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An Investigation of Price – Volume Intraday Patterns under "Bull" and "Bear" Market Conditions

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Abstract

There has been a common belief among stock market practitioners that stock prices move along with trading volume creating certain patterns in price and volume formation. Nevertheless, the above argument was hardly recognised by the academic community since for a number of years statistical results indicated that the stock market is an efficient market i.e. a market where past available information is of no use in predicting future returns profitably, and/or non rational factors do not influence stock prices; The last decade the research for market efficiency was expanded and the use of new large data sets and advanced techniques indicated deviations from the predictions of the Efficient Market Hypothesis (E.M.H.). This study investigates whether there exists a relationship between stock returns and trading volume in the Athens Stock Exchange (A.S.E.) and if such a relationship forms evidence against the E.M.H. We believe that we add to the research in this area since we use intraday data and investigate for a possible relationship under different market states and for different categories of shares.

Keywords: informational efficiency, stock prices, trading volume, causality.
JEL Classification: G14.

1. Introduction

According to Fama (1970,1976), a stock market is efficient if prices reflect rationally, fully and instantaneously all relevant available information. Thus, empirical research for market efficiency investigates if there is past available information which can serve as profitable predictor of future returns. Additionally, empirical research investigates whether non rational factors i.e. factors which are not predicted by the economic theory in the model under consideration, influence stock prices; (Muth 1961, Cootner 1962, Fama 1965, Gowland and Baker 1970, Cutler, Poterba and Summers 1989, MacDonald and Taylor 1988, 1989, Spiro 1990, Cochrane 1991, Frennberg and Hansson 1993, Jung and Boyd 1996, Al-Loughani and Chappel 1997, A. Shleifer 2000).

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There have been some studies testing the EMH for the case of the Athens Stock Exchange (A.S.E.), giving contradicting results (Niarchos 1972, Panas 1990, Koutmos, Negakis and Theodossiou 1993, Alexakis P. and Petrakis 1991, Alexakis P. and Xanthakis 1995, Niarchos and Alexakis C. 1998, 2001). Our study adds to the existing evidence since it aims at investigating how, if at all, trading volume is related to stock market returns in the Athens Stock Exchange, which none of the above studies had investigated. In addition we add to the evidence since we examine the stock price – trading volume relationship with the use of intraday data, for different categories of shares i.e. small, medium and big capitalisation and for different market conditions i.e. "bull" (rising) and "bear" (declining) markets.

Section 2 presents past empirical evidence for the relationship between stock prices and trading volume, while section 3 describes the methodology used in this study. Section 4 presents the empirical results and finally section 5 summarizes the conclusions.

2. Stock Prices and Trading Volume

From the point of view of market practitioners, trading volume has always been an important variable in their efforts to predict stock prices. For instance, a large number of technical analysis indicators, widely used by market participants for forecasting purposes, take into consideration both stock prices and volume of trading. On the other hand, academics recognised the significance of trading volume and stock prices relationship[4]. In the framework of the EMH price changes are interpreted as the market evaluation of new information, while the corresponding volume is considered as an indication of the extend to which investors disagree about the meaning of the information, (Karpoff 1987). In a number of empirical studies was investigated statistically the possibility of dynamics between the two variables. Nevertheless, the evidence indicated a contemporaneous statistical relationship with no predictive power for either variables.

In an early empirical examination of the price - volume relationship (Granger and Morgerstern 1963), discern no relation between movements in a Securities and Exchange Commission Composite Index and the aggregate level of volume for the New York Stock Exchange. It was then argued that in the stock market the classical theory of demand and supply does not apply and the reason offered was that market participants can not be neatly divided into the groups of buyers and sellers and so there is not likely to be a clear cut relationship between volume and price or price change. Furthermore, Godfrey, Granger and Morgerstern (1964) did not find any relationship between price changes or the absolute value of price

[4] According to Beaver (1986) an important distinction between the price and volume tests is that the former reflects changes in expectations of the market as a whole while the latter reflects changes in expectations of individual investors. In addition, the price - volume relationship is useful for the so called event studies because if price and volume are jointly determined, then by incorporating the price - volume relationship the power of these tests is increased. Finally, the price - volume relation has significant implications for research into the futures markets as it is argued that price volatility may affect the volume of trade in futures market contracts.

differences and volume. Subsequent empirical evidence by Ying (1966), indicated that a small volume is accompanied by a fall in price, a large volume by a price rise, while a large increase in volume is accompanied by either a large rise or fall in price. The above empirical evidence indicated a positive correlation between price changes (ΔP) and volume (V) and between the absolute value of price change ($|\Delta P|$), and volume (V).

