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Trading Volume and Returns Relationship in Greek Stock Index Futures Market: GARCH vs. GMM

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Abstract

This paper examines the relationship between trading volume and returns in Greek stock index futures market. For both available stock index futures contracts of the Athens Derivatives Exchange (ADEX), we study GARCH effects in our data and test how well these effects are explained by trading volume (under both GARCH and GMM). For FTSE/ASE-20, trading volume contributes significantly in explaining GARCH effects. However, GMM system estimation suggests that there is a significant relationship between lagged volume and absolute returns, while a positive contemporaneous relationship does not hold. Taken together, these findings indicate that market participants use volume as an indication of prices. For FTSE/ASE Mid 40, the empirical results give different conclusions. Both GARCH and GMM methods confirm that there is no evidence of positive relationship between trading volume and returns. These findings are helpful to financial managers dealing with Greek stock index futures.

Keywords: Futures, Volume, MDH, ADEX, GARCH, GMM.
Jel Classification Codes: G13, G15.

I. Introduction

There are many reasons that traders pay attention to trading volume . Theoretically, low volume[1] means that the market is illiquid. This also implies high price volatility [2]. On the other hand, high volume usually implies that the market is highly liquid, resulting in low price variability. This also reduces the price effect of large trades. In general, with an increase in volume, broker revenue will

[1] Volume is the number of transactions in a futures contract during a specified period of time (Sutcliffe 1993).

[2] According to Telser (1981) higher margins will raise the cost of trading in futures. Margins use up part of the trader's precautionary balances, and this money is no longer available to deal with unexpected events. This increase in the cost of trading leads to lower trading volume and open interest. He argues that this lower volume will result in a less liquid market, which will lead to a rise in price volatility.

increase, and market makers have greater opportunity for profit as a result of higher turnover. However, traders who wish to participate in movements of the market may use index futures more easily than shares. The existence of index futures allows index arbitrage and risk hedging. Both increase trading volume.

The relationship between returns and trading volume has interested financial economists and analysts for a number of years. In general, previous empirical studies have noted strong positive correlations between trading volume and price volatility/ absolute returns, see Karpoff (1987). In other words, it is concluded that trading volume plays a significant role in the market information. Therefore, the trading volume reflects information about changes and agreement in investors' expectations, see Harris and Raviv (1993).

Most previous studies have examined the leading theories (hypotheses) that explain the information arrival process in financial markets. The competing hypotheses are the 'mixture of distributions hypothesis' (MDH) and the 'sequential information arrival hypotheses'. According to the MDH, information dissemination is contemporaneous. In other words, futures prices (and volume) change only when information arrives, and evolve at a constant speed in event time, see Sutcliffe (1993). MDH suggests that daily price changes and trading volume are driven by the same underlying latent "news" arrival, or information flow, variable (Luu and Martens, 2003). News arrivals can be proxied by the volume of trade (Clark 1973; Epps and Epps, 1976). Under MDH, the daily returns and the daily trading volume is the sum of a random number of individual price increments and volumes. This random number depends on the rate of information arrival during the day. MDH implies only a contemporaneous relationship between volume and (absolute) returns. It is associated with Clark (1973), Epps and Epps (1976), Tauchen and Pitts (1983) and Harris (1986). An important assumption is that the variance per transaction is monotonically related to the volume of that transaction. In general, according to Grammatikos and Saunders (1986), under MDH framework the correlation between price (returns) and volume should be positive due to joint dependence on a common directing variable or event.

MDH is initially developed by Clark (1973) who argues that the rate of information arrival implies a positive contemporaneous correlation between volume and volatility. Clark (1973) shows that the values of the consequential price change and trading volume are distributed independently from each other. Hence, each variable is independently and identically distributed over a series of information arrivals. Also, the number of arrivals of information per time period varies. Tauchen and Pitts (1983) develop a model in which average daily volume and the variance of daily price change are positive functions of the daily flow of information. Furthermore, Harris (1987) and Sutcliffe (1993, p.188) report the following implications of MDH model:

- *Provided the number of information arrivals is sufficiently large, the central limit theorem can be used to argue for normality in the distribution of price changes and volume.*
- *For a given number of information arrivals, there is zero correlation between volatility and volume.*
- *For a given time period, there is a positive correlation between volatility and volume. This is because both are positive functions of the rate of arrival of information during the time period.*
- *There will be leptokurtosis in the distribution of price changes computed over equal time periods.*

In addition, according to the MDH, a serially correlated mixing variable measuring the rate at which information arrives to the market explains the GARCH effects in the returns (Lamoureux and Lastrapes, 1990). According to Lamoureux and Lastrapes (1990), using daily trading volume as a proxy for the mixing variable, the introduction of volume as an explanatory variable in the conditional variance equation eliminates the GARCH effects. Furthermore, Sharma *et al*. (1996) extend the work of Lamoureux and Lastrapes (1990) by testing for the GARCH effects in market returns. According to Sharma *et al.* (1996, p. 338), the empirical study by Lamoureux and Lastrapes (1990) can be further enhanced on two main forms: (i) the ability of the daily data on trading volumes to fully capture the information flow effects on the market returns would partly rest on the degree of market efficiency, and (ii) volatility can be generated by firm-specific factors and market-wide factors (both of which affect volume). This should make volume a good or poor proxy for information (news arrival) which contributes to conditional heteroscedasticity.

