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ΘΕΜΑ:
STOCK RETURNS AND VOLATILITY: A FIRM-LEVEL ANALYSIS OF THE GREEK STOCK EXCHANGE

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STOCK RETURNS AND VOLATILITY.

A FIRM-LEVEL ANALYSIS OF THE GREEK STOCK EXCHANGE.

1. INTRODUCTION

This paper examines the relationship between stock returns and volatility for the Geek Stock Exchange. The significant boom that took place in the Greek equity market in 1999, which turned to be a dramatic bubble for the majority of listed stocks and the majority of active investors, forced us to examine any possible relation between stock returns and volatility.

By the end of 1998 there were up to 390.000 end-client (investors) trading codes in the ASE's trading system. At 31/12/2004 these codes are up to 2.363.000. 1.114.367 new codes (about 50% of today's existing codes) were added to the system in 1999. This figure shows how important 1999 was in Greek people life, how much their life was influenced by the so called "stock madness" later on.

ASE's General index from about 1.000 points in early 1997 jumped up to 6.500 point by the end of 1999. After that dropped to 1.500 in 2003.

At the late 1990s, new laws and institutional reform took place, in terms of trading activity, regulation and organization of the market operation, and the type of companies that could operate in this field (from individual brokers to SA companies). Moreover, 10 years later, the Greek market was included in the developed markets (May 2001), as the number of listed companies increased dramatically, and the deregulation continued, with measures such as the margin account, initiation of the market maker, increase of listing requirements, new markets (EAGAK, NEXA), creation of the derivatives market. Under that scope, it is rather interesting to examine and analyse the relation between changes in stock market volatility and stock returns.

2. PREVIOUS RESEARCH

A lot of research has been done investigating the relationship between stock returns and volatility for developed markets.

1. Black (1976) and Christie (1982) found that stock prices decline for individual firms raises financial leverage, which resulted in an increase in equity's volatility. They found a negative relationship between changes in volatility and stock returns.

Black (1976) argued that a fall in a firm's stock value relative to the market value of its debt causes a rise in its debt-equity ratio and increases its stock volatility.

2. Cheung and Ng (1992) using EGARCH models also found evidence of negative relationship between the log of the one-day-ahead conditional volatility and stock returns. This effect is commonly known in the literature as the "leverage effect".

   Cheung and Ng (1992) analyse the relation between stock price dynamics and firm size and found evidence that conditional future volatility of equity returns is negatively related to the level of stock price and that this effect is stronger for small firms and with higher financial leverage.

3. French, Schwert and Stambaugh (1987) examined the inter-temporal relationship between volatility and expected returns for the U.S. and found evidence that the expected market risk premium is positively related to volatility of stock returns.

   In this paper they examined the relation between stock returns and stock market volatility. They found evidence that the expected market risk premium (the expected return on a stock portfolio minus the Treasury bill yield) is positively related to the predictable volatility of stock returns. There is also evidence that unexpected stock market returns are negatively related to the unexpected change in the volatility of stock returns. The negative relation provided indirect evidence of a positive relation between expected risk premiums and volatility.

They used daily values of the Standard and Poor's (S&P) composite portfolio to estimate the monthly standard deviation of stock market returns from January 1928 through December 1984. First, by sampling the return process more frequently, they increased the accuracy of the standard deviation estimate for any particular interval. Second, the volatility of stock returns is not constant. They obtained a more precise estimate of the standard deviation for any month by using only returns within that month. Finally, our monthly standard deviation estimates use non-overlapping samples of returns, whereas adjacent rolling twelve-month estimators share eleven returns.

As a conclusion, we can say that they found evidence of a positive relation between the expected risk premium on common stocks and the predictable level of volatility. The variability of realized stock returns is so large, however, that it is difficult to discriminate among alternate specification of this relation. They presented several estimates of the relation between the expected risk premium and the predicted volatility of NYSE common stocks over the 1928-1984 period.

There is also strong negative relation between the unpredicted component of stock market volatility and excess holding period returns. If expected risk premiums are positively related to predictable volatility, then a positive unexpected change in volatility (and an upward revision in predicted volatility) increases future expected risk premiums and lowers current stock prices. The magnitude of the negative relation between contemporaneous returns and changes in volatility is too large to be attributed solely to the effects of leverage discussed by Black (1976) and Christie (1982), so they interpreted this negative relation as evidence of a positive relation between expected risk premiums and ex ante volatility.

4. Theodossiou and Lee (1995) inspect the intertemporal relationship between risk and expected return for ten industrialized countries. The 2 authors use a GARCH in mean model and test for the conditional variance and expected market return relationship. They found no significant relationship between conditional volatility and expected return for any of these countries.

   The object of their paper was to provide additional insight into the nature of stock market volatility and its relation to expected returns for ten industrialized countries. These countries were Australia, Belgium, Canada, France, Italy, Japan, Switzerland, The United Kingdom, the United States and (West) Germany. Significant conditional heteroskedasticity was found to be present in the return series of all ten markets, indicating the presence of volatility clustering, that is, the tendency of large stock price changes to be followed by large stock price changes, but unpredictable sign. No relationship is found between conditional volatility and expected returns in any of the ten national stock markets. Stock prices for markets of Australia, Belgium, Canada, France and Italy violated the Martingale model.

5. Mougoné and Whyte (1996) study the connection between stock returns and volatility for the German and French equity markets. They have found that the impact of volatility on stock returns is insignificant. This study utilized daily stock return data for the German and French equity markets. The data on the stock market indices were obtained from Morgan Stanley Capital International and span the period from December 31, 1979, to July 7, 1991, for a total of 3,023 observations. The market coverage of the German and French indices was 61.2% and 56.3%, respectively. The empirical study used a version of the GARCH model proposed by Bollerslev (1986). The GARCH model is an extension of the ARCH model introduced by Engle (1982). Both ARCH and GARCH models allow conditional variances to change over time as a function of past errors.

   This paper examined the relationship between stock returns and volatility in the German and French equity markets. Under the assumption of a conditional student t density function, the results indicated that stock returns in both countries might be described by the GARCH (1,l) model. The paper also examined the possibility that the 1987 US stock market crash affected the mean-variance relationship. Results indicated that the stock market crash affected the mean-variance relationship in both countries, and the model's fit is significantly improved by explicitly taking the crash into account.

Interestingly, the index of relative risk aversion is positive in both countries but is only significant in Germany when the stock market crash is incorporated into the analysis. Additionally, the impact of settlement procedures on returns and volatility is assessed. The results show that returns are significantly affected by delays resulting from settlement procedures in both countries, but volatility is only significantly affected by delays in France. The results also suggested that accounting for structural shifts is important in ascertaining the relationship between stock returns and volatility.

6. De Santis and Imrohoroglu (1997) study the dynamics of expected returns and volatility for emerging markets and found that the level of volatility in emerging markets is considerably higher than that of more mature markets. They also scrutinize the issue of whether liberalization would increase/decrease volatility. They found evidence suggesting that country-specific risk does not play any role in explaining conditional expected returns.

   This paper studied the dynamics of expected stock returns and volatility in emerging financial markets. They found clustering, predictability and persistence in conditional volatility, as others have documented for mature markets. However, emerging markets exhibit higher conditional volatility and conditional probability of large price changes than mature markets. Exposure to high country-specific risk does not appear to be rewarded with higher expected returns. They detected a risk-reward relation in Latin America but not in Asia when they assume some level of international integration. They did not find support for the claim that market liberalization increases price volatility.

They focused their attention on the following questions. First, does stock return volatility change over time? If so, are volatility changes predictable? Second, how frequent are large price changes in emerging stock markets? Third, what is the relation between market risk and expected returns? Fourth, has the liberalization of emerging financial markets affected return volatility?

They proceed in steps. First, they estimated a model that assumed full market segmentation while allowing for time-varying volatility. In this scenario, they tested whether investors can successfully predict future changes in volatility and, most important, if they are rewarded with higher expected returns for being exposed to a higher level of anticipated risk. Second, they relaxed the assumption of full segmentation and analyse a number of models that assumed different degrees of market integration. Also in this case they focused their attention on the relation between expected returns and market risk. Finally, they evaluated the claim that liberalization is not necessarily beneficial for many developing countries, because it may increase the volatility of their financial markets.

The main results in the paper can be summarized as follows. They found strong evidence of time-varying volatility. From a qualitative point of view, their results resemble those of many studies on developed markets: periods of high/low volatility tend to cluster, volatility shows high persistence and is predictable. However, from a quantitative point of view, they found that volatility is considerably higher in emerging markets, both at the conditional and unconditional level. This implies that any prediction interval for future expected returns has very little information content. They also found support for a fat-tailed conditional distribution of returns, which implies that large changes in speculative prices are expected relatively often. This evidence is much stronger for emerging markets than for developed markets.