Further empirical research by Crouch (1970), confirmed the absolute price change - volume correlation but with no evidence of predictability. The discovered relation was almost entirely contemporaneous, as most leading and lagged variables were statistically insignificant, contradicting the old Wall Street proverb 'it takes volume to make prices move'. Another familiar Wall Street adage is that '*Volume is relatively heavy in "bull" markets and light in "bear" markets*'. Following Ying's results, empirical studies have shown a positive correlation between volume and price change per se but again no lagged relationship has been found, implying a contemporaneous relationship between price change per se and volume (Rogalski 1978, Harris and Garel 1986, Hiemstra and Jones 1994).

Nevertheless, based on recent evidence, some researchers argue that volume may provide insights regarding the quality of trader's information than cannot be obtained from price statistics and the joint analysis of past price and volume data can be proved useful in providing information about future price movements, (Blume et al 1994), and especially in emerging markets, (Antoniou et al 1997).

Because of the recent availability of intraday transaction data, basically a result of computer based trading, it has been possible to observe the behaviour of individual investors as they deal in the market. In general, the results of some earlier studies suggest that mean stock returns exhibit distinct intraday patterns, with overall high returns at the beginning and the end of the trading day (Wood, McInish and Ord, 1985, Harris 1986, Terry 1986, Jain and Joh 1988, Harris 1989, Aitken, Brown and Walter 1995).

Not only stock returns but volume of trading indicates systematic patterns as well. The highest volume occurs at the opening time, during the trading day the volume subsides, and near the close time it increases again, albeit not to the same level as at the opening. A significant intraday pattern in trading activity could imply that the information content of stock prices differs in several periods of the trading day (Jain and Joh 1988, Foster and Viswanathan 1993). Nevertheless, there is no strong statistical evidence in the studies which use intraday data that stock prices and trading volume are related with a lead-lag relationship which could help to predict either variable.

3. The methodology employed

A very popular way to test the existence of any temporal statistical relationship with predictive value between two time series is the Granger "causality" test (Granger 1969, 1988). Nevertheless, the term "causality" is unfortunate; thus, when we test for "causality" we in fact test for precedence and for linear precedence, in particular. Granger's definition for "causality" is in terms of predictability: A variable X causes another variable Y, with respect to a given information set that

includes X and Y, if present Y can be better forecasted by using past values of X than by not doing so.

Granger's tests for causality in the sense of precedence are based on the following statistical reasoning: if we consider two time series as Y_t and X_t, the series X_t fails to Granger cause Y_t, if in a regression of Y_t on lagged Y's and lagged X's the coefficients of the latter are zero.

That is, consider equations 1 and 2:

$$Y_t = \alpha + \sum_{i=1}^{n} \beta_i Y_{t-1} + \sum_{y=1}^{n} \gamma_i X_{t-1} + \varepsilon_t \quad (1)$$

$$X_t = \alpha + \sum_{i=1}^{n} \delta_i Y_{t-1} + \sum_{y=1}^{n} \zeta_i Y_{t-1} + v_t \quad (2)$$

If in the above equations, $\gamma_i = 0$ for $i = 1,2,...,n$ in equation (1) we can conclude that X_t fails to Granger cause Y_t. If also $\zeta_i = 0$ for $i = 1,2,3...,n$ in equation (2) then Y_t fails to "Granger cause" X_t. Then we can conclude that the two series are temporally uncorrelated.

If $\gamma_i \neq 0$ for $i = 1,2,3...,n$ in (1) and $\zeta_i = 0$ for $i = 1,2,3...,n$ in (2) then X_t "Granger cause" Y_t. Also if $\gamma_i = 0$, $i = 1,2,3...,n$ in (1) and $\zeta_i \neq 0$, $i = 1,2,3...,n$ in (2) then Y_t "Granger cause" X_t.