However, empirical studies by Najand and Yung (1991) and Bessembinder and Seguin (1992, 1993) report evidence against MDH. In addition, Bessembinder and Seguin (1993) suggest that the volatility-volume relation in financial markets depends on the type of trader.

On the other hand, the sequential arrival of information hypothesis suggests gradual dissemination of information such that a series of intermediate equilibria exist, see Copeland (1976) and Tauchen and Pitts (1983). Copeland (1976) develops a model of the effects of the arrival of a single piece of information on price and trading volume. Clark (1973) shows that volume is a positive function of the logarithm of the number of traders, and a positive function of the logarithm of the strength of the information. He argues that if the information is simultaneously received by all traders, there will be a negative correlation between volume and the absolute value of price changes. In other words, it is the sequential arrival of information that leads to the positive relationship between volume and value of price changes (volatility). Further, the model implies the continuation of higher volatility after the initial information shock rather than spikes in volatility, see Wiley and Daigler (1999). Also, according to Grammatikos and Saunders (1986, p. 326) '*sequential information arrival models imply the possibility of observing lead relations between daily contract price variability and volume*'. The sequential arrival information model argues that each trader observes the information sequentially.

Furthermore, McMillan and Speight (2002) argue that the sequential arrival hypothesis supports a dynamic relationship whereby past volume provides information on current absolute returns, and past absolute returns contains information on current volume. In other words, the dynamic relationship is very important as it gives useful information about trading volume and forecasts of returns and volatility. Recent empirical studies have investigated the dynamic relationship between trading volume and returns. Some theoretical papers suggest 'causality' between changes in volatility and volume. This is due to the arrival of new (private) information.

In general, both MDH and sequential arrival of information hypotheses support a positive and contemporaneous relationship between volume and absolute returns and assume a symmetric effect for price increases and price decreases for futures contracts, see Karpoff (1987). Notice that in the case of an efficient (futures) market, neither a contemporaneous relationship nor a dynamic relationship hold.

The price (returns)-volume relations have significant implications into futures markets. Price changes affect the trading volume in futures contracts. In particular, the time to delivery of a contract affects not only the trading volume but possibly also the changes of price (Karpoff, 1987). Previous studies show a strong positive relationship between volume of futures trading and volatility (returns) of futures prices. They test the MDH using GARCH models (Hogan *et al*., 1997; Jacobs and Onochie, 1998; Montalvo, 1999) or a Generalized Method of Moments (GMM) system of equations (Gwilym *et al*., 1999; Wang and Yau, 2000).

In this paper, we investigate the volatility (returns)-volume relationship from one direction: the contemporaneous relationship on the futures markets of the Athens Derivatives Exchange (ADEX). We look at the price-volume relationship as '*it is related to the role of information in price formation, with volatility and volume providing measures of the significance of the information reflected in the market*', see Wiley and Daigler (1999, p.1). Karpoff (1987, pp. 109-110) explains the importance of the price-volume relationship as follows:

> *"The models predict various price-volume relations that depend on the rate of information flow to the market.*
> *It is important for event studies that use a combination of price and volume data.*
> *The price-volume relation is critical to the debate over the empirical distribution of speculative prices.*

> *Price-volume relations have significant implications for research into futures markets. Price variability affects the volume of trade in futures contracts. This has bearing of the issue of whether speculation is a stabilizing or destabilizing factor on futures prices. … The price-volume relation can also indicate the importance of private versus public information in determining investors' demands".*

Furthermore, according to Sutcliffe (1993, p.194), '*if price volatility increases as delivery approaches, and price volatility increase as volume increases, it is implied that volume increases as delivery approaches'*.

This paper follows Sharma *et al*. (1996), Gwilym *et al*. (1999), Ciner (2002) and McMillan and Speight (2002). We investigate the empirical relationship between price changes and trading volume for index futures contracts traded in the ADEX (Greece). In addition, we study GARCH effects in our data and test how well these effects are explained by trading volume. We provide a test to investigate if GARCH effects arise from time variation in information arrival. We examine the role of volume as a proxy for information arrival in explaining the conditional variance of the market return. In addition, we investigate the role of the rate of information arrival variable relating to Greek futures prices (returns). Furthermore, we analyse the contemporaneous relationship between returns and volume using a system of simultaneous equations (GMM). Notice that no previous paper has tested the relationship between price change (returns) and trading volume in the Greek futures markets.

The paper continues as follows. Section II presents the literature review, while in Section III we outline the methodology. Section IV presents the data used in this study. Empirical results are reported and discussed in V. Finally, concluding remarks are made in Section VI.

II. Literature Review

We examine empirically the contemporaneous relationship between returns-volatility and trading volume. The Mixture of Distributions Hypothesis (MDH) suggests that the correlation between price variability and volume should be positive. Previous empirical studies have noted a strong positive relationship. First, Clark (1973) and Epps and Epps (1976) argue that the distribution of futures prices can be explained by the MDH. Epps and Epps (1976) present a theoretical model in which trading volume and absolute returns form a positive function of the amount of disagreement between traders. Copeland (1976) also develops a simple sequential information arrival model in which the information is received by one trader at a time, and each trading on this information before it becomes known to anyone else.

However, the majority of empirical evidence is summarized in the paper by Karpoff (1987). In particular, this paper cites several reasons why the price-volume relationship is positive (see also Board and Sutcliffe, 1990). Other research includes Cornell (1981) and Tauchen and Pitts (1983). Cornell (1981) shows a positive correlation between changes in average daily volume and changes in the standard deviation of daily log price relatives for 14 of the 18 examined commodities. Also, Tauchen and Pitts (1983) support the MDH and show that the joint distribution of changes in price and volume are modelled as a mixture of bivariate normal distributions. Next, we review the previous empirical studies related to the contemporaneous relationship between returns and trading volume.