They did not find any relation between expected returns and country-specific risk. This is somewhat surprising, since many of the markets that they analysed were legally segmented, at least for part of the sampling period. When they relaxed the assumption of segmentation, they found that systematic risk is priced in the Latin American markets, but not in the Asian markets.

7. Thomas C. Chiang and Shuh-Chyi Doong (2001) investigate the time-series behaviour of stock returns for seven Asian stock markets. In most cases, higher average returns appeared to be associated with a higher level of volatility. Testing the relationship between stock returns and unexpected volatility, the evidence showed that four out of seven Asian stock markets have significant results. Further analysing the relationship between stock returns and time-varying volatility by using Threshold Autoregressive GARCH(1,1)-in-mean specification indicated that the null hypothesis of no asymmetric effect on the conditional

volatility is rejected for the daily data. However, the null cannot be rejected for the monthly data.

The data used in this study were the daily stock-price indexes for seven Asian stock markets from January 1988 through June 1998. The data consisted of the Hang Seng Index (Hong Kong), the Kuala Lumpur Composite Price Index (Malaysia), the Manila SE Composite Price Index (the Philippines), the Straits Times Industrial Index (Singapore), the Korea Composite Price Index (South Korea), the Stock Exchange of Thailand Daily Index (Thailand), the Taiwan Stock Exchange Weighted Stock Index (Taiwan), the Nikkei 225 Index (Japan), and the S&P 500 Index (United States).4 U.S. and Japan stock returns are included for comparison with the major developed markets. Daily stock returns were obtained by taking the logarithmic difference of the daily stock index times 100. That is, *Rt* = 100 *(*log *Pt,* log *Pt*.1). To avoid a possible weekend effect, weekly indexes were derived by utilizing closing prices quoted on Thursday. If Thursday price data are not available, then Wednesday's closing prices are used. With respect to monthly data, the stock indexes were measured by the last trading day of each month.

In this paper, they examined the empirical relationship between the market stock returns and volatility based on seven Asian stock market indexes. Employing the methodology proposed by French et al. (1987), they found that four out of the seven Asian stock markets have a significant relationship between stock returns and unexpected volatility.

In general, unexpected volatility has a more significant effect on stock returns than does the expected component. Further analysing the relationship between stock returns and time-varying volatility by using a TAR-GARCH(1,1)-in-mean model indicated that the GARCH parameters are highly significant in the daily return series for all of the Asian stock markets studied. However, the size and the significance level of the GARCH effect become smaller in the weekly-return series. With few exceptions, the evidence showed very little GARCH effect on monthly data. An important finding from their study was that the hypothesis of no asymmetric effect is strongly rejected at a high level of significance. Since the sum of estimated coefficients in the variance equation is close to unity, volatility evolution appears to display a persistent fashion. The evidence showed that the asymmetric effect disappeared if low frequency data were used.

8. Apergis and Eleptheriou (2001) investigate the volatility of the Athens Stock excess stock returns over the period 1990-1999 through the comparison of various conditional hetero-skedasticity models. The empirical results indicate that there is significant evidence for asymmetry in stock returns, which is captured by a quadratic GARCH specification model, while there is strong persistence of shocks into volatility. In their study they examined the behavior of the emerging Greek stock market volatility over the period 1990-1999.

Various conditional volatility models were compared with regard to their ability to explain certain characteristics of the unconditional distribution of excess stock returns, such as leptokurtosis, skewness, and volatility clustering. When applied to daily ASE excess returns data, the asymmetric GQARCH(1,2) model was found to provide a satisfactory description of the returns volatility. Moreover, the presence of persistence in volatility clustering implied the inefficiency of the ASE market, despite the large improvements in the Greek market over the recent years. Potential determinants of this inefficiency could be the lack of technical organization, resulting in the gradual spread of information reflected in stock prices, as well as the low daily trading volume (Dockery and Kavussanos 1996). This study considered daily stock prices (SP) of companies traded on the ASE. The ASE index is used as a proxy to measure stock prices. The time interval for this study has been chosen so as to concentrate on the behaviour of the ASE market over the period January 1990-July 1999, yielding 2,391 observations. Returns were calculated as the difference in the natural logarithm of the index value for two consecutive days

9. Benjamin Miranda Tabak and Solange Maria Guerra (2002) examine the relationship between stock returns and volatility over the period of June 1990 to April 2002 for the Brazilian stock market. They studied firm-level relationship between stock returns and volatility for a sample of 25 time series for Brazilian stocks. Using Seemingly Unrelated Regressions (SUR) empirical evidence suggested that contemporaneous returns and volatilities are significantly and positively

correlated while there is a negative relationship between changes in volatility and stock returns. Finally, the "leverage effect" seemed to hold for Brazilian stocks as shown by the results from an AR(1)-EGARCH(1,1) estimation.

In this paper they tested whether there is a contemporaneous relation between stock returns and current and future volatility for Brazilian stocks, employing Seemingly Unrelated Regressions. The data covered the period of June 1990 to April 2002. A robustness test has been done analysing two sub-periods. The first sub-period covers June 1990 to August 1994 while the second August 1994 to April 2002, to account for changes in stock market due to the Real stabilization plan, which has been successful in reducing inflation in Brazil. Empirical evidence suggested that as in the U.S. case studied by Duffee (1995) Brazilian stocks have a positive relationship between stock returns and contemporaneous volatility. Furthermore, using nonparametric techniques they tested for firm size, market capitalization and debt/equity ratios as potential explanatory variables for results found. This paper focused on this relationship using two methodologies. The relationship between stock returns and volatility was tested using single regressions methods for the most liquid stocks and Nelson's (1991) exponential GARCH, basically an AR(1)-E-GARCH(1,1) estimation. Results found provide evidence that for the Brazilian stock market there is a strong relationship between stock returns and current volatility.

They have tested the relationship between stock returns and current and future volatility. In line with the findings of Cheung and Ng (1992) and Duffee (1995) they found evidence suggesting that stock returns are significantly related to current volatility while the relation with future volatility is much weaker. They also found that there is a structural break in 1994 in the behaviour of stock series dynamics. As coefficients on their regressions are unstable and this period has been identified as the major cause of instability. Therefore, they presented results for the period prior to August 1994 and afterwards. Evidence presented using both a SUR methodology and an AR(1)-EGARCH(1,1) estimation suggests that changes in volatility are negatively related to stock returns, a result that has been found in the literature examining this relationship since Black (1976). Many explanations have been given for this phenomenon.

Duffee (1995) has argued that this relationship has been found to be negative due to a positive relation between current volatility and stock returns. This test has been applied to 25 Brazilian stocks and was found evidence that Duffee's hypothesis cannot be rejected. They finally used Spearman rank correlation (nonparametric statistic) to check whether the magnitude of the coefficients in the regressions relating volatility and stock returns and in the AR(1)- EGARCH(1,1) were related to variables such as firm size (measured by market capitalization and total assets) and debt/equity ratios. These correlations were not significant for the entire sample and for sub-periods analysed.

10. Duffee (1995) claims that the reason for a negative relationship between stock returns and future changes in stock return volatility is that a positive stock return corresponds to an increase in current volatility. He tested this assertion and found a strong positive contemporaneous relation between firm stock returns and volatility, both using daily and monthly data.

Previous than Duffee's research, had shown that individual firms' stock return volatility rises after stock prices fall (Black, 1976; Christie, 1982; Cheung and Ng, 1992). Two of the most popular explanations for this well-known relation are the leverage effect and time-varying risk premia. The leverage effect posits that a firm's stock price decline raises the firm's financial leverage, resulting in an increase in the volatility of equity (Black, Christie). The popularity of this explanation is such that the term 'leverage effect' is often applied to the statistical relation itself, rather than the hypothesized explanation.

The positive contemporaneous correlation between stock returns and stock return volatility at the firm level stands in contrast to the well-known negative contemporaneous correlation between aggregate stock returns and aggregate stock return volatility (French, Schwert, and Stambaugh, 1987; Campbell and Hentschel,1992). He examined this issue in the context of a multifactor model for stock returns. His results (which should be regarded as exploratory) show that idiosyncratic firm returns are positively skewed, a market factor is negatively skewed, and a separate factor associated with small firms appears to be positively skewed.

In his paper he followed much of the previous work in this area by using daily stock returns from the CRSP tape. One feature common to Black, Christie, and Cheung and Ng was that they examine only firms that exist throughout their sample periods, with two effects that are relevant in this study. First, their samples were, on average, larger firms. Second, their samples could not capture the behaviour of firm stock returns near the time that firms exit the CRSP tape. Firms disappear from the CRSP tape for reasons that may have implications for the relation between stock returns and volatility. Two examples are takeovers and bankruptcy. A company that is subject to a takeover could experience both a few large positive stock returns and high stock return volatility at the time news about the takeover is revealed. Stock returns of companies that go bankrupt could be characterized by large negative stock returns and high stock return volatility surrounding the events that drive the firm to bankruptcy. If so, a survivorship bias will remove firms with highly positively skewed returns and/or firms with highly negatively skewed returns.