Finally, if γ_i and ζ_i are different from zero in equations (1) and (2) then we conclude that between X_t and Y_t there is a bi-directional "causality". Note that in all the above regressions ε_t and v_t should be white noise and uncorrelated at any lag other than t.

The presence of "causality" implies market inefficiency in the following sense:

Under the Efficient Market Hypothesis for the return of a stock index, say j, it must be true that:

$$E(R_{jt}/I_{t-1}) = 0 \quad (3)$$

where $I_{t-1} = [P_{j,t-1}, P_{j,t-2}, P_{j-t-3}, ...,P_{j,t-n}]$ and $P_{jt-1}, ..., P_{jt-n}$ is the price history of the stock index j.

If it is also true that:

$$E(R_{jt}/H_{t-1}) = 0 \quad (4)$$

where $H_{t-1} = [P_{j,t-1}, P_{j,t-2}, P_{j,t-3}, ..., P_{j,t-n}, P_{k,t-1}, P_{k,t-2}, P_{k,t-3}, ..., P_{k,t-n}]$ and $P_{k,t-1}, ..., P_{k,t-n}$ is the history, not necessarily price history, of a variable k different than j, then no Granger "causality' exists and the market is still efficient with respect to the information set, H_{t-1}. The opposite case implies that past values of variable k can help to predict the return of stock j, and the market is inefficient with respect to the information set, H_{t-1}.

Nevertheless, in our case not only a "causality" which runs from trading volume to stock returns but also a "causality" which runs from stock returns to trading

volume would form an evidence against the Efficient Market Hypothesis. In the former case the reasoning is straightforward i.e. past values of a variable can help to predict stock returns. In the latter case, where lagged stock returns influence trading volume, we can argue that market participants take into account past information in their trading actions or that their trading actions are influenced by some psychological factors which are generated by the lagged returns e.g. a positive lagged return may create optimism (trend extrapolation) or pessimism (correction) for future returns and some investors trade based on that feeling where some other investors' trades are not based on sentiment.

4. Data and Results

In this study we use ultra high frequency stock market data. Analytically, we use intraday stock prices (P) of individual stocks of big, medium and small capitalization companies. We chose the companies to be representative of their category and their shares actively traded in the Athens Stock Exchange. For every category individual stocks were used with an equal weight in order to compose an index.

The time interval we used in our study is that of five trading minutes. Five minute time intervals are short enough to present the trading activity of the market and long enough, we believe, to include market reaction to new information. The stock prices of these intervals refer to the average price in the five minute period weighted by the corresponding volume i.e. a price at which heavy trading took place accounts more than a price at which light trade took place. In all cases we used the logarithmic transformation (lP) of the price series and we calculated the stock returns as the difference of the logarithmic stock prices. The trading volume, as the other variable under examination, refers to the total number of shares which were traded during the five minutes trading period.

The calendar periods under examination were chosen to represent a period of rising prices and a period of declining prices so that the validity of the popular belief that "volume goes with trend" could be examined. As Edwards and Magee (1992) point out "…..for the general truth that trading activity tends to expand as prices move to the direction of the prevailing trend. Thus in a bull market volume increases when prices rise and dwindles as prices decline; in bear markets turnover increases when prices drop and dries up as they recover ..."

The "bull" market was taken to be the three-month period of June, July and August 1999 (Diagram 1), and the "bear" market the period September, October and November 2000 (Diagrams 2).

Tables Ia and Ib present the Dickey Fuller statistics (D.F.) for the series under investigation in the "bull" and "bear" market respectively. We performed the Augmented Dickey-Fuller regression in order to ensure white noise residuals in the Dickey-Fuller regressions. For the price variable the null hypothesis that any of the level series have unit roots cannot be rejected. This is confirmed by the A.D.F. statistics which test for unit roots in the first differenced series. In each case the null hypothesis is easily rejected. Together with the results in the level series, it implies that the price series are integrated of order one I~(1). On the other hand the statistical results indicate that the volume series are integrated of order zero I~

(0). Based on the above results the Granger "causality" tests will be performed on the first difference logarithmic transformation of the original series. For the case of the stock prices the above transformation approximates the intraday returns and for the case of trading volume the logarithmic difference transformation expresses the positive or negative volume changes.