Ying (1966) suggests that a small (large) volume is usually accompanied by a fall (rise) in price. Cornell (1981) finds positive relations between volume and changes in the variability of prices for 17 futures contracts. In addition, Harris (1983, 1984), Grammatikos and Saunders (1986) and Karpoff (1987) report a positive and contemporaneous correlation between volume and price variability. This kind of correlation appears to be consistent with the MDH (Grammatikos and Saunders, 1986). Also, Harris (1984) reports that the rate of information flow is a directing variable that leads to a positive contemporaneous change in response to the new information.

Most of recent papers extend the work of Lamoureux and Lastrapes (1990) by investigating the effect of trading volume to the market returns using the generalised autoregressive conditional heteroscedasticity (GARCH) model. They estimate a GARCH model where trading volume is included as an explanatory variable in the conditional variance equation. They find that volume has a positive effect on conditional volatility. Although previous research suggests that volume is a good proxy for information arrival, the opposite may be true for the market.

Sharma *et al*. (1996) examine the GARCH effects in the NYSE. The paper extends the work of Lamoureux and Lastrapes (1990) and shows how the GARCH effects in market returns are explained by market volume. For this reason, a simple GARCH (1,1) model with and without daily volume is considered. Also, Sharma *et al*. (1996) take into consideration the assumption of conditional normality and conditional t-distribution. The data covers the period 1986-1989. The results suggest that volume may contribute significantly in explaining the GARCH effects. In other words, the introduction of volume does not eliminate the GARCH effects completely. However, the coefficient of volume is found to be positive and statistically significant.

As mentioned, Karpoff (1987) reviews previous studies on the price-volume relation and concludes that there is a positive correlation between volatility and volume. Lamoureux and Lastrapes (1990) show that the introduction of volume in the conditional variance equation eliminates GARCH effects. They find that all other coefficients in the conditional variance equation (i.e. GARCH model) are statistically insignificant when volume is included. In addition, they argue that volume has a positive effect on conditional volatility. However, past residuals do not contribute much information regarding the variance when volume is included. Also, Kawaller, Koch and Koch (1990) find that daily volume of trading in the S&P 500 futures contract has a significantly positive effect on the volatility. In another study, Board and Sutcliffe (1990) also find support to the hypothesis of a positive relationship between volatility and volume for the FTSE-100 index. Further, Bessembinder and Seguin (1993) divide volume into expected and unexpected components to examine the relation between price volatility and trading volume for futures markets. They use daily prices and trading volumes for eight futures markets over the interval May 1982 to March 1990. In general, the results from AR and ARMA models show a positive relation between volume and volatility. Also, Bessembinder and Seguin (1993) suggest that 'the effect of unanticipated volume shocks on volatility is asymmetric'. As they conclude, their findings are consistent with the hypothesis that volatility is affected by existing market depth.

Using VAR, Granger-causality test and GARCH models, Hiemstra and Jones (1994), Gallant *et al.* (1993) and Tauchen *et al*. (1996) report a positive correlation between volatility and trading volume. Brailsford (1994) examines empirically the relationship between trading volume and volatility in the Australian Stock market. The sample covers the period 24 April 1989 to 31 December 1993. This study supports the hypothesis that the asymmetric relationship between volume and price changes. Also, the results show a reduction in GARCH coefficients and in the persistence of variance when trading volume is used. Further, Brailsford (1996) use data from Australian stock market in order to examine the relationship between trading volume and stock return volatility and trading volume and conditional volatility. The results from the GARCH (1,1) model are found to be insignificant when the volume is taken into consideration.

Ragunathan and Pecker (1997) focus on the relationship between volume and price variability for the Australian futures market. They consider return series of the contracts for the period January 1992 to December 1994. Using the models developed by Schwert (1990) and Bessembinder and Seguin (1993), they provide strong evidence that unexpected volume has a greater impact on volatility than expected volume.

Hogan *et al*. (1997) use a bivariate GARCH model to test the relationship between program trading volume and market volatility. They use daily data, from 3 January 1988 to 31 December 1991, of the S&P 500 cash and the CME S&P 500 near-term futures contracts. Their results show that there is a strong positive relationship between trading volume and volatility.

Also, Daigler and Wiley (1999) examine the volatility-volume relation in futures markets. They use the Chicago Board of Trade's Liquidity Data Bank to examine the Customer Trade Indicator (CTI) data that separates total futures volume into four types of traders. Accordingly, the general public drives the positive volatility-volume relation [3]. In addition, they find that the unexpected volume series is more important than the expected volume series in explaining volatility.

Jacobs and Onochie (1998) examine the relationship between return variability and trading volume in futures markets. The data set consists of daily observations for six futures contracts traded on the LIFFE. A bivariate GARCH-in-mean model is used. Their results indicate a positive relationship between trading volume and price volatility.

In addition, Montalvo (1999) examines the Spanish Government Bond Futures Market using the approach proposed by Lamoureux and Lastrapes (1990). Montalvo (1999) suggests that the daily volume and frequency have a positive effect on volatility. Consistently, Gwilym *et al*. (1999) analyse the contemporaneous relationship between volatility and volume for stock index (FTSE-100), short-term interest rate (Short Sterling) and government bond (Long Gilt) futures contracts traded at the LIFFE. That data covers the period 24 January 1992 to 30 June 1995. Evidence from estimation of a GMM system for volatility and volume supports a significant positive and contemporaneous correlation between volatility and volume.