For this paper he considered a broader set of firms. There are 2,617 firms with stock returns for January 3, 1977 on the CRSP Amex/NYSE daily tape. Of these firms, 2,494 have at least 12 months of observations after this date with which to estimate. This set of 2,494 firms is the universe of firms examined in this paper. For each firm, he constructed monthly stock returns and estimates of the standard deviation of monthly stock returns from January 1977 through the last month in which the firm appeared on the 1991 version of the CRSP tape (no later than December 1991). Monthly returns were defined as the sum of log daily returns in the month less the one-month Treasury bill return from Ibbotson (1992). (No equivalent adjustment was made to the daily returns owing to the lack of a daily risk less interest rate series.) Standard deviations were estimated by the square root of the sum of squared log daily returns in the month. (Results using demeaned daily returns were not materially different.)

For the 3,600 cases (1.1% of all observations) in which a firm had fewer than 15 nonmissing daily returns in a given month, the firm's return and standard deviation for that month were set to missing values. For the 23 cases in which a firm's daily returns in a month were all zero, the firm's standard deviation for that month is set to missing instead of zero because I work with log standard deviations.

In this paper he document a strong positive contemporaneous relation between firm stock returns and volatility. (This finding was qualitatively similar to positively skewed returns.) The relation between firm returns and one-period-ahead volatility is much weaker. It is positive at the daily frequency and negative at the monthly frequency. These relations largely explain the finding of Black, Christie, and Cheung and Ng that firm stock returns and changes in volatility are negatively correlated.

Smaller firms exhibit a greater positive contemporaneous relation between returns and volatility than do larger firms. In addition, this contemporaneous relation is much greater for firms that are eventually delisted. Therefore, a survivorship bias has an important effect on the results of earlier empirical work. The behaviour of returns near the time that a firm is delisted is responsible for much of the difference between delisted firms and survivors.

Black and Christie hypothesize that variation over time in a firm's financial leverage could explain at least part of the negative correlation between returns and changes in volatility. However, this leverage effect induces a negative correlation between returns and changes in volatility through a negative correlation between returns and future volatility, not through a positive correlation between returns and current volatility. Therefore, the leverage effect (although it may exist) cannot explain the observed relation between returns and changes in volatility. The leverage effect implies that firms with higher debt/equity ratios should exhibit a stronger negative relation between current returns and future volatility than firms with lower debt/equity ratios. Although he found evidence supporting this implication, he was hesitant to interpret it as support for the leverage effect because firms with higher debt/equity ratios also exhibit a stronger negative relation between returns and contemporaneous volatility than do firms with lower debt/equity ratios. Because this latter evidence cannot be explained by the leverage effect, there must be some other unknown force at work linking firm debt/equity ratios with the relation between returns and volatility.

Many have suggested that the positive relation between returns and volatility can be explained by viewing a firm's stock as an option on the assets of the firm. Since an option's price rises when the underlying asset volatility rises, one might think that a stock price should rise when the volatility of the value of the firm (and therefore the volatility of the value of the stock) rises. However, this explanation implies that firms with higher debt/equity ratios should exhibit stronger positive correlations between stock returns and volatility than should firms with lower debt/equity ratios; i.e., the equity of the highly leveraged firm is more 'option-like'. This implication was inconsistent with his results.

At the aggregate return index level, there is a well-known negative contemporaneous relation between returns and volatility. The most important question raised by the results in this paper was why firm-level and aggregate-level returns behave so differently. For example, are idiosyncratic firm returns positively skewed because firm-specific news is generally good? Is there a positively skewed common factor that primarily affects small firms?

3. DATA DESCRIPTION

This paper examines the relation between stock returns and current and future volatility for Greek stocks.

To the best of our knowledge this is the first paper that addresses the relationship between current and future volatility and stock returns on a firm-level analysis for the Greek Stock Exchange.

The data examined cover the period form January 1996 to December 2004. All data was retrieved form Athens Stock Exchange. We rejected all data prior to this period was rejected because before 1996 there was no electronic trading system in the Athens Stock Exchange, and therefore data is not accurate for many stocks.

Data was taken from the Exchange in XL format in series for each stock covering the required period. Initially data for 434 was taken. Out of these stocks, 98 stocks were rejected, lowering our sample to 336 stocks. For these 336 stocks the tests that will be further described, were performed.

The sample was reduced because three types of stocks were excluded:
a) Preferred stocks

b) De-listed stocks through out this period and

c) Stocks traded with auctions by the end of 2004.

Our prior interest was to examine the above-mentioned relation for common stocks and out of those the continuously traded stocks. We consider continuously traded also the stocks that have some missing values due to corporate actions.

After this grouping, these 336 series were imported into an e-views work file.

- 336 series concerning daily returns for each stock were calculated and
- 336 series concerning absolute daily returns were calculated.

4. METHODOLOGY USED

The next step had a major challenge for our work. It was practically impossible and the danger for making mistakes was enormous, to type and estimate the 336 needed to be estimated regressions. Time limitations directed our interest to learning how someone can estimate these regressions using programs written in the e-views environment.

The solution was self-education using e-views manual and testing our knowledge with sample time series. The fruits of this long period of practicing can be found in the Appendix A, were all programs used for this study are presented.

Regressions estimated for the needs of this study were the same that Dr. Duffee used in his paper in 1995 and are presented as follows:

$$(|r_{t+1}| - |r_t|) / \overline{|r|} = a_0 + l_0 r_t + e_{t+1,0} \quad (1)$$

$$(|r_t|) / \overline{|r|} = a_1 + l_1 r_t + e_{t,1} \quad (2)$$

$$(|r_{t+1}|) / \overline{|r|} = a_2 + l_2 r_t + e_{t+1,2} \quad (3)$$

The first (1) regression examines the relation between stock returns and changes in volatility.

The second (2) examines the contemporaneous relation between stock returns and volatility.

The third (3) examines the relation between stock returns and one-period-ahead volatility.

Using equation (1), changes in volatility are measured as a fraction of the average level of volatility and not as a fraction of immediately prior level of volatility that could alternatively be used.

Step 1: ADF tests

In order to analyse results from regressions we first tested for stationarity of the return time series. We performed augmented Dickey Fuller unit root tests. The first program in Appendix A was created in order to perform this test. Appendix B presents results for the unit root tests and evidence suggests that all series can be regarded as stationary as the null of a unit root is rejected in all cases for stock returns with 99% level of confidence.

Step 2: Regressions estimation

The next step was to perform OLS regressions for 336 Greek stocks corrected for heteroskedasticity and autocorrelation with Newey-West method.

Program No 2 in Appendix A was created and applied for all series. Detailed results were summarized in a large matrix, part of which is the matrix presented in Appendix C. Table 1 in Empirical Evidence section presents the mean coefficient for all stocks.

Step 3: Calculating the statistical significance of a given mean coefficient

After running these estimations, the big challenge now was to perform some kind of test that would confirm that figures in Table 1 are the results of the market as a hole. At this point we incorporated the SUR (Seemingly Unrelated Regressions) method.

We had to use SUR in order to calculate the statistical significance of the Table's 1 mean coefficients.

The computing of the statistical significance of a given mean coefficient used in this paper is to consider the distribution of the individual λ's.

Consider:

1. The estimated λ_0's from firm-by-firm estimation of regression (1) above.
2. Denote the number of firms by K. I assume that each $\lambda_{i,0}$ λ=1,……,K, is drawn from a distribution with a variance var(λ). This assumption cannot literally be correct, because the variance of $\lambda_{i,0}$ should depend on the number of observations for firm i's regression. Computing the standard error of a given estimate of $\bar{\lambda}$ requires some assumption about the joint distribution of λ_i and λ_j i # j. Because these statistics are computed over overlapping time periods, aggregate shocks to returns and return volatilities induce dependence between λ_i and λ_j. Denote the correlation between $\lambda_{i,0}$ and $\lambda j_{,0}$ as $\rho_{i,j}$. The variance of the mean $\bar{\lambda}$ is:

$$\mathrm{var}(\overline{\hat{\lambda}}) = \frac{\mathrm{var}(\hat{\lambda})}{K}\left(1 + \frac{1}{K}\sum_{i=1}^{K}\sum_{i\neq j}^{K} \rho_{i,j}\right)$$

We estimate var($\hat{\lambda}$) with the sample variance of $\hat{\lambda}$. To estimate the mean cross-correlation of firms' statistics, we ran (1) for all firms with seemingly unrelated regressions (SURs). The firms were sorted into eight (8) groups of forty-two (42) firms; eight SURs were then estimated. The estimated cross-correlations for equations (1), (2) and (3) are 0.0865, 0.1281, and 0.0283, respectively. Given these estimated cross-correlations and. the sample variances of the distributions of the coefficients of (1) (2), and (3), the estimated standard errors for these coefficients can be computed. They are 0.2941, 0.3580 and 0.1684 respectively.

