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ΧΡΗΜΑΤΟΟΙΚΟΝΟΜΙΚΗΣ ΚΑΙ ΤΡΑΠΕΖΙΚΗΣ ΔΙΟΙΚΗΤΙΚΗΣ

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"Forecasting the beta coefficient in a market characterised by thin trading"

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CHAPTER 1:

1. Introduction:

As we all know, investment in financial assets such as the stocks of companies listed in organized stock markets is one of the most important issues of finance. Moreover the concept of the risk related to the investment on stock markets has widely permeated the financial community so that everyone knows the necessity of analyzing risk in investment analysis and finding ways and methods of dealing with it. A major object of controversy is still the question of what constitutes risk and how it should be measured. The measure of risk with the widest acceptance in the academic community is the coefficient of non- diversifiable risk, or beta coefficient of the market model (i.e. Single-Index model). The systematic risk has been chosen instead of the total risk (i.e. Total risk = Systematic risk + non-systematic risk), as the non-systematic risk can be reduced through diversification and the formation of portfolios of stocks according to the portfolio theory developed by Markowitz (1952) as we will see in the following.

The Single-Index model, developed by Sharpe (1964) is widely used for the estimation of the stocks' systematic risk. The beta coefficient therefore, estimated according to this model exhibits several characteristics as a lot of previous researches have shown. One of them is the consistent tendency documented for **a stock or portfolio with a low (high) historical beta, calculated for a given time period, to usually show a higher (lower) value for the subsequent time period**. Bearing in mind that high and low betas are defined in relation to the market beta which equals one, betas seem to reveal an overall convergence tendency to one and thus a relative **instability (non stationarity) along time**.

We have to note here that the practical importance of estimating the beta coefficient of a stock is mostly for using it as a measure of **predicting the <u>future</u> risk of a stock** and thus with the above tendency of non-stationarity of betas along time, the estimation of betas based on past data is not sufficient for being used as a predictor of systematic risk for the future. Thus several techniques have been proposed for forecasting the future betas and therefore the future risk of a stock or a portfolio and a relative investment on it. As we will see in the Literature review, the most of the previous researches on the issue such as, Klemkovsky and Martin (1975), Eubank and Zumwalt (1979) and Diakogiannis (1989) have established the superiority of two adjusted method techniques amongst all of the others. These techniques are the autoregressive non-weighted Blume's model originally proposed by Blume (1971) in 1971 and the autoregressive weighted Vasicek's technique based on the findings of Bayes and proposed by Vasicek (1973).

There are a lot of factors therefore, which can affect the estimation of the systematic risk, such as the selection of the **market index** used as a proxy for the market portfolio, the selection of the **time period** used for the estimation of the systematic risk of a stock, the selection of the **time interval** used for estimating the returns of the shares (i.e. "interval effect") and most importantly the existence in the stock market of the phenomenon of **"Thin Trading"** (or Infrequent Trading or non-synchronous trading).

The last point of "Thin Trading" will be one of the major issues which are going to be analyzed in this research. This concept refers to the case, often faced in small markets where trading is thin, in which not all stocks are effectively frequently traded and thus unsynchronous observations for stock prices and the market portfolio turn out to be a significant problem. This introduces a major econometric source of error when the market model is applied mainly observed in the form of the tendency of beta estimates of **frequently traded securities being biased upward (downward), while the corresponding estimates for infrequently traded securities are biased downward (upward) with respect to a market index favouring the active (thin) securities.** Several methodologies have been suggested for dealing with the problem of thin trading, from which the one we consider as the most appropriate and we are going to use, is the Scholes' & Williams methodology[1].

Bearing in mind all of the above, we have to make clear the major goals of this work, which are the following:

1) We are interested in testing if the observed in many markets non-stationarity of betas through time, is still observable in a small market characterized by thin trading, the Athens Stock Exchange (ASE). For this purpose we are going to use the two methods originally proposed by Chawla (2001) of introducing and additional time variable in the classical OLS model and of using dummy variables to measure the change of the slope over time.

[1] Although there is still much argument on which is the most appropriate technique, other techniques such as the Dimson's estimator one have been proven to be incorrect (i.e. not specified correctly) and thus cannot generally be expected to yield consistent beta estimates (Fowler & Rorke (1982)).