Wang and Yau (2000) examine the relationship between trading volume and price volatility for futures markets using OLS and GMM. The sample is based on two financial futures contracts (S&P 500 and DM) and two metal futures contracts (silver and gold), and covers the period 2 January 1990 to 29 April 1994. Their results show a positive relationship between trading volume and price volatility and a negative relationship between price volatility and lagged trading volume.

Watanabe (2001) examines the relation between price volatility and trading volume for the Nikkei 225 stock index futures. The data covers the period 24 August 1990 to 30 December 1997. Following the method developed by Bessembinder and Seguin (1993), this paper shows a statistically significant and positive relationship between volatility and unexpected volume. Also, for the period when the regulation increased gradually, Watanabe (2001) suggests that there is no relationship between price volatility and volume.

Furthermore, Pilar and Rafael (2002) analyse the effect of futures on Spanish stock market volatility and trading volume. For this purpose, a GJR model with a dummy variable is used. Their results show a decrease in the volatility and increase in trading volume. However, Illueca and Lafuente (2003) find no significant link between spot volatility and trading volume in the Spanish stock index futures market. Finally, Luu and Martens (2003) test the MDH using realized volatility. They find that the mixed evidence on MDH in the existing literature can in part be attributed to the use of poor realized volatility measures.

III. Methodology

Following Bhar and Malliaris (1998) and Malliaris and Urrutia (1998), the trading volume is a function of equilibrium futures price and time. That is

$$V = V(t, F) \tag{1}$$

where V denotes trading volume, F denotes futures price and t denotes time. Assuming the price F follows an *Ito process* with drift μ and volatility σ, then:

$$dF = \mu dt + \sigma dZ \tag{2}$$

where Z denotes a *standardised Wiener process*. Although (1) is a general model, the model described by equation (2) is favourable, as *Ito's processes* describe better continuous random walks with a drift which lead to market efficiency. Another application of *Ito's lemma* results in

$$dV = \left[V_t + V_p \mu + \frac{1}{2} V_{pp} \sigma^2 \right] dt + V_p \sigma dZ \tag{3}$$

[3] Also, Bessembinder and Seguin (1993, p. 38) suggest that the volume-volatility relation depends on the class of traders involved.

where V_t, V_p and V_{pp} denote partial derivatives.

Models (1) and (3) describe trading volume theoretically and show whether it follows a random walk. If futures prices follow a random walk, trading volume also follows a random walk. Further, taking expectations of (3), we obtain the following expression:

$$E(dV) = V_t + V_p\mu + \frac{1}{2}V_{pp}\sigma^2 \tag{4}$$

This expression shows that the change in volume depends on V_t, the drift rate μ and the volatility of futures prices σ^2 We can also test the above hypothesis with the following model

$$E(dV) = at + \beta\mu + \gamma\sigma^2 \tag{5}$$

This implies a positive relationship between price variability and trading volume. Finally, using stochastic calculus, the volatility of trading volume is given by:

$$Var(dV) = V_p^2\sigma^2 \tag{6}$$

where the volatility of trading volume is a function of the futures price volatility. This hypothesis can be tested by the following expression:

$$Var(dV) = a + \delta\sigma^2 \tag{7}$$

For empirical testing equations (6) and (7), we get the following expression:

$$\left|\Delta V_t\right| = a + \delta\left|\Delta F_t\right| \tag{8}$$

Equation (8) tests the hypothesis that price volatility has a significant impact on volume volatility, see Bhar and Malliaris (1998)[4] and Malliaris and Urrutia (1998).

Contemporaneous Relationship

We analyse the contemporaneous relationship between volatility and volume in line with Sharma *et al.* (1996), Gwilym *et al*. (1999) and McMillan and Speight (2002).

According to Grammatikos and Saunders (1986), there are several measures of volatility . For example, Rutledge (1979) uses the absolute log change from one trading day to the next while Tauchen and Pitts (1983) use the square of the first difference of the futures price of adjacent periods. In addition, Karpoff (1987) uses the absolute value of the first difference to measure volatility[5]. In this study, we investigate the return (volatility)-volume relationship using the definition

$$R_t = \ln(F_t) - \ln(F_{t-1})$$

where F_t is the daily closing futures price. We also measure the volume parameter as follows:

$$LNVOL_t = \ln\frac{V_t}{V_{t-1}} \tag{9}$$

First, an approach that has been used to explain the return-volume relationship is based on (G)ARCH models. Previous works suggest that ARCH effects capture the properties of the information mixing variable. First, Lamoureux and Lastrapes (1990) assume that the presence of ARCH in returns is due to MDH. However, their results show that trading volume removes significance of ARCH and GARCH coefficients in the GARCH(1,1) model, implying that volume is a good alternative for the GARCH process. As a result, the persistence in volatility is reduced. On the other hand, Bessembinder and Seguin (1992, 1993) and Foster (1995) suggest that trading volume is not sufficient to remove the lagged volatility effects in current variance. Furthermore, Brailsford (1996), using the GARCH(1,1) model, concludes that there is a strong support for the above model only when absolute returns are considered.

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4 They suggest that volume is related to price volatility and volume volatility is related to price volatility.