It is known that SUR needs to run on systems of regressions. Hardware and software limitations did not allow us to run one SUR for all regressions for λ_0 and another one for λ_1 and a third one for λ_2. Thus, 24 systems of 42 stocks each were created and 24 SURs were estimated.

Creating all these systems and performing the SUR tests was another challenging target, since an automatic way to create these systems should be used in order to eliminate any possible mistake. In this case programs 7 and 8 were created and used in the e-views environment. XL was also used in order for all the regressions to be created.

Step 4: Calculating mean coefficient t-statistic

After estimating all regressions for $\lambda_{0,}$ λ_1 λ_2 with SUR, 24 variance-covariance (84X84) matrixes were produced and pasted in XL files. At this point all correlations were calculated in a triangular form, excluding variance-covariance of regression's constant figure.

Finally t-statistics was calculated. Results of all the above mentioned steps are presented in Table 3.

5. EMPIRICAL EVIDENCE

Table 1 presents the averages for all stocks. These figures are crucial because if they are statistically significant, then the result that these figures are markets mean coefficients, is concrete.

Table 1: Mean Regressions coefficient

	Mean β_0	Mean β_1	Mean β_2
Mean coefficients	-4.403	5.456	1.037

Were:

$$Mean\beta_0 = \frac{1}{K}\sum_{i=1}^{K}\beta_{i,0}, \quad Mean\beta_1 = \frac{1}{K}\sum_{i=1}^{K}\beta_{i,1}, \quad Mean\beta_2 = \frac{1}{K}\sum_{i=1}^{K}\beta_{i,2}$$

Table 2 is also useful because we can see that there is a small part of the stocks in which the sign of the coefficients are reversed.

Table 2: Positive/negative regression oefficients (for 336 stocks)

	β_0	β_1	β_2
$\hat{\beta} < 0$	322 (90,5%)	23 (6,8%)	73 (21,7%)
$\hat{\beta} > 0$	14 (9,5%)	313 (93,2%)	263 (78,3%)
Total	336	336	336

<u>Table 3: Mean coefficients and the results for mean coefficient t-statistic, using SUR methodology.</u>

	Mean $\hat{\lambda}_0$	**Mean** $\hat{\lambda}_1$	**Mean** $\hat{\lambda}_2$
Mean $\hat{\lambda}$ ($\bar{\hat{\lambda}}$)	**-4.403**	**5.456**	**1.037**
Variance $\hat{\lambda}$ (var($\hat{\lambda}$))	**23.269**	**33.852**	**7.494**
$\sum_{i=1}^{K}\sum_{i\neq j}^{K} r_{i,j}$	**83.652**	**91.350**	**91.054**
$\text{var}(\bar{\hat{\lambda}}) = \frac{\text{var}(\hat{\lambda})}{K}\left(1+\frac{1}{K}\sum_{i=1}^{K}\sum_{i\neq j}^{K} r_{i,j}\right)$	**0.0865**	**0.1281**	**0.0283**
Std. Error $\bar{\hat{\lambda}}$	**0.2941**	**0.3580**	**0.1684**
t-statistic $\bar{\hat{\lambda}}$	***-14.971***	***15.240***	***6.159***

An other interesting point is to compare our results with Dr. Duffee's results as these were presented in his paper in 1995. As we can see the conclusions are similar and are summarized in the "concluding remarks" paragraph.

Table 4: Comparison with Duffee's results

	Per Duffee	**Per our study**
$\overline{\lambda}_0$	-6.361	-4.403
St. error for mean coefficient	(0.822)	(0.294)
$\overline{\lambda}_1$	7.210	5.456
St. error for mean coefficient	(1.160)	(0.358)
$\overline{\lambda}_2$	0.856	1.037
St. error for mean coefficient	(0.356)	(0.168)

6. CONCLUDING REMARKS

In this paper we have tested the relationship between stock returns and current and future volatility for the Greek equity market. In line with the Duffee's findings (1995) we have found evidence suggesting that stock returns are significantly related to current volatility, while the relation with future volatility is much weaker.

Evidence presented using both a SUR methodology and an OLS estimation suggests:

a. Strong positive contemporaneous relation between stock returns and volatility **(λ_1)**
b. The relation between firm returns and one-period-ahead volatility is much weaker **(λ_2)**
c. Firm stock returns and changes in volatility are negatively correlated **($\lambda_0 < 0$: $\lambda_0 = \lambda_2 - \lambda_1$)**

Duffee (1995) has argued that this relationship has been found to be negative due to a positive relation between current volatility and stock returns.

This test has been applied to 336 Greek stocks and we found evidence that Duffee's hypothesis is strong for the Greek Market.

An interesting extension of this paper would be:

1. to perform these tests in sub-periods
2. to create smaller samples of stocks, i.e.: Per sector, large/small caps, liquid/illiquid stocks etc
3. to include in the large sample the rejected stocks
4. to perform these tests on the rejected stocks: preferred stocks, de-listed stocks, trade with auctions stocks
5. to incorporate in the study financial ratios i.e.: p/e ratio, debt/equity ratio (leverage effect) etc.

References

Black, F., 1976, Studies of stock price volatility changes, Proceedings of the 1976 meetings of the American Statistical Association, Business and Economics Statistics Section (American Statistical Association, Washington, DC) 177-181.

Cheung, Yin-Wong and Ng, Lilian K., 1992, Stock price dynamics and firm size: an empirical investigation, The Journal of Finance 47, 1985-1997.

Christie, A., 1982, The stochastic behaviour of common stock variances: Value, leverage, and interest rate effects, Journal of Financial Economics 10, 407-432.

De Santis G. and Imrohoroglu, S., 1997, Stock returns and volatility in emerging financial markets, Journal of International Money and Finance 16, 561-579.

Duffee, G., 1995, Stock return and volatility: A firm level analysis, Journal of Financial Economics 37, 399-420.

French, K.R., Schwert, G.W. and Stambaugh, R.F., 1987, Expected Stock Returns and Volatility, Journal of Financial Economic 19, 3-29.

Mougoué, M. and Whyte, A.M.,1996, Stock returns and volatility: an empirical investigation of the German and French equity markets, Global Finance Journal 7, 253-263.

Nelson, D.B., 1991, Conditional heteroskedasticity in asset returns: A new approach, Econometrica 59, 347-370.

Ng, S.and Perron, P., 1995, Unit roots tests in ARMA models with data dependent methods for the selection of the truncation lag, Journal of the American statistical Association 90, 268-281.

Ng, S. and Perron, P., 2001, Lag length selection and the construction of unit roots tests with good size and power, Econometrica 69, 1519-1554.

Theodossiou, P. and Lee, U., 1995, Relationship between volatility and expected returns across international stock markets, Journal of Business Finance & Accounting 22, 289-300.

Nicholas Apergis and Sophia Eleptheriou, 2001, Stock Returns and Volatility: Evidence from the Athens Stock Market Index, Journal of Economics and Finance, 25, 50-61.