Tables IIa and IIb presents the basic statistics for the variables which will be used in the "causality" analysis. According to the above statistics the average returns are found to be positive in the bull market and negative in the bear market and the standard deviation of returns, as a measure of risk, was found to be bigger for small and medium capitalisation companies as it is predicted by the financial theory. Finally, according to the calculated statistics the distributions of returns and trading volume changes are found to have thicker tails than the normal distribution.

The results obtained from the standard Granger "causality" tests for the "bull" and "bear" markets are presented in tables III and IV respectively. In the "causality" tests a major decision emerges in the choice of the lag length used. We used the "general to specific" modeling strategy to eliminate lags with insignificant parameter estimates, taking into account model selection criteria as the Akaike criterion. The above modeling strategy indicated that both variables under investigation have autoregressive representations i.e. they are autocorrelated series.

We must note that the "causality" regressions were estimated with heteroscedasticity consistent covariance matrices and adjusted to take in to account possible ARCH effects. Apart from the "causality" statistic for the above regressions we report the Box - Ljung Q statistic for autocorrelated errors and the LM statistic for possible ARCH effects.

Finally, as far as "causality" is concerned the relevant statistics indicate that in the case of the "bull" market in almost all cases a bi-directional "causality exists". The lagged returns "cause" changes in the trading volume and vise versa. For the case of the "bear" market the results change. Analytically, the "causality" from returns to trading volume still runs but not the "causality" from changes in trading volume to returns.

5. Conclusions and Policy Implications

The statistical results of this study indicated that the intraday trading volume is a highly autocorrelated series. Analytically, the autocorrelation pattern indicates significant autocorrelations for a lag length of twelve periods which represents a time period of an hour. This statistical result indicates that trading activity may excite further trading activity, possibly without any economic justification i.e. psychology may influence trading decisions. The above explanation is inconsistent with the rationality element of the Efficient Market Hypothesis, because if volume measures interest in or attention to a stock, then interest is proportional to the interest already there (Osborne 1962, Granger and Morgerstern 1963).

Another statistical finding of this study is that the lagged price change helps to forecast the change in the volume of trading in both "bull" and "bear" markets. This can be attributed to the character of the stock market, influenced again by

psychological factors. It seems that past price changes create an unjustified by the economic theory signal for some investors to trade on it. For example, if investors extrapolate trends in price changes, a positive price change may create optimism (an expectation of a further price increase) and a negative price change pessimism (an expectation of a further price decrease) and some investors may trade based on that psychological influence (DeLong et al 1990). Additionally, some less informed investors, possibly due to cost restrictions, may interpret past price changes as a signal for relevant information which will reach the market in some future point of time. Having no direct access to that information, they trade on lagged returns as a proxy for the forthcoming information.

Finally, for the case of the "bull" market the opposite "causality" also holds i.e. lagged changes in trading volume "cause" changes in stock prices. It is well known that under rising market conditions the trading volume is higher that the trading volume in declining market conditions. According to table V the trading volume is more than double in the "bull" market in comparison to the "bear" market. Thus, a change in high levels of trading volume is noticeable and traders may take it into account when the buy or sell stocks. On the contrary, for the relatively low levels of trading during the "bear" market a change may not be noticed, at least as a base for trading actions[5]. Whatever the explanation for the above results, the different behaviour under "bull" and "bear" market conditions would indicate that stock price trends and possibly the psychology they create among investors are a major factor of stock price determination contrary to the prediction of the efficient market hypothesis.

Since in this study we use intraday data, it is reasonable to assume that the observed patterns are created by intraday traders. The cheap entry and exit commission fee of the Athens Stock Exchange and the tax free potential capital gains may be some reasons for the existence of psychology based trading i.e. people trade based on their psychology since it is cheap to do so. A possible taxation with increased commission costs for intraday trading may help to avoid the unpleasant psychological effects on stock trading since it is well known that investors psychology may drive price far away from fundamental values. In that case the Stock Exchange will not operate as an efficient allocative mechanism of the surplus funds in the economy. On the other hand it is accepted that intraday trading gives liquidity to the market and produces a continuous pricing process. Thus, taxation in intraday trading may create a less liquid market. From the above it is clear that investors' behaviour and the stock market microstructure are closely related. Nevertheless, the correct policy actions may need much more knowledge of the stock market workings. This study is among the first studies regarding the Greek market which use intraday data. Perhaps future research may be much more fruitful with the use of more information on investor behaviour like bid and ask prices.

