and access to the trading system is granted to the member firms only. Any members who have their own system, which is a client server interface for customers or multi-functioning system, can access the KSE system directly. Overseas brokers or dealers cannot access the Korean Stock Exchange system directly, but they can connect to a member's system located in Korea through international securities companies' global network.

We first construct a detrended activity series[13] by deducting an equally weighted moving average of length 200 days, centered on the estimated trend component, from the original series. Standard one-sided (weighted) averages are used for the start and end of the sample as suggested by Brockwell and Davis (1987). Further we partition the detrended activity series into expected and unexpected components using an ARIMA(0,0,10) model. The ARIMA (0,0,10)[14] model estimates the expected value using the 10-day moving average of the change in detrended volume. This is in line with the Bessembinder and Seguin (1993) who interpret the unexpected component of the detrended series as the daily activity shock and the expected component as activity that is forecastable but highly variable across days. The moving average component of length 200 days captures the long-run changes in the trading activity. Finally, we include open interest as a trading activity variable due to its association with the number of active informed traders. Bessembinder and Seguin (1993) argue in favor of using open interest in conjunction with volume data as it may provide insights into the price effects of market activity generated by informed versus uninformed traders or hedgers versus speculators.

[13] The detrended trading activity series are stationary for all trader types and open interest.

[14] We use 10 lags in the ARMA specification so that we are consistent with previous studies while further investigation into alternative lag structures gives rise to expected and unexpected components highly correlated with the ones arising from the 10 lag structure.

7.2 Log-Volume Results

In this section we try to evaluate whether the number of active value-motivated traders can have a significant impact on the volatility-volume relationship (Kyle,1985, Admati and Pfleiderer, 1988). We repeat the prior analysis using the natural logarithm of each trader type volume and open interest. By taking the log differences of the original trading volume series and its 200 day centered moving average, we get a detrended series interpreted as percentage deviations from trend. The approach is motivated by the fact that log differences of volume series are approximately stationary, as argued by Andersen (1996). Further we decompose the resulting correlated detrended series into expected and unexpected components using an ARIMA(0,0,10). Trading volume shocks now represent deviations of volume from its expectation (the 10-day moving average of the change in percentage deviation from trend). Thus, the unexpected log volume series is unaffected by trend growth in volume.

Table A1 shows the results of regressing volatility on the natural logarithm of member and non-member investors' trading volume. The unexpected trading activity of all non-member investors (institutional, individual and foreign) is significant and positively associated with all volatility measures (Return VLT, Garman-Klass VLT and High-Low VLT). The effect of non-member individuals is the highest on the range-based volatility (Garman-Klass, High-Low) but negligible on the return volatility. Also surprises on member institutional investors trading volume are positively associated with range-based volatility and negatively associated with return volatility.The expected component of trading volume is significant for the two major players of the Korean Stock Exchange, namely the member institutional and non-member individual investors. The effect of member institutional investors is negative and significant while the effect of non-member individuals in positive and significant over all volatility estimators.

Interestingly the moving average component appears to be quite significant over all types of traders. Among the non-member investors, institutional and foreigners seem to have a stabilizing effect (negative) upon volatility with the effect of foreign investors being more significant across all measures of volatility. However, the long-run effect of non-member individual investors is positive and very significant. Moreover, the moving average component of member institutional investors is negative for all volatility proxies while somewhat less significant for the range-based volatility ones (Garman-Klass VLT, High-Low VLT). Finally, the moving average component of open interest is positive over all different measures of volatility while the unexpected component is significant and negatively associated with the range-based volatility estimators. These results also are quite consistent with the raw volume results.

Table A1. Regressions of Volatility on Expected and Unexpected Log - Volume by Trader Type

Volumes are detrended by subtracting the 200-day centered moving average from each series, prior to partitioning into expected and unexpected components using an ARMA (0,10) model. Values in brackets are t-statistics for the hypothesis that the coefficient is zero using White (1980) heteroscedasticity consistent standard errors. Test statistics for 10 lagged coefficients are F-statistics for the hypothesis that the sum of the 10 coefficients is zero. Coefficients on raw volumes are scaled so the underlying unit is one trillion of Korean Won. Time series means are deducted from each volume series. VLT stands for volatility. ENTIRE PERIOD RESULTS.