2) After establishing the "non-stationarity" tendency, we are interested in testing the forecasting ability of Blume's and Vasicek's methods to predict betas along time and conclude on which is the most appropriate amongst the two of them.
3) Moreover, we are going to evaluate the significance of a "correcting for thin-trading" technique in the estimation of beta and whether there is an improvement or not in the forecasting ability of the Blume's and Vasicek's methods to predict betas along time, when using as historical data, betas estimated by the a correcting procedure instead of estimating them by the classical OLS method. For this purpose we have chosen the Scholes' & Williams' methodology.
4) Finally, we are interested in checking whether the frequency of stock data collection has a significant impact (i.e. interval effect) on the forecasting ability of stock betas, by comparing the results achieved with daily and monthly data.

It is important to note here that this work is motivated by the following two factors:

- The likelihood of the forecasting techniques such as Blume's and Vasicek's has substantially increased through their wide acceptance as efficient according to the several relative researches. Thus the choice between them becomes more critical. Hence the results from the new testing of their efficiency will **add more robustness** to the results already obtained from the previous researches.
- The importance of predicting the future systematic risk of a stock through the relative coefficient is fundamental for the investors. Thus the exploration of the best possible way for doing this, such as our proposal and testing of a method combining the Scholes & Williams methodology with the best available forecasting techniques of Blume and Vasicek respectively is extremely important.

CHAPTER 2:

2.1 Portfolio Theory:

Investing in financial assets such as stocks is a very common form of investment, which is a long term investment enabling high levels of risk. Portfolio theory has developed models of expected return to risk and measures of measuring them in order to provide an investor with best possible tools of analyzing the available information and making rational decisions.

One of the important notions of portfolio theory has been the **diversification of risk** by forming portfolios of assets instead of investing all of our money on just a single stock. By diversifying our investment in several assets we reduce the total risk taken and thus the possibility of loss of our money.

Another interesting concept is the separation of the total risk of an investment in **systematic risk** which is attributed to factors affecting the total of the market (i.e. macroeconomic factors, GDP growth rate, unemployment, inflation rate etc.) and all of the stocks and thus it is not reduced through diversification (non-diversifiable risk). On the other hand, there is the **non-systematic risk**, which is attributed to factors unique for each company, the stock of whom we examine, such as the efficiency of the company's administration, its dividend policy etc. Thus the non-systematic risk can be reduced (i.e. diversifiable risk) by forming a portfolio of several stocks exhibiting the highest possible negative correlation between them.

Portfolio theory was firstly developed by Markowitz and has contributed significantly in the progress of financial analysis, as according to it, investors have the ability to combine several financial assets and thus forming a portfolio. A portfolio can be defined as a combination of stocks or other financial assets which is characterized by the weights of investment on each of its assets. By forming optimal portfolios, the investors aim to minimize their investment risk.

The fundamental assumption of Markowitz was that investors prefer to avoid risk, i.e. they are risk averse. In other words, investors accept to take more risk only when there is the possibility of getting higher returns from the investment.

Portfolio theory as was developed by Markowitz[2], is based on the following four ***assumptions***:

[2] Markowitz, H. (1952). "Portfolio Selection", *The Journal of Finance,* Volume 7, No 1, pp77-91

1. Investors have a clear and isolated investment horizon.
2. Every single stock for the investors is represented by a probability distribution of the expected returns. The expected price of this distribution is a measure of the expected return of the stock while the variance of the returns gives us a measure of its risk.
3. A portfolio of single stocks can be completely described by the expected return of the portfolio and the relevant variance of this return.
4. Investors exhibit rational behaviour as this is determined by the following two basic adoptions:
    - Investors prefer the highest possible returns for each level of risk.
    - Investors prefer the less possible risky returns for each level of returns.

Thus portfolio theory attempts to specify the best portfolio under conditions of uncertainty. It examines the possible combinations of single stocks in portfolios with characteristics of risk and expected returns and provides an investor with the ability of choosing one which maximizes the expected benefit of the investor.

The ***basic points*** of Markowitz's theory are the following:

1. The basic characteristics of a portfolio are the expected return and a measure of dispersion of the possible returns around the mean return.
2. The rational investors select efficient portfolios. Such portfolios are those which maximize the expected return for a given level of risk and minimize the risk for a given level of return.
3. The construction of efficient portfolios is possible. This process requires analysis and knowledge of the basic characteristics of the investments such as the expected return, the variance of it and also the possible autocorrelations of the returns of those investments.