Appendix A – Programs created and used in e-views environment

1. This program performs the augmented Dickey-Fuller for all 336 stock returns time series

```
'Performs ADF test for all stock returns series
table(400, 20) adf
setcolwidth(adf, 1, 12)
adf(1, 2) = "ADF t-stat"
adf(1, 3) = "ADF prob"
for !x=1 to 336
output(t)
r!x.uroot(adf)
freeze(adf_r!x) r!x.uroot(adf)
adf(!x+2, 1) = !x
if @left(adf_r!x(7,1),3)="Aug" then
   adf(!x+2, 2) = adf_r!x(7,4)
   adf(!x+2, 3) = adf_r!x(7,5)
endif
close r!x
delete adf_r!x
next
```

2. The following program is a routine, which estimates λ_0, λ_1, λ_2 using Least Squares corrected with Newey-West, for all 336 Greek Market stocks, according to Duffee's model.

```
table(1500, 20) results
setcolwidth(results, 1, 12)
results(1, 5) = "L0"
results(1, 8) = "L1"
results(1, 11) = "L2"
results(2, 2) = "L0"
results(2, 3) = "L1"
results(2, 4) = "L2"
results(2, 5) = "Std. Error"
results(2, 6) = "t-Statistic"
results(2, 7) = "Prob."
results(2, 8) = "Std. Error"
results(2, 9) = "t-Statistic"
results(2, 10) = "Prob."
results(2, 11) = "Std. Error"
results(2, 12) = "t-Statistic"
results(2, 13) = "Prob."
for !x=1 to 336
output(t)
equation l0s!x.ls(n,p) (ar!x(+1)-ar!x)/@mean(ar!x) c r!x
freeze(l0s!x_f) l0s!x.ls(n)
equation l1s!x.ls(n,p) (ar!x)/@mean(ar!x) c r!x
```

```
freeze(l1s!x_f) l1s!x.ls(n)

equation l2s!x.ls(n,p) (ar!x(+1))/@mean(ar!x) c r!x

freeze(l2s!x_f) l2s!x.ls(n)

results(!x+2, 1) = !x

if @left(l0s!x_f(11,1),1)="R" then

   results(!x+2, 2) = l0s!x_f(11,2)

   results(!x+2, 5) = l0s!x_f(11,3)

   results(!x+2, 6) = l0s!x_f(11,4)

   results(!x+2, 7) = l0s!x_f(11,5)

endif

if @left(l0s!x_f(12,1),1)="R" then

   results(!x+2, 2) = l0s!x_f(12,2)

   results(!x+2, 5) = l0s!x_f(12,3)

   results(!x+2, 6) = l0s!x_f(12,4)

   results(!x+2, 7) = l0s!x_f(12,5)

endif

if @left(l1s!x_f(11,1),1)="R" then

   results(!x+2, 3) = l1s!x_f(11,2)

   results(!x+2, 8) = l1s!x_f(11,3)

   results(!x+2, 9) = l1s!x_f(11,4)

   results(!x+2, 10) = l1s!x_f(11,5)

endif

if @left(l1s!x_f(12,1),1)="R" then

   results(!x+2, 3) = l1s!x_f(12,2)

   results(!x+2, 8) = l1s!x_f(12,3)

   results(!x+2, 9) = l1s!x_f(12,4)
```

```
   results(!x+2, 10) = l1s!x_f(12,5)
endif
if @left(l2s!x_f(11,1),1)="R" then
   results(!x+2, 4) = l2s!x_f(11,2)
   results(!x+2, 11) = l2s!x_f(11,3)
   results(!x+2, 12) = l2s!x_f(11,4)
   results(!x+2, 13) = l2s!x_f(11,5)
endif
if @left(l2s!x_f(12,1),1)="R" then
   results(!x+2, 4) = l2s!x_f(12,2)
   results(!x+2, 11) = l2s!x_f(12,3)
   results(!x+2, 12) = l2s!x_f(12,4)
   results(!x+2, 13) = l2s!x_f(12,5)
endif

delete l0s!x_f
delete l1s!x_f
delete l2s!x_f
next
```

3. **A program that examines if the series have any missing values and presents the results in a matrix.**

```
table(1500,10) missing_values
for !b=1 to 336
!k=0
  for !a=1737 to 3753
    if st!b(!a,1) = NA then
      !k = !k +1
    endif
  next
missing_values (!b+1, 1) = !b
missing_values (!b+1, 2) = !k
next
```

4. **A program that creates returns and absolute returns for all 336 stocks.**

```
smpl 1737 3753
for !x=1 to 336
series r!x = (st!x-st!x(-1))/st!x(-1)
series ar!x=abs(r!x)
next
```

5. **ARCH, GARCH models need to have series with no missing values. This program fills in missing values with last value.**

```
for !b=1 to 3
  for !a=1737 to 3753
      if st!b(!a,1) = NA then
        st!b(!a,1) = st!b((!a-1),1)
      endif
   next
next
```

6. **A program that runs ARCH(1,1)-in-mean regression for all 336 stocks and runs ARCH LM test for the regression's residuals. Results are summarized in matrix form.**

```
'ESTIMATE ARCH(1,1) WITH 1 TIME LAG
for !x= 331 to 336
    equation s!x.arch(1,1,v) r!x c r!x(-1)
    freeze(s!x_arch_f) s!x.arch(1,1,v) r!x c r!x(-1)
    s!x.archtest(1)
    freeze(s!x_archtest_f) s!x.archtest(1)
    ARCH_MEAN(!x+2, 1) = !x
     if @left(s!x_archtest_f(17,1),8) ="STD_RESI" and
s!x_archtest_f(17,5) > 0.05 then
        ARCH_MEAN(!x+2, 2) = s!x_arch_f(16,2)
```

```
        ARCH_MEAN(!x+2, 3) = s!x_arch_f(16,4)
        ARCH_MEAN(!x+2, 4) = s!x_arch_f(16,5)
        ARCH_MEAN(!x+2, 6) = s!x_archtest_f(17,5)
      endif
   CLOSE s!x
   CLOSE s!x_arch_f
   next
```

7. The following creates the formulas one-by one in an eviews table for λ_0, λ_1 and λ_2.

```
table(500,20) l0_temp
for !x = 1 to 336
   l0_temp(!x,1) = "(ar"
   l0_temp(!x,2) = !x
   l0_temp(!x,3) = "(+1)-ar"
   l0_temp(!x,4) = !x
   l0_temp(!x,5) = “)/@mean(ar"
   l0_temp(!x,6) = !x
   l0_temp(!x,7) = ")=c("
   l0_temp(!x,8) = !x
   l0_temp(!x,9) = ")+c("
   l0_temp(!x,10) = 340+!x
   l0_temp(!x,11) = ")*r"
   l0_temp(!x,12) = !x
next
```

```
table(500,20) l1_temp
for !x = 1 to 336
    l1_temp(!x,1) = "(ar"
    l1_temp(!x,2) = !x
    l1_temp(!x,3) = ")/@mean(ar"
    l1_temp(!x,4) = !x
    l1_temp(!x,5) = ")=c("
    l1_temp(!x,6) = !x
    l1_temp(!x,7) = ")+c("
    l1_temp(!x,8) = 340+!x
    l1_temp(!x,9) = ")*r"
    l1_temp(!x,10) = !x
next
table(500,20) l2_temp
for !x = 1 to 336
    l2_temp(!x,1) = "(ar"
    l2_temp(!x,2) = !x
    l2_temp(!x,3) = "(+1))/@mean(ar"
    l2_temp(!x,4) = !x
    l2_temp(!x,5) = ")=c("
    l2_temp(!x,6) = !x
    l2_temp(!x,7) = ")+c("
    l2_temp(!x,8) = 340+!x
    l2_temp(!x,9) = ")*r"
    l2_temp(!x,10) = !x
next
```

8. All formulas for λ0, λ1, λ2 regressions were created with the use of "CONCATENATE" command in XL environment, where eviews table were inserted. After that, the formulas were copied pasted in 24 eviews systems contains 42 formulas each. The following program runs 24 SURs for all the 24 eviews systems.

```
'RUN SUR FOR L0
system_l0_1_42.sur
freeze(system_l0_1_42_f) system_l0_1_42.sur
close system_l0_1_42_f
system_l0_43_84.sur
freeze(system_l0_43_84_f) system_l0_43_84.sur
close system_l0_43_84_f
system_l0_85_126.sur
freeze(system_l0_85_126_f) system_l0_85_126.sur
close system_l0_85_126_f
system_l0_127_168.sur
freeze(system_l0_127_168_f) system_l0_127_168.sur
close system_l0_127_168_f
system_l0_169_210.sur
freeze(system_l0_169_210_f) system_l0_169_210.sur
close system_l0_169_210_f
system_l0_211_252.sur
freeze(system_l0_211_252_f) system_l0_211_252.sur
close system_l0_211_252_f
```

```
system_l0_253_294.sur

freeze(system_l0_253_294_f) system_l0_253_294.sur

close system_l0_253_294_f

system_l0_295_336.sur

freeze(system_l0_295_336_f) system_l0_295_336.sur

close system_l0_295_336_f


'RUN SUR FOR L1

sys_l1_1_42.sur

freeze(sys_l1_1_42_f) sys_l1_1_42.sur

close sys_l1_1_42_f

sys_l1_43_84.sur

freeze(sys_l1_43_84_f) sys_l1_43_84.sur

close sys_l1_43_84_f

sys_l1_85_126.sur

freeze(sys_l1_85_126_f) sys_l1_85_126.sur

close sys_l1_85_126_f

sys_l1_127_168.sur

freeze(sys_l1_127_168_f) sys_l1_127_168.sur

close sys_l1_127_168_f

sys_l1_169_210.sur

freeze(sys_l1_169_210_f) sys_l1_169_210.sur

close sys_l1_169_210_f

sys_l1_211_252.sur

freeze(sys_l1_211_252_f) sys_l1_211_252.sur

close sys_l1_211_252_f
```

```
sys_l1_253_294.sur
freeze(sys_l1_253_294_f) sys_l1_253_294.sur
close sys_l1_253_294_f
sys_l1_295_336.sur
freeze(sys_l1_295_336_f) sys_l1_295_336.sur
close sys_l1_295_336_f

'RUN SUR FOR L2
sys_l2_1_42.sur
freeze(sys_l2_1_42_f) sys_l2_1_42.sur
close sys_l2_1_42_f
sys_l2_43_84.sur
freeze(sys_l2_43_84_f) sys_l2_43_84.sur
close sys_l2_43_84_f
sys_l2_85_126.sur
freeze(sys_l2_85_126_f) sys_l2_85_126.sur
close sys_l2_85_126_f
sys_l2_127_168.sur
freeze(sys_l2_127_168_f) sys_l2_127_168.sur
close sys_l2_127_168_f
sys_l2_169_210.sur
freeze(sys_l2_169_210_f) sys_l2_169_210.sur
close sys_l2_169_210_f
sys_l2_211_252.sur
freeze(sys_l2_211_252_f) sys_l2_211_252.sur
close sys_l2_211_252_f
```