5 Also, Sutcliffe (1993, p. 176) presents some of the definitions of price volatility

Following the work of Sharma *et al*. (1996), we study GARCH effects in our data and examine the effect of volume on return volatility using the GARCH(1,1) model. We test how well GARCH effects are explained by trading volume and examine the effect of trading volume on conditional volatility, see also Lamoureux and Lastrapes (1990). The conditional variance equation of the GARCH(1,1) model is given by:

$$\sigma_t^2 = \omega + a_1\varepsilon_{t-1}^2 + \beta_1\sigma_{t-1}^2 + \gamma LNVOL_t \qquad (10)$$

where $LNVOL_t$ is the daily return of trading volume. The model given by Equation (10) includes lagged conditional variance terms and errors. Daily trading volume is used as a proxy variable for the mixing variable (i.e. the number of daily price changes). The model given above is a GARCH(1,1) model that is found to be parsimonious and easier to identify and estimate (Enders, 1995). We use the GARCH(1,1) model because it provides positive and significant parameters for both indices. Only GARCH(1,1) is reported here because it is an adequate representation. Also, it is a well-documented result in the literature that most financial time series follow a GARCH(1,1) process, see Sharma *et al*. (1996). We also select the parsimonious GARCH(1,1) model since many papers argue that it accounts for temporal dependence in variance and excess kurtosis, see Ciner (2002). Here, we assume that the errors are conditionally normally distributed.

In addition, we examine the contemporaneous relationship between daily trading volume and futures returns, using several different techniques. In particular, to test whether the positive contemporaneous relationship between trading volume and stock index futures returns exists, the following AR(1)-GARCH (1,1) model is estimated:

$$R_t = \mu + a_1R_{t-1} + a_2LNVOL_t + \varepsilon_t \qquad (11\text{-}1)$$

$$\sigma_t^2 = \omega + a_1\varepsilon_{t-1}^2 + \beta_1\sigma_{t-1}^2 \qquad (11\text{-}2)$$

Equation (11-1) presents the mean equation and Equation (11-2) the variance equation.

Finally, we analyse the contemporaneous relationships using the methodology proposed by Gwilym *et al*. (1999) and Ciner (2002). We model the series using the equations:

$$|R_t| = \omega + aLNVOL_t + \gamma|R_{t-1}| + \varepsilon_t \qquad (12\text{-}1)$$

$$LNVOL_t = \phi + \lambda|R_t| + \mu LNVOL_{t-1} + \xi_t \qquad (12\text{-}2)$$

Gwilym *et al*. (1999) and Ciner (2002) estimate a system of simultaneous equations via Generalized Method of Moments (GMM). Also, Richardson and Smith (1994) test MDH using a GMM estimator. Recently, Holmes and Tomsett (2004) use the GMM approach to demonstrate that the link between futures volume volatility can be attributed to the flow of information [6].

Since the system uses volume and absolute value of returns as endogenous variables, it would not possible to use OLS[7]. The GMM is introduced by Hansen (1982). Accordingly, '*the idea is to choose the parameter estimates so that the theoretical relation is satisfied as closely as possible*'. In general, the GMM approach allows estimation of the contemporaneous relationship whilst avoiding any simultaneity bias and yielding heteroscedasticity and autocorrelation consistent estimates in the process, see Gwilym *et al.* (1999). GMM estimation requires a list of instruments. In this case, following Gwilym *et al.* (1999) and Ciner (2002), we use lagged volatility and volume to identify the GMM estimator. In particular, instrumental variables control for simultaneity bias and the GMM system controls for possible heteroskedasticity in error terms. We also select the 'Weighting Matrix: Time Series (HAC)' option to alleviate heteroscedasticity and autocorrelation. In addition, GMM has the advantage of reporting the J-statistic to test the validity of overidentifying restrictions (usually, when there are more instruments than parameters). Under the null hypothesis that the overidentifying restrictions are satisfied, the J-statistic times the number of regression observations is asymptotically

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[6] They show that price movements are dominated by informed rather than noise trading.

[7] Since is correlated with error term , then is not equal to zero, as required by OLS. Similarly for and .

chi-squared with degrees of freedom equal to the number of overidentifying restrictions (we also report the p-value of the test statistic). Notice that we always estimate GMM using "Heteroscedasticity Consistent Standard Errors". According to Ciner (2002), the significance of and shows a contemporaneous relation between trading volume and absolute returns. Also, the significance of the parameter indicates that lagged volume contains information about absolute returns. As a result, market traders use trading volume as an indication of market (prices) on previous trading volume, see also Foster (1995) for details.

IV. Data Description

Daily closing prices and volume for FTSE/ASE-20 index are used over the period September 1999-August 2001. For FTSE/ASE Mid 40 index, daily closing prices and trading volume are used over the period January 2000- August 2001. Here, trading volume [8] is the number of trades in a futures contract during a specified period of time (i.e. number of daily contracts in one day). Focusing on the above periods, (i) we test the hypotheses using data from the early stage of the ADEX (started its official operation on 27 August 1999), and (ii) we investigate whether the hypotheses exist after the dramatic rise of Athens Stock Exchange (ASE) stock prices [9]. Graphical plots of return-volume coefficients are presented in Appendix 1 and Appendix 2 for FTSE/ASE-20 and FTSE/ASE Mid 40, respectively.