Portfolio theory and the selection of the efficient portfolio include the following ***three stages***:

1. ***Analysis of the characteristics of the assets (i.e. stocks).***

In this stage the investor analyzes the returns of single stocks for a given time interval and estimates the expected return of the stock, its variance and the covariance and correlation coefficient between the returns of the stocks.

The following formulas are used:

Return of stock *i* = Capital yield + Dividend yield

Where:

Capital yield: It is ought to the rise (capital profits) or fall (capital losses) of the price of the stock during the examined period.

Dividend yield: It is ought to the dividend which was distributed during the examined period.

As a consequence the total return of the stock *i* is estimated according to the formula:

$$R_{it} = \frac{P_{it} - P_{it-1}}{P_{it-1}} + \frac{D_{it}}{P_{it-1}}$$

Where:

P_{it} : The price of the stock *i* during the period *t*

P_{it-1} : The price of the stock *i* during the period *t-1*

D_{it} : The dividend of the stock *i* during the period *t*

Expected return of the stock i: $E(R_{it})$: It equals the weighted average of the possible returns of the stock *i* where the weights are the probabilities of these returns, i.e.

$$E(Rit) = \sum_{i=1}^{k} p_k R_{ik}$$

Where:

p_k : The possibility of getting the return R_{ik} .

Variance of the returns of the stock i: $s^2(R_{it})$: It is a measure of dispersion of the actual returns from the expected one and it measures the variability of the return of an asset. It is calculated as the weighted average of the squared deviations of the possible returns from the mean value, having as weights the probabilities of appearance of these returns and it is given by the following formula:

$$s^2(R_i) = \sum_{i=1}^{k} p_k (R_{ik} - E(R_{ik}))^2$$

Where:

p_k : The possibility of the appearance of R_{ik}

Standard deviation of the returns of the stock i: $s\left(R_{it}\right)$: It is the square root of the variance of the returns of the stock *i*.

Coefficient of variation CV: It is the ratio of the standard deviation to the expected return of a stock *i* and it is given by the formula:

$$CV = \frac{s\left(R_i\right)}{E\left(R_i\right)}$$

Covariance between the returns of two stocks *i* and *j*: $Cov\left(R_i, R_j\right)$: The covariance between two stocks shows us the direction towards which, the returns of the stocks *i* , *j* tend to move. If the covariance is positive, then the returns of the two stocks *i* , *j* move to the same direction while, if it is negative move to the opposite one.

The covariance between the returns of the two stocks *i* , *j* is given by the formula:

$$Cov\left(R_i, R_j\right) = s_{ij} = \sum_{k=1}^{N} p_k\left(R_{ik} - E\left(R_i\right)\right) * \left(R_{jk} - E\left(R_j\right)\right)$$

Where:

p_k is the common probability of appearance of the returns R_{ik} and R_{jk}

Correlation coefficient between two stocks *i, j*: $\left(r_{ij}\right)$:

As the covariance shows only the direction towards which, the returns of the stocks *i* , *j* tend to move, we need another measure which can give us the strength of their relation. This purpose is served by the correlation coefficient which takes values from the interval [-1,1]. Depending on the values of the above coefficient we distinguish the following cases:

- For $r_{ij} = 1$, the returns of the two stocks are perfectly positively correlated. This is the only case in which the diversification cannot reduce risk at all.
- For $0 < r_{ij} < 1$, the returns of the two stocks are positively correlated.

- For $r_{ij} = 0$, the returns of the two stocks are independent.
- For -1 < r_{ij} < 0, the returns of the two stocks are negatively correlated.
- For $r_{ij} = -1$, the returns of the two stocks are perfectly negatively correlated. In this case we have a totally riskless portfolio.

The correlation coefficient is calculated by the formula:

$$r_{ij} = \frac{Cov(R_{it}, R_{jt})}{s(R_{it}) * s(R_{jt})}$$

Where:

$Cov(R_{it}, R_{jt})$: The covariance of the returns R_{ik} and R_{jk} between the two stocks *i, j* and

$s(R_{it})$ and $s(R_{jt})$: The standard deviations of the returns R_{ik} and R_{jk} between the two stocks *i, j*.