sys_l2_253_294.sur

freeze(sys_l2_253_294_f) sys_l2_253_294.sur

close sys_l2_253_294_f

sys_l2_295_336.sur

freeze(sys_l2_295_336_f) sys_l2_295_336.sur

close sys_l2_295_336_f

Appendix B – Augmented Dickey Fuller test results

Stock No	ADF t-statistic	ADF prob
1	-37.620	0.000
2	-38.594	0.000
3	-38.568	0.000
4	-35.203	0.000
5	-38.645	0.000
6	-30.591	0.000
7	-36.698	0.000
8	-35.386	0.000
9	-36.661	0.000
10	-36.484	0.000
11	-37.668	0.000
12	-36.668	0.000
13	-36.849	0.000
14	-37.671	0.000
15	-37.910	0.000
16	-36.136	0.000
17	-37.826	0.000
18	-39.524	0.000
19	-36.748	0.000
20	-42.616	0.000
21	-39.089	0.000
22	-39.987	0.000
23	-31.366	0.000
24	-37.529	0.000
25	-29.600	0.000
26	-37.628	0.000
27	-30.815	0.000
28	-40.686	0.000
29	-38.042	0.000
30	-30.684	0.000
31	-36.372	0.000
32	-34.439	0.000
33	-38.385	0.000
34	-38.895	0.000
35	-37.340	0.000
36	-37.273	0.000
37	-40.255	0.000
38	-37.930	0.000
39	-38.521	0.000
40	-38.837	0.000
41	-39.155	0.000
42	-36.824	0.000
43	-36.325	0.000
44	-36.839	0.000
45	-30.932	0.000
46	-38.065	0.000

47	-38.621	0.000
48	-37.430	0.000
49	-31.202	0.000
50	-30.966	0.000
51	-31.191	0.000
52	-37.493	0.000
53	-40.328	0.000
54	-36.311	0.000
55	-35.686	0.000
56	-38.687	0.000
57	-39.332	0.000
58	-36.909	0.000
59	-38.011	0.000
60	-39.105	0.000
61	-38.458	0.000
62	-37.851	0.000
63	-35.763	0.000
64	-37.312	0.000
65	-37.212	0.000
66	-37.306	0.000
67	-36.748	0.000
68	-36.735	0.000
69	-36.500	0.000
70	-38.488	0.000
71	-35.388	0.000
72	-37.603	0.000
73	-37.656	0.000
74	-37.836	0.000
75	-37.867	0.000
76	-39.710	0.000
77	-38.711	0.000
78	-31.269	0.000
79	-37.450	0.000
80	-38.081	0.000
81	-38.435	0.000
82	-40.071	0.000
83	-36.350	0.000
84	-38.671	0.000
85	-38.661	0.000
86	-38.306	0.000
87	-31.853	0.000
88	-37.874	0.000
89	-34.698	0.000
90	-39.270	0.000
91	-37.759	0.000
92	-36.415	0.000
93	-42.741	0.000
94	-32.675	0.000
95	-42.431	0.000
96	-38.423	0.000

97	-40.127	0.000
98	-35.820	0.000
99	-29.423	0.000
100	-40.426	0.000
101	-39.050	0.000
102	-43.580	0.000
103	-34.659	0.000
104	-40.063	0.000
105	-31.602	0.000
106	-39.942	0.000
107	-35.045	0.000
108	-35.552	0.000
109	-44.417	0.000
110	-39.904	0.000
111	-38.636	0.000
112	-36.188	0.000
113	-32.065	0.000
114	-31.823	0.000
115	-39.036	0.000
116	-37.589	0.000
117	-35.384	0.000
118	-36.611	0.000
119	-39.613	0.000
120	-34.266	0.000
121	-39.021	0.000
122	-38.641	0.000
123	-40.527	0.000
124	-20.373	0.000
125	-30.627	0.000
126	-39.479	0.000
127	-38.556	0.000
128	-39.991	0.000
129	-37.180	0.000
130	-38.075	0.000
131	-36.909	0.000
132	-36.644	0.000
133	-36.030	0.000
134	-39.245	0.000
135	-38.527	0.000
136	-40.067	0.000
137	-37.545	0.000
138	-35.748	0.000
139	-37.449	0.000
140	-38.119	0.000
141	-31.753	0.000
142	-37.534	0.000
143	-37.624	0.000
144	-38.944	0.000
145	-38.247	0.000
146	-37.609	0.000

147	-36.348	0.000
148	-37.257	0.000
149	-37.733	0.000
150	-34.642	0.000
151	-39.701	0.000
152	-39.962	0.000
153	-38.172	0.000
154	-37.287	0.000
155	-40.657	0.000
156	-36.871	0.000
157	-34.076	0.000
158	-39.394	0.000
159	-34.198	0.000
160	-37.288	0.000
161	-36.598	0.000
162	-28.746	0.000
163	-32.143	0.000
164	-35.780	0.000
165	-32.191	0.000
166	-33.607	0.000
167	-39.263	0.000
168	-32.373	0.000
169	-42.771	0.000
170	-19.737	0.000
171	-30.263	0.000
172	-31.937	0.000
173	-24.462	0.000
174	-25.385	0.000
175	-45.498	0.000
176	-48.467	0.000
177	-27.455	0.000
178	-30.807	0.000
179	-31.963	0.000
180	-32.032	0.000
181	-29.004	0.000
182	-27.882	0.000
183	-31.274	0.000
184	-28.526	0.000
185	-29.916	0.000
186	-25.952	0.000
187	-26.249	0.000
188	-30.555	0.000
189	-29.740	0.000
190	-26.476	0.000
191	-33.288	0.000
192	-30.086	0.000
193	-27.853	0.000
194	-29.118	0.000
195	-22.298	0.000
196	-29.035	0.000

197	-14.639	0.000
198	-30.383	0.000
199	-26.232	0.000
200	-27.256	0.000
201	-20.122	0.000
202	-25.083	0.000
203	-25.363	0.000
204	-28.744	0.000
205	-29.041	0.000
206	-23.454	0.000
207	-30.007	0.000
208	-23.986	0.000
209	-30.450	0.000
210	-26.599	0.000
211	-26.258	0.000
212	-16.615	0.000
213	-12.308	0.000
214	-14.644	0.000
215	-12.773	0.000
216	-9.028	0.000
217	-37.019	0.000
218	-37.540	0.000
219	-38.228	0.000
220	-35.454	0.000
221	-16.987	0.000
222	-39.343	0.000
223	-42.812	0.000
224	-35.934	0.000
225	-30.824	0.000
226	-35.399	0.000
227	-37.839	0.000
228	-36.910	0.000
229	-38.376	0.000
230	-38.361	0.000
231	-35.607	0.000
232	-39.267	0.000
233	-38.621	0.000
234	-38.456	0.000
235	-36.881	0.000
236	-37.585	0.000
237	-35.877	0.000
238	-36.780	0.000
239	-28.714	0.000
240	-37.544	0.000
241	-32.782	0.000
242	-32.129	0.000
243	-35.009	0.000
244	-36.624	0.000
245	-28.633	0.000
246	-30.206	0.000