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[5] The above proposition was examined by regressions of the stock return on the absolute level of the trading volume. According to the results a strong statistical relationship was found only in the case of the 1999 "bull" market.

Diagram 1
Bull Market

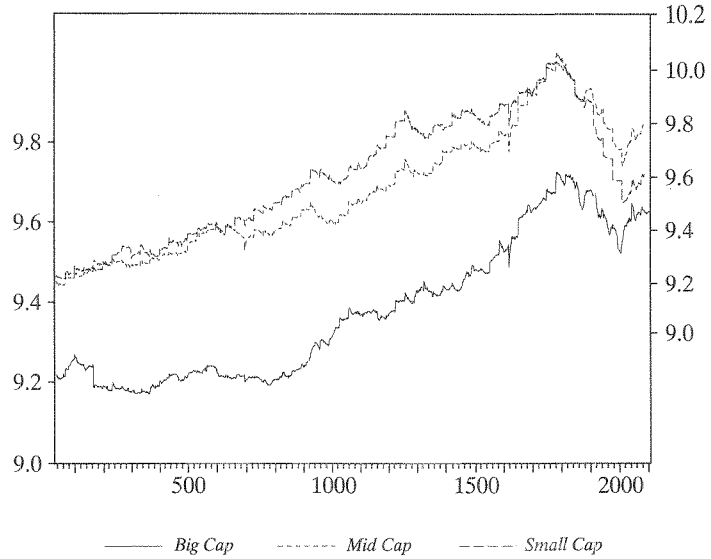

Diagram 2
Bear Market

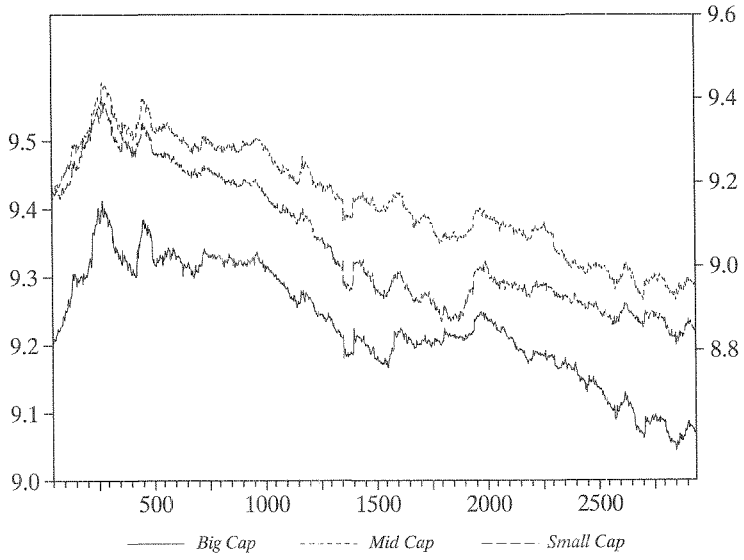

Table Ia,b A.D.F. tests

Table Ia: *"Bull" Market - A.D.F. tests*

Variable	Levels	First Difference
Price Big Cap	-0,06	-19,95**
Volume Big Cap	-8,07**	-
Price Mid Cap	-1,00	-20,26**
Volume Mid Cap	-9,11**	-
Price Small Cap	-1,66	-20,31**
Volume Small Cap	-10,22**	-

Double star(**) indicates significance at 99 % confidence interval.

Table Ib: *"Bear" Market - A.D.F. tests*

Variable	Levels	First Difference
Price Big Cap	0,11	-25,53**
Volume Big Cap	-11,88**	-
Price Mid Cap	-0,009	-25,96**
Volume Mid Cap	-11,83**	-
Price Small Cap	-0,35	-25,41**
Volume Small Cap	-13,02**	-

Double star(**) indicates significance at 99 % confidence interval.