<u>Coefficient of determination:</u> (R^2):

It is the squared price of the correlation coefficient and it represents the proportion of the total variation of a dependent variable explained by the regression of the dependent variable on the independent one, i.e. A value of $R^2 = 65\%$ means that the regression of the dependent variable on the independent, explains 65% of the total variation of the dependent one.

2. ***<u>Analysis of the portfolios.</u>***

After the selection of the stocks in the previous stage, here an investor combines them in 2, 3 or any other number and forms portfolios from which he chooses those ones having the maximum expected return with the minimum possible risk. Such portfolios are called **efficient portfolios** and graphically presented they form the so-called **efficient frontier**.

A portfolio is characterized as efficient if:

- There is no other portfolio with the same expected return, having less risk (i.e. smaller standard deviation)
- There is no other portfolio with the same or smaller standard deviation, yielding higher expected return.

Expected return of a portfolio: $E\left(R_p\right)$: It equals the weighted average of the single returns of two or more stocks where the weights are the percentages of investment on each stock, i.e.

$$E\left(R_p\right)=\sum_{i=1}^{N} w_i E(R_i)$$

Where:

N = The number of stocks in the portfolio.

w_i = The percentage of the total investment of the portfolio placed on each stock *i*.

$E\left(R_i\right)$ = The expected return of stock *i*.

The sum of the weights on all the stocks of the portfolio has to be equal to one in every case, i.e. $\sum w_i = 1$

Variance of the returns of a portfolio: $s^2\left(R_p\right)$: It is a measure of dispersion of the actual returns from the expected one and it measures the variability of the returns of a portfolio. Its calculation precludes the estimation of the single variances of the stocks forming the portfolio and their corresponding covariance.

In the case of a portfolio of two stocks, the variance is given by the following formula:

$$s_p^{\,2} = w^2 s_i^{\,2} + \left(1-w\right)^2 s_j^{\,2} + 2w\left(1-w\right)s_{ij}$$

Where:

w_i = The percentage of the total investment of the portfolio placed on each stock *i*.

s_i = The standard deviation of the returns of the stock *i*.

s_j = The standard deviation of the returns of the stock *j*.

s_{ij} = The covariance of the stocks *i* and *j*.

3. Selection of the portfolio.

From all the portfolios of the efficient frontier, the investor chooses the portfolio which has the desirable level of “expected return – risk” according to his preferences and his behaviour i.e. risk lover or risk averse.

For example, a risk lover investor will accept to undertake a higher level of risk in order to gain a higher expected return, while a risk averse investor will forego an amount of expected return in order to secure having small risk for his investment.

2.2 Single Index Model (Market Model):

As it is clear from the previous section of portfolio theory, the analysis according to Markowitz's model requires a great number of calculations (i.e. expected return and variance for each stock candidate for inclusion in our portfolio, multiple covariances between them, etc.) in order to select an efficient portfolio of assets. This practical inefficiency in its application, led to the development of the Single Index Model or Market Model. Major contribution to its forming and its latter further development creating the Capital Asset Pricing Model, was given by the working papers of Sharpe (1964), Lintner (1965) and Mossin (1966).

The fundamental concept under this model is that the return of a stock *i* is linearly dependent with the return of the market portfolio *m*. Thus, it accepts the basic assumption that there is no other factor affecting the stocks' returns than the market. As a proxy of the market is usually used a relevant price index.

The mathematical formula of the Single Index Model is the following:

$$\tilde{R}_{it} = a_i + b_i \tilde{R}_{mt} + \tilde{e}_{it}$$

Where:

$\tilde{R}_{it}$: The return of the stock *i* during the period [t-1, t]

a_i : The return of the stock *i* when the return of the market portfolio equals zero or alpha coefficient. For example, if the alpha coefficient is positive and statistically significant the stock exhibits a significant factor of over valuation. On the other hand, when the alpha coefficient is negative and statistically significant the stock exhibits a significant factor of depreciation.

b_i : The systematic risk of the stock *i* or beta coefficient. It is the coefficient of sensitivity of the returns of a stock or a portfolio to the fluctuations in the returns of the market, usually represented by a relative price index. It is also called as coefficient of systematic risk.

$\tilde{R}_{mt}$: The return of the price index used as a proxy of the market portfolio.