247	-32.127	0.000
248	-35.682	0.000
249	-35.426	0.000
250	-41.087	0.000
251	-42.332	0.000
252	-27.236	0.000
253	-33.291	0.000
254	-25.557	0.000
255	-27.414	0.000
256	-34.029	0.000
257	-32.356	0.000
258	-27.134	0.000
259	-35.306	0.000
260	-37.335	0.000
261	-30.946	0.000
262	-40.918	0.000
263	-31.723	0.000
264	-29.394	0.000
265	-32.318	0.000
266	-30.354	0.000
267	-30.659	0.000
268	-30.545	0.000
269	-35.946	0.000
270	-29.810	0.000
271	-23.655	0.000
272	-28.862	0.000
273	-31.698	0.000
274	-30.125	0.000
275	-29.194	0.000
276	-30.223	0.000
277	-30.448	0.000
278	-30.393	0.000
279	-31.429	0.000
280	-32.189	0.000
281	-25.532	0.000
282	-28.583	0.000
283	-30.948	0.000
284	-31.738	0.000
285	-29.324	0.000
286	-27.190	0.000
287	-30.200	0.000
288	-24.651	0.000
289	-27.933	0.000
290	-28.123	0.000
291	-27.673	0.000
292	-29.706	0.000
293	-30.769	0.000
294	-27.163	0.000
295	-26.297	0.000
296	-27.500	0.000

297	-30.014	0.000
298	-28.557	0.000
299	-23.488	0.000
300	-24.761	0.000
301	-32.268	0.000
302	-29.328	0.000
303	-26.484	0.000
304	-31.322	0.000
305	-28.319	0.000
306	-26.735	0.000
307	-27.115	0.000
308	-28.115	0.000
309	-25.966	0.000
310	-23.739	0.000
311	-21.190	0.000
312	-24.931	0.000
313	-23.678	0.000
314	-24.222	0.000
315	-23.610	0.000
316	-24.430	0.000
317	-19.748	0.000
318	-22.748	0.000
319	-21.774	0.000
320	-21.215	0.000
321	-22.197	0.000
322	-13.308	0.000
323	-23.164	0.000
324	-17.016	0.000
325	-20.668	0.000
326	-11.321	0.000
327	-18.125	0.000
328	-15.805	0.000
329	-21.310	0.000
330	-17.983	0.000
331	-18.488	0.000
332	-17.297	0.000
333	-13.103	0.000
334	-13.594	0.000
335	-13.837	0.000
336	-13.452	0.000

Appendix C – Regression coefficient - Detailed figures for each stock

Stock No	λ_0	λ_1	λ_2
`1	-4.2116	6.4932	2.2852
2	-4.6516	5.9145	1.2419
3	-5.0031	4.3137	-0.6964
4	-6.4667	7.8460	1.3774
5	-7.1851	7.3898	0.2027
6	-4.7287	7.1067	2.3800
7	-5.8682	7.6557	1.7858
8	-4.3648	10.8796	6.5162
9	-6.0790	6.2374	0.1553
10	-6.8610	8.9662	2.1030
11	-2.7491	6.7758	3.9543
12	-6.2996	10.6870	4.3891
13	-3.7014	8.6751	4.9559
14	-5.4317	7.9464	2.5144
15	-2.1450	4.1644	2.0059
16	-2.3383	5.2884	2.9202
17	-2.7642	5.8110	3.0443
18	-0.4360	2.2794	1.8449
19	-0.3423	5.5708	5.2304
20	-1.7686	3.5442	1.7523
21	-3.0486	2.8422	-0.2104
22	-3.9476	5.8381	1.8875
23	-5.8466	4.6382	-1.2061
24	-0.3066	1.3347	1.0971
25	-3.2317	3.4700	0.1594
26	-2.7928	4.1375	1.4618
27	-2.5009	3.5581	1.0568
28	-4.6291	4.7543	0.1235
29	-3.5573	4.8954	1.3403
30	-2.0022	4.5279	2.5279
31	-1.8367	2.6421	0.8409
32	-1.8412	4.4421	2.6008
33	-2.8381	4.3278	1.4882
34	-1.5903	2.0475	0.4442
35	-2.0482	4.2470	2.2001
36	-1.7880	3.5927	1.8013
37	-2.8924	2.7036	-0.1865
38	-2.7538	3.9323	1.2690
39	-2.6857	4.3402	1.6380
40	-2.3932	4.3358	1.9422
41	-2.1610	3.1273	0.9654
42	-0.8018	3.9494	3.1453
43	-0.3570	2.3582	2.0009
44	-1.8685	3.2737	1.4220

45	-2.3863	4.1599	1.7834
46	0.0037	1.4530	1.4240
47	-3.9271	4.0823	0.1593
48	-2.9249	4.7656	1.8436
49	-2.1394	2.6858	0.5114
50	-2.8870	3.8664	0.9791
51	-4.3672	5.2850	0.9359
52	-4.7184	6.4836	1.7680
53	-6.0545	5.2854	-0.7718
54	-2.7853	4.4604	1.6733
55	-1.4660	1.7261	0.2578
56	-4.3504	3.0963	-1.2510
57	-6.4125	7.4682	1.0524
58	-3.9540	7.9246	3.9736
59	-2.2646	3.1710	0.9080
60	-2.2222	2.9395	0.7171
61	-4.9125	5.5364	0.6245
62	-1.7327	2.7057	0.9219
63	-2.2176	3.9298	1.7103
64	-2.6888	5.7198	3.0327
65	-0.6959	2.1778	1.4916
66	-1.5446	1.5947	0.0223
67	-4.5559	5.9983	1.4358
68	-1.4238	2.7158	1.2920
69	-5.5291	7.2736	1.7442
70	-1.1817	2.8729	1.7039
71	-2.8234	5.0238	2.2030
72	-2.6684	3.9630	1.2853
73	-2.9708	4.5010	1.5297
74	-4.0803	4.9591	0.8802
75	-3.1880	4.5671	1.3931
76	-6.1282	6.2995	0.1714
77	-2.2991	3.1478	0.8439
78	-2.9693	3.5717	0.7322
79	-1.4203	4.9986	3.5437
80	-4.7745	5.0522	0.2774
81	-0.8237	2.2590	1.4350
82	-3.0017	3.5931	0.5945
83	-5.6342	6.4615	0.8306
84	-2.1148	4.1755	2.0637
85	-4.0015	5.2397	1.2397
86	-1.6628	3.1542	1.4888
87	-1.6476	3.3253	1.6774
88	-5.6626	5.6407	-0.0302
89	-3.2005	5.8166	2.6144
90	-3.6251	5.4533	1.7830
91	-3.1010	4.3595	1.2604
92	-0.6359	2.6696	2.0573
93	-4.7318	6.4696	1.7402
94	-7.5309	9.6666	2.1360
95	-7.4557	9.4431	2.0819
96	-4.1308	6.1295	2.0001

97	-4.0054	4.0932	0.0844
98	-4.8461	6.1724	1.3243
99	-2.8179	4.1818	1.3666
100	-3.0191	4.2379	1.2210
101	-5.0694	5.5634	0.4739
102	-1.2092	1.0395	-0.1706
103	-3.4799	4.5009	0.6883
104	-7.1276	6.4118	-0.7106
105	-1.7509	3.3597	1.6066
106	-1.8629	4.8967	3.0365
107	-2.4753	4.7449	2.2720
108	-1.1815	2.1901	1.0104
109	-1.9319	3.4423	1.5097
110	-0.7092	1.8965	1.2011
111	-5.9949	6.9024	0.9098
112	-5.4669	6.4261	0.9614
113	-0.2356	2.8260	2.6460
114	-1.8442	3.1950	1.3504
115	-2.3523	4.9138	2.5614
116	-3.6001	5.7418	2.1379
117	-1.6287	4.5545	2.9287
118	-1.0296	2.2355	1.2065
119	-1.2309	1.2954	0.0657
120	-3.2940	7.4653	4.1706
121	-3.9459	4.4681	0.5231
122	-2.9679	4.2527	1.3528
123	-1.9627	3.5540	1.5821
124	-3.6302	8.0780	4.4501
125	-2.2507	3.3708	1.0891
126	-2.4288	4.3269	1.9003
127	-5.1593	5.1153	-0.0452
128	-3.7456	4.4049	0.6590
129	-3.4506	5.0663	1.6159
130	-3.9040	5.0691	1.1554
131	-1.3778	3.3332	1.9551
132	-0.7257	2.0477	1.3265
133	-3.9524	5.6116	1.6626
134	-4.9685	6.5023	1.5199
135	-3.5222	4.4028	0.8758
136	-2.6902	2.7230	0.0484
137	-4.4160	4.9538	0.5393
138	-4.4461	5.4862	1.0414
139	-2.1779	3.7932	1.6124
140	-4.0927	4.3989	0.2828
141	-3.4631	3.2650	-0.1978
142	-3.9006	5.4683	1.5680
143	-6.9594	7.3791	0.3603
144	-4.5002	5.4593	0.9220
145	-6.1093	8.4854	2.3591
146	-2.6437	5.3031	2.6619
147	-3.8002	5.5821	1.7793
148	-3.9388	5.7992	1.8484