	Volatility measures		
Regression coefficients	Return VLT	Garman-Klass VLT	High-Low VLT
Intercept	1.2479 (6.15)***	0.1709 (4.72)***	0.1389 (9.86)***
KOSPI200 futures volume			
Member Institutional Inv.			
Moving average	-0.8917 (-2.18)***	-0.0731 (-0.94)	-0.0295 (-1.40)*
Expected	-1.4987 (-2.44)***	-0.3371 (-2.76)***	-0.0465 (-1.75)**
Unexpected	-0.5425 (-2.21)***	0.0721 (0.92)	0.0283 (1.44)*
Non-member Institutional Inv.			
Moving average	-0.0313 (-0.15)	-0.067 (-1.81)**	-0.0053 (-0.49)
Expected	0.3609 (0.87)	0.1179 (1.27)	0.0239 (1.13)
Unexpected	0.6122 (2.69)***	0.0663 (1.35)*	0.0417 (3.81)***
Non-member Individuals Inv.			
Moving average	0.8677 (3.73)***	0.1986 (4.39)***	0.0731 (6.57)***
Expected	0.9464 (1.75)**	0.1851 (1.69)**	0.0792 (2.97)***
Unexpected	0.0408 (0.12)	0.4845 (6.68)***	0.1705 (9.38)***
Non-member Foreign Inv.			
Moving average	-0.7505 (-5.19)***	-0.1640 (-4.89)***	-0.0680 (-8.50)***
Expected	0.2015 (1.12)	0.0678 (1.74)**	0.0054 (0.54)
Unexpected	0.7950 (6.31)***	0.1293 (6.04)***	0.0553 (8.73)***
KOSPI200 open interest			
Moving average	0.8411 (2.73)***	0.1448 (2.47)***	0.0443 (2.71)***
Expected	-0.2979 (-0.74)	0.0301 (0.36)	0.0003 (0.01)
Unexpected	0.2592 (0.42)	-0.2126 (-1.43)*	-0.0867 (-2.41)***
Sum of 10 lagged volatilities	0.4835 (45.3)***	0.5721 (41.8)***	0.5446 (147.8)***
Sum of 10 lagged unex. returns	-0.127 (3.12)**	-0.0468 (7.38)***	-0.0131 (10.1)***
Regression $\bar{R}^2$	0.275	0.428	0.579

*,**,*** Denotes statistical significance at 0.15, 0.10, 0.05 level.

The results for the after crisis period (Table A2) reveal that the unexpected component of all non-member investors remains positive and significant for most of the cases. The strongest effect on volatility is imposed by individuals in the case of range-based volatility while their effect remains still negligible in the case of return standard deviation. As regards surprises in the trading activity of member institutional investors, the mixed and significant effect on volatility evidenced for the whole sample becomes insignificant after the crisis. Moreover, activity forecastable across days (expected component) remains highly significant and of the same sign (positive) only for non-member individual investors. So after the crisis, the expected component of non-member individuals' trading volume continues to fluctuate in the same direction as volatility. The expected trading activity of member investors is still negative in sign; however, it becomes insignificant after the crisis.

Table A2. Regressions of Volatility on Expected and Unexpected Log - Volume by Trader Type

Volumes are detrended by subtracting the 200-day centered moving average from each series, prior to partitioning into expected and unexpected components using an ARMA (0,10) model. Values in brackets are t-statistics for the hypothesis that the coefficient is zero using White (1980) heteroscedasticity consistent standard errors. Test statistics for 10 lagged coefficients are F-statistics for the hypothesis that the sum of the 10 coefficients is zero. Coefficients on raw volumes are scaled so the underlying unit is one trillion of Korean Won. Time series means are deducted from each volume series. VLT stands for volatility. AFTER CRISIS RESULTS.

	Volatility measures		
Regression coefficients	Return VLT	Garman-Klass VLT	High-Low VLT
Intercept	2.0531 (7.25)***	0.2436 (6.42)***	0.1735 (9.49)***
KOSPI200 futures volume			
Member Institutional Inv.			
Moving average	-0.7084 (-1.82)**	-0.0308 (-0.46)	-0.0285 (-1.39)
Expected	-0.2734 (-0.61)	-0.0578 (-0.58)	-0.0088 (-0.30)
Unexpected	-0.4232 (-1.35)	-0.0149 (-0.18)	0.0214 (0.81)
Non-member Institutional Inv.			
Moving average	-0.0594 (-0.26)	-0.0514 (-1.33)	-0.0008 (-0.07)
Expected	0.3241 (0.69)	-0.0193 (-0.25)	0.0063 (0.26)
Unexpected	0.6689 (2.62)***	0.0977 (2.47)***	0.0401 (3.07)***
Non-member Individuals Inv.			
Moving average	0.4117 (1.03)	0.0790 (1.04)	0.0527 (2.35)***
Expected	1.3498 (2.07)***	0.1625 (1.52)*	0.096 (2.85)***
Unexpected	-0.4341 (-1.02)	0.5456 (7.01)***	0.1613 (6.91)***
Non-member Foreign Inv.			
Moving average	-0.5379 (-2.27)***	-0.1096 (-2.34)***	-0.0631 (-4.46)***
Expected	-0.1020 (-0.40)	0.0832 (1.60)*	0.0098 (0.67)
Unexpected	1.5347 (8.03)***	0.1971 (5.94)***	0.0939 (9.20)***
KOSPI200 open interest			
Moving average	0.4434 (1.25)	0.0752 (1.22)	0.0368 (1.89)***
Expected	-0.5550 (-1.27)	-0.0458 (-0.59)	-0.0274 (-1.23)
Unexpected	-0.8534 (-1.36)	-0.4341 (-2.85)***	-0.1298 (-3.13)***
Sum of 10 lagged volatilities	0.2910 (10.5)***	0.5071 (52.1)***	0.4697 (67.8)***
Sum of 10 lagged unex. returns	-0.0918 (1.54)	-0.0275 (3.15)**	-0.0127 (8.37)***
Regression $\bar{R}^2$	0.256	0.482	0.592

*,**,*** Denotes statistical significance at 0.15, 0.10, 0.05 level.