$\tilde{e}_{it}$: A random disturbance term which exhibits the following properties:

- ü Zero expected return $(Ee_{it} = 0)$
- ü Constant Variance $(Vare_{it} = s^{2})$ (Homoskedasticity assumption)
- ü Independent from the price index's return $(e_{it}, R_{mt}) = 0$
- ü There is no correlation between the prices of the disturbance term $Cov(e_{it}, e_{t-1}) = 0$. (No autocorrelation assumption)

It is necessary for the above conditions to be met so as to have unbiased and consistent estimators, because in the opposite case we would have serious problems of reliability in the estimated price of our beta coefficient[3].

For example, in the case that the second condition of Homoskedasticity was violated, our OLS estimators although they would be unbiased and consistent, nevertheless they wouldn't be efficient and asymptotically consistent.

[3] A relative work has been done in the following working paper, presented in the "Literature review" chapter: Karathanasis G. & Philipas N. (1994), "Validity tests of the assumptions of the market model in the Athens Stock Exchange", *Spoudai,* Volume 44, pp.62-78.

2.3 Applications of the Single Index Model (Market Model):

Systematic risk is one of the most common criteria for evaluating single stocks and portfolios of them and thus it is necessary its consistent and unbiased estimation. It has a lot of application in the field of finance such as:

- For the estimation of beta coefficient for single stocks and portfolios,
- The simplification of the process of portfolio analysis and selection and
- Provides the necessary variables for using in indices such as the Treynor's measure.

We will now have a closer look to the above:

Estimation of the beta coefficient:

Beta coefficient is a measure of the sensitivity in the expected return of a stock as compared to the returns of the market. It is considered as the most representative measure of the systematic risk of stocks and portfolios. As we saw in a previous section, the systematic risk is that part of the total risk which is attributed to all those factors (economical, political, social, etc.) affecting the total of the market and can be reduced through diversification thus its estimation is important.

The beta coefficient is defined by the following formula:

$$b_i = \frac{Cov(R_i, R_m)}{s^2(R_m)}$$

Where:

$Cov(R_i, R_m)$: The covariance between the returns of the stock ***i*** and the market's portfolio *m* (usually represented by a relative price index of the local market, which by definition has a beta coefficient equal to one).

$s^2(R_m)$: The variance of the returns of the market's portfolio.

The stocks and the portfolios are classified according to the price of their beta coefficient. As larger as is the price of the beta coefficient, by that much is considered as risky the investment on this asset or portfolio. More clearly depending on the prices of the beta coefficient, we distinguish the following three major cases:

- For $\beta < 1$: The stocks are characterized as defensive, i.e. with low risk and investing on them is rational on periods when the market exhibits depression (bear market).
- For $\beta = 0$: the fluctuations of the market will not affect the returns of the corresponding stock.
- For $\beta > 1$: The stocks are characterized as offensive, i.e. with high risk and investing on them is rational on periods when the market exhibits rise (bull market).

<u>Simplification of the process of portfolio analysis and selection:</u>

The classical Single Index Model (S.I.M.) can be used for the simplification of the process of forming efficient portfolios according to the Markowitz's theory. The major contribution of the S.I.M. is attributed to the reduction of the necessary parameters for estimating efficient portfolios.

For example, in the case that we want to include 30 different assets in a portfolio, we need to estimate 30 different expected returns, 30 different variances and 435 different covariances, each one for each pair of assets. Thus in total 495 parameters. On the other hand, by using the S.I.M. we just need to estimate 30 beta coefficients, 30 standard deviations and one standard deviation for the market. Thus the total number of the required parameters is reduced to 61.

Generally the required parameters in each case are given by the following table:

Markowitz Model		**Single Index Model**	
Expected Returns	N	Beta coefficients	N
Standard Deviations	N	Standard Deviations	N
Correlation Coefficients	N(N-1)/2	Standard Deviation of the market	1
Total	**N(N+3)/2**	**Total**	**2N+1**

Providing the necessary variables for using in indices such as the Treynor's measure:

Treynor's measure (1965) which is given by the following formula:

$$\frac{R_p - R_f}{b_p}$$

Where:

Rp: The expected return of a portfolio of stocks

Rf: The expected return of a risk-free asset

βp: The systematic risk of a portfolio of stocks

This measure is used for the evaluation of portfolios of stocks or mutual funds. Those with higher values given by the measure are preferred from those with lower ones. Thus the consistent and reliable estimation of beta is necessary in such case in order to allow to the Treynor's measure to work efficiently and subsequently classify the portfolios for evaluation accordingly.