The FTSE/ASE-20 comprises 20 Greek companies, quoted on the Athens Stock Exchange (ASE), with the largest market capitalisation (blue chips), while the FTSE/ASE Mid 40 comprises 40 mid-capitalisation Greek companies. Futures contracts are quoted on the Athens Derivatives Exchange (ADEX). The price of a futures contract is measured in index points multiplied by the contract multiplier, which is 5 Euros for the FTSE/ASE-20 contract and 10 Euros for the FTSE/ASE Mid 40 contract. There are four delivery months: March, June, September and December. Trading takes place in the 3 nearest delivery months, although volume in the far contract is very small. Both futures contracts are cash-settled and marked to market on the last trading day, which is the third Friday in the delivery (expiration) month at 14:30 Athens time. For more information about the Greek stock index futures, see Floros and Vougas (2006, 2004).

V. Empirical Results

First, we provide summary statistics of absolute returns and (log-)volume, and present unit root tests. Table 1 provides information for FTSE/ASE-20 and Table 2 for FTSE/ASE Mid 40 stock index futures.

Table 1: Statistics for FTSE/ASE-20 (Abs. Return – Tr. Volume)

FTSE/ASE-20	ABS. RETURN	TR. VOLUME
MEAN	0.013647	6.747424
MEDIAN	0.009300	6.665644
MAXIMUM	0.104776	8.992682
MINIMUM	0.000000	3.044522
STD. DEV	0.014347	1.075815
SKEWNESS	2.135955	-0.081702
KURTOSIS	9.559634	2.413449
JARQUE-BERA	1340.457	8.125462
PROB.	0.000000	0.017202

8 Some other measures of volume used in empirical studies are: the value of contracts traded, the level of open interest, and the level of open interest multiplied by the price.

9 The Athens Stock Exchange (ASE), an important European emerging equity market, experienced a dramatic rise of stock prices between the years 1998-1999, followed then by an equally dramatic fall.

Table 2: Statistics for FTSE/ASE MID 40 (Abs. Return – Tr. Volume)

FTSE/ASE MID 40	ABS. RETURN	TR. VOLUME
MEAN	0.020070	6.798633
MEDIAN	0.013693	6.866931
MAXIMUM	0.151776	8.495970
MINIMUM	0.000000	3.761200
STD. DEV	0.020161	0.715681
SKEWNESS	1.878317	-0.546412
KURTOSIS	8.417987	3.666502
JARQUE-BERA (J-B)	751.6148	28.40049
PROB.	0.000000	0.000001

Both FTSE/ASE-20 and FTSE/ASE Mid 40 absolute returns have positive skewness, positive kurtosis and high J-B statistic. This implies that the distribution is skewed to the right and that the pdf is leptokurtic. The J-B statistic test indicates that the null hypothesis of normality is rejected. In addition, the results for the trading volume series indicate negative skewness, low positive kurtosis and lower value of J-B statistics (still rejecting normality). Hence, summary statistics for trading volumes show that the distribution is skewed to the left and that the null hypothesis of normality is also not rejected, but not as strongly.

Unit Root Tests

Empirical tests assume the variables (i.e. returns and trading volume) in the system are stationary. We test for the stationarity of log-futures and trading volume series. Returns and trading volume are expected to be stationary (in line with the literature). To test futures and log(volume) for a unit root we employ the augmented Dickey-Fuller (ADF) test. Table 3 shows that the null hypothesis that the futures trading volume series are non-stationary is rejected for both FTSE/ASE-20 and FTSE/ASE Mid 40 stock index futures. We conclude that the trading volume is stationary (for both indices), while futures series are both non-stationary. However, the logarithmic returns of futures series are stationary.

Table 3: Unit Root Tests (Price – Tr. Volume)

FTSE/ASE-20 INDEX	ADF (PRICE)	ADF (VOLUME)
(Lags: 3)	**Critical Values:**	**Critical Values**
	1%: -3.4452 5%: 2.8674 10%: 2.5699	1%: -3.4452 5%: -2.8674 10%: -2.5699
ADF 1ST DIFF. ADF	-0.777813 -11.55063	-2.737684 -15.37652
FTSE/ASE MID 40 INDEX	**ADF (PRICE)**	**ADF (VOLUME)**
(Lags: 2)	**Critical Values:**	**Critical Values**
	1%: -3.4483 5%: 2.8688 10%: 2.5706	1%: -3.4484 5%: -2.8688 10%: -2.5706
ADF 1ST DIFF. ADF	-1.954468 -12.81365	-3.535182 -10.22955

I. Contemporaneous Relationship (FTSE/ASE-20)

Further, we investigate whether trading volume has any explanatory power for futures market returns by fitting a GARCH (1,1) model with volume included in the conditional variance equation. Table 4 reports the results for FTSE/ASE-20. The parameter γ is positive and statistically significant (i.e. there is a positive effect), indicating also that it is reflective of the contribution of volume in explaining the GARCH effects in futures markets returns. In other words, the volume contributes significantly in explaining the GARCH effects (Sharma *et al.*, 1996).

Table 4: GARCH (1,1) Model $\sigma_t^2 = \omega + a_1\varepsilon_{t-1}^2 + \beta_1\sigma_{t-1}^2 + \gamma LNVOL_t$

Dependent Variable: R_t		
Mean Equation	**Coefficient**	**t-Statistic**
Constant	**-0.0017**	**-2.9354***
Variance Equation		
ω	5.37E-05	2.3791*
a_1	0.1572	2.6600*
β_1	0.6842	6.7913*
LNVOL	0.0001	6.0479*

** Significant at the 5% or 10% level.*

In addition, we examine the contemporaneous relationship between trading volume and futures returns, using a GARCH (1,1) model with volume included in the mean equation only. From Table 5, trading volume coefficients are positive. The coefficient is positive and significant (i.e. there exists a positive contemporaneous relationship between trading volume and returns).