Table IIa,b Basic Ststistics

Table IIa: *"Bull" Market - Basic Statistics*

Variable	Mean	Max	Min	St. Dev.	Skewness	Kurtosis
ΔPrice - Big Cap	0,002	0,04	-0,05	0,004	-0,50	52,37
ΔVolume - Big Cap	0,0007	1,65	-2,30	0,41	-0,33	4,98
ΔPrice - Mid Cap	0,0003	0,06	-0,06	0,005	0,09	51,78
ΔVolume - Mid Cap	-0,00001	3,05	-2,81	0,47	0,21	7,25
ΔPrice - Small Cap	0,0002	0,05	-0,08	0,006	-1,93	53,87
ΔVolume - Small Cap	0,0001	5,74	-4,18	0,62	0,22	9,36

Table IIb: *"Bear" Market - Basic Statistics*

Variable	Mean	Max	Min	St. Dev.	Skewness	Kurtosis
ΔPrice - Big Cap	-0,00004	0,02	-0,03	0,002	-0,37	21,43
ΔVolume - Big Cap	0,0004	2,49	-2,96	0,60	-0,30	5,15
ΔPrice - Mid Cap	-0,00007	0,03	-0,05	0,004	-0,83	25,51
ΔVolume - Mid Cap	0,00007	2,18	-2,73	0,66	-0,12	3,55
ΔPrice - Small Cap	-0,00012	0,03	-0,05	0,0043	-0,40	17,46
ΔVolume - Small Cap	0,0016	5,57	-4,62	0,97	0,05	5,15

Table IIIa,b,c: "Bull" Market - Granger "causality" tests

Table IIIa: *Big Cap - Granger "causality" Results*

Depended Variable.: Δprice	Depended Variable: ΔVolume	«causality» direction
"Causality" statistic: 3,56 Q_5 =1,94 LM_5 =0,66	"Causality" statistic: 4,96 Q_5 =1,56 LM_5 =0,20	bi-directional "causality"

Double star (**) denotes significance at 99% confidence interval

Table IIIb: *Mid Cap - Granger "causality" Results*

Depended Variable.: Δprice	Depended Variable: ΔVolume	«causality» direction
"Causality" statistic: 9,18 Q_5 =2,82 LM_5 =0,06	"Causality" statistic: 1,16 Q_5 =1,89 LM_5 =0,25	trading volume "causes" stock returns

Double star(**) denotes significance at 99% confidence interval

Table IIIc: *Small Cap - Granger "causality" Results*

Depended Variable.: Δprice	Depended Variable: ΔVolume	«causality» direction
"Causality" statistic: 4,38 Q_5 =2,60 LM_5 =0,14	"Causality" statistic: 3,89 Q_5 =0,33 LM_5 =0,26	bi-directional "causality"

Double star (**) denotes significance at 99% confidence interval

Table IVa,b,c: "Bear" Market - Granger "causality" tests

Table IVa: *Big Cap - Granger "causality" Results*

Depended Variable.: Δprice	Depended Variable: ΔVolume	«causality» direction
"Causality" statistic: 1,67 Q_5 =5,24 LM_5 =1,60	"Causality" statistic: 8,15 Q_5 =1,44 LM_5 =1,90	stock returns "causes" trading volume

Double star (**) denotes significance at 99% confidence interval

Table IVb: *Mid Cap - Granger "causality" Results*

Depended Variable.: Δprice	Depended Variable: ΔVolume	«causality» direction
"Causality" statistic: 1,48 Q_5 =5,82 LM_5 =0,07	"Causality" statistic: 4,76 Q_5 =1,48 LM_5 =3,86	stock returns "causes" trading volume

Double star (**) denotes significance at 99% confidence interval

Table IVc: *Small Cap - Granger "causality" Results*

Depended Variable.: Δprice	Depended Variable: ΔVolume	«causality» direction
"Causality" statistic: 2,50 Q_5 =2,03 LM_5 =3,72	"Causality" statistic: 3,97 Q_5 =0,69 LM_5 =3,67	stock returns "causes" trading volume

Double star (**) denotes significance at 99% confidence interval

Table V: *"Bull" and "Bear" level of trading volume*

	Big Cap	Mid Cap	Small Cap
Bull Market	104,200	50,780	16,222
Bear Market	51,156	21,242	8,317

(in number of shares traded)

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