2.4 Criticism of the Single Index Model (Market Model):

Despite the wide use of the beta coefficient as a measure of the systematic risk and thus as a criterion for the evaluation of stocks and portfolios, it has accepted criticism[4].

The basic points of argument are:

- According to the Single Index Model's assumptions the return of a stock is dependent to the market's portfolio. But there is not clear which market price index and according to what criteria, has to be selected as a proxy for the market portfolio of each local market.

- Practical research and experience has shown that the Single Index Model exhibits very low prices of R^2. Thus the estimated regressions according to the S.I.M. do not explain very well the variation of the return of a stock and thus we have to consider that there also other factors affecting them, probably not being taken under consideration. The possible existence of such omitted variables is a flaw of the model which may lead to insufficient estimations of the beta coefficient. The consideration of this flaw led to the creation of multi-index models trying to get under consideration such omitted variables.

[4] Clare, A. et al (1997). "Is beta dead? The role of alternative estimation methods", *Applied Economics Letters,* Volume 4, pp.559-562.
Clare, A. et al (1998). "Reports of beta's death are premature", *Journal of Banking and Finance,* Volume 22, pp.1207-1229.

2.5 Factors affecting the estimation of the systematic risk:

1.The selection of the market index used as a proxy for the market portfolio.

A first criterion for the selection of the appropriate market index can be a high value of R^2 when running a regression of one or more stocks with it, as in such case means that the fluctuations in the returns of the index explain quite well the variation in the returns of the stocks.

Another criterion can be the number of stocks included in a market index. A larger number of stocks included in an index is preferable as it indicates the use of a larger sample as a proxy of the market.

Moreover, we have to take under consideration the method of weighting. Usually, the value-weighted indices (i.e. indices weighted according to the stock market price of their stocks) are preferable from the equal-weighted indices (i.e. indices having equal weights for each stock.

In the case of the Athens Stock Exchange (ASE), which we are going to se for our study we have to choose amongst the following indices:

- The *General Index of the ASE*:

  It contains 60 stocks and is a wide selection index, weighting the stocks according to their stock market value.
- The *Total Return Price Index*:

  It estimates the total return of the ASE's General Index taking under consideration the reinvestment of the dividends of the stocks contained into it.
- The *Index FTSE ASE-20*

  It contains the first 20 stocks of the ASE with the highest stock market value (High Capitalization Index).
- The *Index FTSE ASE-40*

  It contains the next 40 stocks of the ASE with the highest stock market value (Medium Capitalization Index).
- The *Index FTSE ASE-80*

  It contains the first 80 stocks of the ASE with the highest stock market value.
- The *Index FTSE ASE-140*

It contains the total of the stocks included in the indices FTSE ASE-20, FTSE ASE-40, FTSE ASE-80

2. **The selection of the time period used for the estimation of the systematic risk of a stock.**

As a first thought the selection of a time interval as long as possible will be ideal in the case of estimating the beta coefficient as it would provide us with large amount of information and subsequently the estimated regression would be more consistent.

On the other hand, estimates based on many years of historical data may be of little relevance because the nature of the business risks undertaken by companies may have changed significantly over a very long period, say for example 10 years.

According to Gonedes (1973) and Kim (1993), the choice of a five year estimation period seems to be identical, based on the findings that betas tend to be reasonably stable over five year periods. The selection of a five-year period represents a satisfactory trade-off between a large enough sample to enable reasonably efficient estimation and a short enough period over which the underlying beta could be assumed to be relatively stable.

3. **The selection of the time interval used for estimating the returns of the shares (intervalling effect).**

As matter of fact, beta coefficients change with the return interval because an asst's covariance with the market and the market's variance do not change proportionately as the return interval is changed. More specifically, it has been observed that betas of securities riskier than the market increase with the return interval, whereas betas of securities less risky than the market decrease with the return interval. Moreover, according to the research of Brailsford & Josev (1997), the **beta estimates of high (low) capitalized firms fall (rise) as the return interval is lengthened**. These results support the claim of Cohen et al. (1980) that **thinly (frequently) traded stocks approach their true betas from below (above), implying that their OLS betas are under-estimated (over-estimated)**.

The observed phenomenon that beta estimates change as the return interval changes, has implications for portfolio and risk management, the measurement of abnormal market model returns in event studies, asset pricing tests and other applications which use beta to determine expected returns.