Furthermore, results from the GMM system for FTSE/ASE-20 stock index futures are presented in Table 6. The coefficients a and λ are not significant and we conclude that there is no positive contemporaneous relationship between volatility and volume. In addition, the results state that there is a statistically significant relationship between lagged volume and absolute returns. The parameter μ indicates that lagged volume contains information about absolute returns. Note also that, the J-test is very small indicating that there exists a good fit of the model to the data.

Table 5: GARCH (1,1) Model $R_t = \mu + a_1R_{t-1} + a_2LNVOL_t + \varepsilon_t$ $\sigma_t^2 = \omega + a_1\varepsilon_{t-1}^2 + \beta_1\sigma_{t-1}^2$

Dependent Variable: R_t		
Mean Equation	**Coefficient**	**t-Statistic**
μ	-0.0012	-1.6922*
R_{t-1}	0.1124	2.4457*
LNVOL	0.0038	2.0897*
Variance Equation		
ω	5.14E-05	2.1855*
a_1	0.1668	2.3788*
β_1	0.6953	6.6864*

* Significant at the 5% or 10% level.

Table 6: GMM Models $|R_t| = \omega + aLNVOL_t + \gamma|R_{t-1}| + \varepsilon_t \quad LNVOL_t = \phi + \lambda|R_t| + \mu LNVOL_{t-1} + \xi_t$

Dependent Variable: $\lvert R_t \rvert$		
Instrument list: $\lvert R_{t-1} \rvert \quad LNVOL_{t-1}$		
Variable	**Coefficient**	**t-Statistic**
ω	0.0117	11.618*
LNVOL	-0.0068	-1.0848
$\lvert R_{t-1} \rvert$	0.1461	2.0994*
J-statistic	1.68E-31 (p-val. 1)	
Dependent Variable: LNVOL		
Instrument list: $\lvert R_{t-1} \rvert \quad LNVOL_{t-1}$		
Variable	**Coefficient**	**t-Statistic**
ϕ	-0.1070	-0.6643
$\lvert R_t \rvert$	8.1852	0.6811
LNVOL $_{t-1}$	-0.2784	-5.3638*
J-statistic	1.68E-30 (p-val. 1)	

** Significant at the 5% or 10% level.*

II. Contemporaneous Relationship (FTSE/ASE MID 40)

Table 7 reports results obtained from estimating Equation 10, following Sharma *et al*. (1996). Volume parameter is not statistically significant, when included in the conditional variance equation, thus trading volume does not contribute significantly in explaining the conditional variance when a GARCH (1,1) model is estimated.

Table 7: GARCH (1,1) Model: $\sigma_t^2 = \omega + a_1\varepsilon_{t-1}^2 + \beta_1\sigma_{t-1}^2 + \gamma LNVOL_t$

Dependent Variable: R $_t$		
Mean Equation	**Coefficient**	**t-Statistic**
Constant	**-0.0020**	**-1.2051**
Variance Equation		
ω	0.0001	1.6359
a_1	0.1507	1.6199
β_1	0.5949	2.5424*
LNVOL	0.0002	0.5142

** Significant at the 5% or 10% level.*

Furthermore, Table 8 reports results obtained from a GARCH (1,1) model with volume indicated in the mean equation only. The coefficient of trading volume is positive but not significant. Hence, there is no evidence of positive contemporaneous relationship between trading volume and futures returns for FTSE/ASE Mid 40.

Table 8: GARCH (1,1) Model $R_t = \mu + a_1 R_{t-1} + a_2 LNVOL_t + \varepsilon_t \quad \sigma_t^2 = \omega + a_1 \varepsilon_{t-1}^2 + \beta_1 \sigma_{t-1}^2$

Dependent Variable: R_t		
Mean Equation	**Coefficient**	**t-Statistic**
μ	-0.0021	-1.6783*
R_{t-1}	-0.0178	-0.3186
LNVOL	0.0006	0.2737
Variance Equation		
ω	5.19E-05	2.0908*
a_1	0.1599	2.9491*
β_1	0.7819	12.840*

** Significant at the 5% or 10% level.*

Table 9 reports results from GMM system estimation. The results show that there is no positive and significant contemporaneous relationship between volatility and volume for FTSE/ASE Mid 40. A further point is that the effect of lagged volume is negative in the volume equation, suggesting that the knowledge of increased current volume is a predictor of reduced future volume. Also, the fact that the lagged return is positive (and significant) in the return equation indicates that knowledge of increased current return is a predictor of reduced future return. In addition, the J-test statistic is very small, supporting a good fit to the data.