149	-3.8130	5.6993	1.8892
150	-1.4313	2.6237	1.1921
151	-4.8249	4.9594	0.1341
152	-0.1748	1.7954	1.6239
153	-3.8852	6.0035	2.1216
154	-2.1107	4.1354	2.0437
155	-3.0453	4.1989	1.1516
156	-3.3434	5.1062	1.6541
157	-2.6497	3.3620	0.7294
158	-8.3165	9.0079	0.7544
159	-4.5765	3.8733	-0.7051
160	-6.2276	5.8730	0.0280
161	-5.1745	7.2101	2.0390
162	-10.3702	12.4762	2.1055
163	-4.7154	6.5505	1.8357
164	-9.0976	8.9463	-0.1530
165	-4.4232	6.0465	1.6259
166	-1.4556	2.5167	1.0578
167	0.8977	-0.9506	-0.1028
168	-2.8567	3.6053	0.7540
169	-1.7562	-0.3453	-2.1022
170	-7.5016	12.3215	4.8302
171	-4.1780	1.7518	-2.4232
172	-2.3757	2.7713	0.3965
173	-3.0951	4.2200	1.1458
174	-2.7851	6.6577	3.8771
175	-22.4005	22.4415	0.0759
176	-23.3575	25.4713	2.1188
177	-14.2967	18.7795	4.4838
178	-2.6205	0.8842	-1.7565
179	-0.7384	-0.4691	-1.2027
180	-2.6369	2.5165	-0.1194
181	-4.0255	1.9248	-2.2028
182	-4.5411	-5.5652	-10.1058
183	-7.1807	9.3157	2.1414
184	-6.5054	7.3166	0.8167
185	-7.8343	11.0280	1.9973
186	-3.0001	2.0584	-0.9348
187	-1.9016	5.3927	3.4818
188	-6.6663	8.5610	1.8666
189	-3.3073	3.7477	0.4455
190	-5.0100	7.3706	2.3580
191	-11.1190	9.3308	-1.7769
192	-4.0489	4.8812	0.8390
193	0.6324	8.2504	8.8097
194	-4.1799	3.2894	-0.8842
195	-15.3749	31.1189	15.7562
196	-7.8028	13.3957	5.5867
197	8.0895	10.5588	18.5562
198	-13.5604	15.6992	2.0922
199	-4.5214	8.8321	4.2386
200	-7.2033	9.7990	2.6074

201	-4.0074	6.9592	2.9505
202	-2.7774	3.2261	0.4555
203	-11.7865	11.0015	-0.8041
204	-9.7001	2.3602	-7.8815
205	-10.1565	6.7100	-3.4353
206	-5.4609	16.1204	9.7134
207	-6.5759	5.5339	-1.0486
208	-4.3446	5.1372	0.6649
209	-0.0278	-3.4496	-3.4854
210	-0.4181	3.8336	3.2535
211	-27.3488	31.4055	4.0494
212	-7.9615	12.4761	4.2098
213	2.5289	-0.2975	2.1333
214	-38.1934	42.5014	4.8865
215	-15.6215	12.5473	-3.0368
216	-32.1127	29.7823	-2.3025
217	-1.6998	2.9423	1.2411
218	-2.3177	3.3189	1.0111
219	-1.4337	3.1964	1.7641
220	-2.2562	3.3828	1.1264
221	0.0604	-1.9978	-1.7728
222	-2.1774	2.7479	0.6117
223	-2.4237	2.8760	0.4408
224	-4.9605	7.4934	2.4950
225	-3.3183	5.4806	2.1585
226	-2.0314	3.1217	1.0901
227	0.0962	1.1067	1.2350
228	-3.3371	4.2078	0.8686
229	-1.6064	2.6621	1.1064
230	-4.7890	9.0610	4.2693
231	-3.7574	4.5700	0.8155
232	-2.0936	3.6421	1.5482
233	-4.8719	7.7262	2.8599
234	-2.3967	2.8943	0.4638
235	-4.3698	5.1141	0.7210
236	-3.8410	5.8295	1.9084
237	-2.4870	2.7140	0.4394
238	-5.9457	6.6003	0.6534
239	-7.8199	8.6142	0.7987
240	-1.4604	2.4328	0.9171
241	-1.4376	3.0901	1.6529
242	-1.5307	1.9360	0.4024
243	-2.4162	3.5108	1.0944
244	-1.5489	2.3377	0.7914
245	-1.8871	2.7111	0.8100
246	-4.1227	6.1002	1.9788
247	-4.3781	5.9678	1.5926
248	-6.7385	8.1944	1.4546
249	-3.4639	3.2793	-0.1835
250	-12.4225	13.6246	1.1884
251	-24.3843	31.3510	6.9692
252	-8.9456	9.5407	0.5952

253	-4.1650	2.9710	-1.1999
254	-3.6169	5.0281	1.4100
255	-6.3661	7.5121	1.0626
256	-10.5229	10.8409	0.3145
257	-18.3672	25.4051	7.0418
258	-12.1410	12.8861	0.7483
259	-7.4875	15.0710	7.5826
260	-10.8991	14.3829	3.4981
261	-13.9782	25.8806	11.9035
262	-23.5824	30.7175	7.1398
263	-3.3085	-0.0088	-3.3208
264	-5.6860	5.4087	-0.2371
265	-3.3184	3.1065	-0.2155
266	-2.5663	2.7001	0.1382
267	-5.1282	4.7742	-0.3491
268	-2.4571	4.6038	2.1469
269	-7.0478	7.0605	0.0169
270	0.0331	-0.8164	-0.7649
271	-0.8033	0.6161	-0.1179
272	-4.1191	2.4024	-1.7119
273	-3.2655	2.2138	-1.0506
274	-2.9138	0.9035	-2.0266
275	-0.6006	-0.8966	-1.4932
276	-0.4054	1.5900	1.1457
277	-5.1643	5.3264	0.1707
278	-3.8098	3.8181	-0.0057
279	-3.2286	2.4630	-0.7629
280	-2.5330	0.7273	-1.8048
281	-3.5931	4.9237	1.3287
282	-5.1211	3.0782	-2.1791
283	0.4432	-0.9045	-0.5214
284	-5.8619	7.2916	1.4515
285	-6.0733	3.0202	-3.0552
286	-2.4127	4.7688	2.3786
287	-1.7264	3.3791	1.6061
288	-4.1196	5.6089	1.4786
289	-6.7642	6.9189	-1.7398
290	-3.0083	1.8440	-1.1586
291	-1.1133	1.0170	0.0325
292	-2.9502	3.2900	0.2715
293	-4.3985	3.9681	-0.4355
294	0.4253	-1.6613	-1.2360
295	-1.4540	-1.6804	-3.4098
296	-2.4713	4.6807	2.2047
297	-2.5267	3.3412	0.8140
298	1.6955	-4.4007	-2.7131
299	-0.6898	0.9771	0.1318
300	-4.7919	5.1767	0.3850
301	-1.9037	2.7606	0.7935
302	-6.5822	7.2815	0.6954
303	-2.7500	2.4115	-0.3421
304	-4.6568	5.4089	0.7528

305	-4.0539	6.0211	1.9623
306	-5.0206	7.7228	2.7060
307	1.4026	-4.8815	-3.7873
308	-8.2492	10.8109	2.5614
309	-1.2080	1.4784	0.2733
310	1.4836	-13.4155	-11.5595
311	-5.3508	5.3598	0.0144
312	-2.2006	5.0650	2.9689
313	-2.0172	1.2986	-0.7184
314	-3.2165	-1.4820	-4.5923
315	-0.7650	-0.0139	-1.1831
316	-1.7008	2.2161	0.4951
317	-0.5567	2.3977	1.8349
318	-8.1456	7.4894	-0.6639
319	-4.8982	4.9183	0.0043
320	-2.8002	3.6533	0.2720
321	-7.6438	4.3406	-3.2971
322	-5.8745	7.0656	1.1927
323	-4.9897	5.4886	0.4775
324	-7.5323	7.2080	-0.3224
325	-2.4431	3.4377	1.0031
326	-33.4422	37.2267	3.8029
327	2.1342	-7.9088	-5.7888
328	-1.4734	-0.3256	-1.8034
329	-12.9365	1.7350	-10.9333
330	-5.0092	-0.3325	-4.7887
331	-1.5658	0.7275	-0.8854
332	-5.5186	10.1239	4.6203
333	-4.8278	-2.8708	-7.7084
334	-3.7830	-2.1996	-6.0096
335	-9.8410	7.5624	-2.2755
336	-6.5425	8.2069	1.6436

Average	**λ_0**	**λ_1**	**λ_2**
average	-4.403	5.456	1.037