Among the non-member investors, institutional and foreigners' slowly changing component (moving average) of trading volume is still negatively associated with volatility with the effect of foreigners only remaining highly significant for the after crisis period. The long-run changes in individuals' trading volume continue to be positively associated with volatility while again the after crisis results become of much less significance especially for the case of return and Garman-Klass volatility. Overall, the moving average component of non-member investors remains identical in sign but their effect after the crisis seems to be less significant. As regards the effect of member investors' long-run changes in trading activity on volatility it remains negative but slightly less significant.

Furthermore, the moving average component of open interest remains positive over all measures of volatility but highly significant only for the case of High-Low proxy. More importantly, the unexpected component of open interest is negative in sign and more significant after the crisis. This result provides further evidence on the negative relation between unexpected open interest and volatility. It is consistent with the results found using raw volume as well as with the results in other studies such as Bessembinder and Seguin (1993) and Daigler and Wiley (1999).

The results for this alternative specification of trading volume support some of the conclusions reached on the raw volume regressions. Again we find that surprises in non-member investors' trading volume are positively associated with volatility in most of the cases. This result is consistent with Daigler and Wiley's (1999) finding that the positive volatility-volume relationship is driven by the general public or less informed investors. Recall that non-member investors are treated as less informed here due to the fact that they do not have direct access to the trading system. Moreover, we find that member investors' unexpected trading volume also exhibits a mixed relation with volatility. The positive effect is consistent with Delong et al (1990b) who argue that trading by informed rational speculators can drive prices further away from fundamentals if it triggers positive feedback strategies by noise traders. The negative effect is consistent with Daigler and Wiley (1999), who find that the relation between clearing members and other floor traders with volatility is often negative, suggesting that information about futures pit trading and order flow from trading activities may actually help reduce risk and, therefore, enhance the value of holding a seat. Moreover, forecastable activity across days (expected component) is negatively related to volatility for member institutional and positively related to volatility for non-member individuals. After the financial crisis only non-member individuals coefficients are highly significant and of the same sign as of the whole sample.

The after crisis period has a significant impact on the low-frequency components of member and non-member investors and open interest. Although the sign of the coefficients remain the same, the significance of them diminishes significantly in some cases. Among the non-member individual and foreign investors affecting volatility negatively over the long-run, only the effect of non-member foreign investors remains highly significant after the crisis. As regards the moving average component of non-member individuals, it remains still positive and significant only for the High-Low volatility regression. In addition the low-frequency component of member institutional investors retains its negative sign and importance (although less) after the crisis. Finally, the moving average component of open interest retains its sign but looses most of its significance after the crisis. This result is quite different from the raw volume results where the effect changes from positive to negative but still significant after the crisis.

The sum of lagged volatilities is still significant but smaller in size compared to the raw volume results. Finally, the explanatory power of the volatility-volume regressions does not seem to improve in the log-volume case as we get smaller $\bar{R}^2$ values. Though log volume, as in the case of raw volume, still has better explanatory power over range based volatility proxies than close to close return volatility ones.

7.3 The KOSPI200 Index Futures Market

The KOSPI 200, which is used as an underlying index for the futures contracts, is a market capitalization weighted index composed of 200 major stocks listed on the Korean Stock Exchange (KSE) and it represents about 80% of the total market capitalization of the KSE stock market. The KOSPI 200 is calculated using real time stock prices and is published every 10 seconds. The selection criteria for the 200 underlying stocks, which include both market capitalization and liquidity, is devised to have the KOSPI 200 index closely track the movement of the whole Korean stock market. Foreigners who want to become a member of the KSE have to establish an office in Korea that is licensed as a securities company by the Financial Supervisory Commission.

As of September 2002, the total number of KSE members stood at 52 of which 15 are foreign brokerage firms. All transactions in the KSE market are automatically processed and executed by the computerized trading system without the intervention of market makers. Access to the trading system is granted to the member firms only. Any members who have their own system, which is a client server interface for customers or multi-functioning system, can access the KSE system directly. Overseas brokers or dealers cannot access the KSE system directly, but they can connect to a member's system located in Korea through international securities companies' global network (see KOSPI 200 Futures and Options booklet, published by the Korean Stock Exchange, for an illustrative diagram of the information dissemination process as well as the market participants during a trading day in the futures market).

During the trading hour, all orders are continuously matched at a satisfactory level to both the selling and buying parties according to price and time priority. At the time of market opening and closing, however, orders are pooled over a fixed period of time and matched at a single price that minimizes any imbalance between the buying and selling parties. All trading on the KSE is processed automatically by computer system.

The contract months for futures are March, June, September and December, and the longest maturity period is one year. The last trading day of each contract is the second Thursday of each expiration month.