Table 9: GMM Models $|R_t| = \omega + aLNVOL_t + \gamma|R_{t-1}| + \varepsilon_t \quad LNVOL_t = \phi + \lambda|R_t| + \mu LNVOL_{t-1} + \xi_t$

Dependent Variable: $\lvert R_t \rvert$		
Instrument list: $\lvert R_{t-1} \rvert \quad LNVOL_{t-1}$		
Variable	**Coefficient**	**t-Statistic**
ω	0.0174	11.826*
LNVOL	-0.0013	-0.2416
$\lvert R_{t-1} \rvert$	0.1317	2.4509*
J-statistic	5.85E-31 (p-val. 1)	
Dependent Variable: LNVOL		
Instrument list: $\lvert R_{t-1} \rvert \quad LNVOL_{t-1}$		
Variable	**Coefficient**	**t-Statistic**
ϕ	-0.1206	-0.5975
$\lvert R_t \rvert$	6.1107	0.6049
$LNVOL_{t-1}$	-0.2912	-6.0996*
J-statistic	7.01E-31 (p-val. 1)	

** Significant at the 5% level.*

VI. Summary and Conclusions

The relationship between returns and trading volume has interested financial economists and analysts for a number of years. A widely documented result is the positive contemporaneous relationship between price returns and trading volume. The two most important theoretical models, which have been used to explain this relationship, are the ‘mixture of distributions hypotheses’ (MDH) and ‘sequential information arrival hypotheses’. MDH is examined by Clark (1973), Epps and Epps (1976) and Harris (1987), while sequential information is used by Copeland (1976). Karpoff (1987) reviews previous studies on price-volume relation and confirms the positive correlation between volatility (returns) and volume on various financial markets.

In this paper, we investigate the contemporaneous relationship between volume and returns in Greek stock index futures market. Using GARCH models, the results for FTSE/ASE-20 show positive and significant effect, indicating that volume contributes significantly in explaining the conditional variance (in line with Sharma *et al*., 1996), and little support to MDH or sequential information arrival models. Furthermore, GMM system estimation suggests that there is a significant relationship between lagged volume and absolute returns, while a positive contemporaneous relationship does not hold. Taken together, these findings indicate that market participants use volume as an indication of prices, see Foster (1995). Also, volume and returns do not respond to the same exogenous variable in the GMM system, that is the daily flow of information to the market. The latter is in contrast with Ciner (2002).

For FTSE/ASE Mid 40, the results are mixed (the findings are in contrast with previous results for FTSE/ASE-20). Both GARCH and GMM methods confirm that there is no evidence of positive relationship between trading volume and returns. Also, GMM results show that the knowledge of increased current volume could be a predictor of reduced future volume for FTSE/ASE Mid 40 index. These findings are helpful to financial managers dealing with Greek stock index futures.

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Appendix

Appendix 1: Graphical plots of FTSE/ASE-20*

Figure 1:

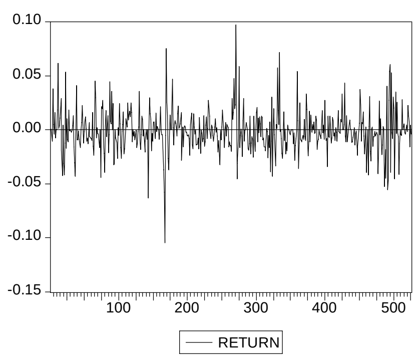


Figure 2:

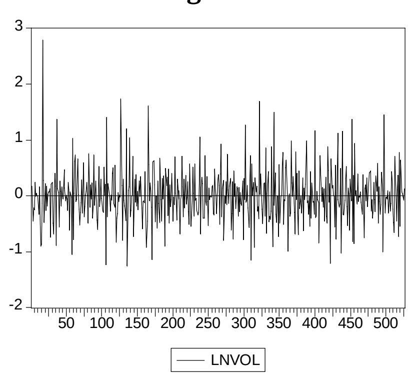
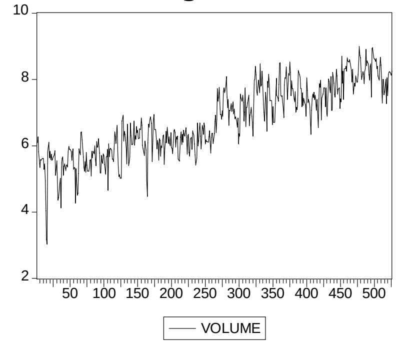


Figure 3:



** Graphical plots of return, lnvol, and volume (in levels) for FTSE/ASE-20.*

Appendix 2: Graphical plots of FTSE/ASE MID 40*

Figure 1:

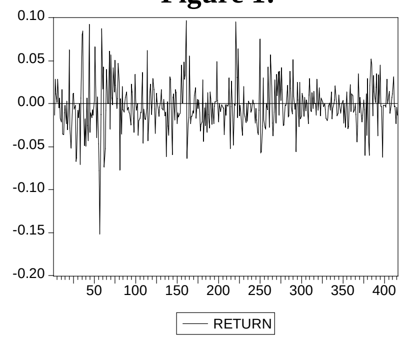


Figure 2:

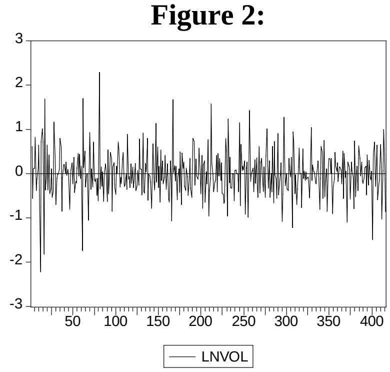
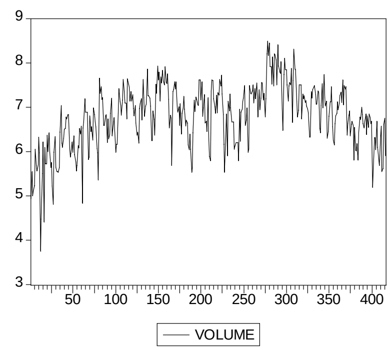


Figure 3:



* Graphical plots of return, lnvol and volume (in levels) for FTSE/ASE Mid 40

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