The "intervalling effect" can be generally attributed to the non-synchronous" trading (i.e. thin trading) and to the trading frictions that contribute to a distinction between observed and "true" betas.

By using smaller time intervals for the estimation of the returns of a stock or a price index the estimation of the beta coefficient is vulnerable to the phenomenon of "thin trading"[5] and our estimation may be biased because of the reduction in the correlation of a stock with the market's portfolio. Moreover, Handa, Kothari & Wasley (1989), by estimated beta coefficients using several return intervals varying from one day to one year, provided evidence that the annual betas were incrementally significant thus supporting the opinion that daily data adds too much noise in the calculation.

But on the other hand, in this case the estimation of the beta coefficient has the advantage of providing us with larger amount of information and thus our estimated regression can be more consistent. In addition, there are supporting empirical results such as Couto & Duque (2004) comparing the results by using different time intervals and getting more significant betas with high frequency data.

Pogue and Solnik (1974) were the first to measure the impact on the estimates of beta obtained by using different return interval lengths. Much research has been directed at establishing the impact that different interval lengths may have on estimates of beta. Subsequently, Blume (1975), Eubank and Zumwalt (1979) and more recently Corhay (1992) have assessed the effect that various interval lengths have on the predictive power of beta estimates.

The most accepted opinion is that researchers are encouraged to use monthly intervals (over a five year period) to compute the returns needed for the estimation process, resulting in 60 data points of monthly returns.

[5] See the section relative with the "thin trading".

4. Thin Trading (or Infrequent Trading):

As we have already said in the introduction, one of the major targets of this paper is to examine the behaviour of the beta coefficients under the conditions of thin-trading, which is a major characteristic of many stock markets around the world such as the Athens Stock Exchange, the Brussels Stock Exchange, the Helsinki Stock Exchange and many others. As it is a major source of bias for our beta estimations and thus a major problem, we have to explore new ways for dealing with it.

Empirical studies using thinly traded securities are now particularly significant. Firstly, although virtually every European country has its own stock market, new markets are forming in eastern European countries. These emerging stock markets are characterized by a light volume, as measured by the average number of shares traded, and a very thin market capitalization. Secondly, as mentioned by Heinkel and Kraus (1988), there is substantial interest in the price behaviour of small firms, whose shares are often thinly traded. Thirdly, empirical analysis of asymmetric information models requires the use of thinly traded stocks since information asymmetry is potentially greater in data sets that exhibit thin trading. In any case, the beta which measures the relative responsiveness of an individual company's assets market value to general market movements is an important tool for almost all institutional investors

The thin trading problem is mainly caused by the fact that some securities listed on organized exchanges are traded only infrequently, with only few securities so actively traded that prices are recorded almost continuously ' Because price for most securities are reported only at distinct random intervals, completely accurate calculation of returns over any fixed sequence of periods is virtually impossible. In turn this introduces into the market model the econometric problem of errors in the variables as we have missing observations.

The thin trading problem can cause bias whether we use a small data return interval such as daily returns of the securities or a longer interval such as monthly returns.

When using a small return interval such as daily returns, the bias is caused as a result of the missing observations of securities prices for certain dates and thus resulting a vast number of zero returns. Therefore, we observe the tendency of beta estimates of frequently traded securities being biased upward (downward), while the corresponding estimates for infrequently traded securities are biased downward (upward) with respect to a market index favouring the active (thin) securities. These biases are likely to be stronger in stock markets of small developing nations, where inadequate liquidity and incomplete institutional infrastructure impede the flow and utilization of information and hence the frequency of trading, inducing large operational costs (bid-ask spreads).

When using a long return interval such as daily returns, the month end price for a thinly traded stock may not arise from a trade on that day, but may be instead recorded as the price last traded during the month. Consequently, the recorded price on the market index at month-end may not be matched to a trade for the stock on the day and thus a mismatch occurs. This mismatching phenomenon clearly has an impact on the covariance estimate between the stock and the market proxy, leading to a downward bias in this covariance estimate. The thin trading bias manifests it self in the OLS beta estimate because the OLS estimate of beta has this covariance term in the numerator according to the equation:

$$b_i = \frac{Cov(R_{it}, R_{mt})}{Var(R_{mt})}$$

Where:

$\tilde{R}_{it}$: The return of the stock *i* during the period [t-1, t]

$\tilde{R}_{mt}$: The return of the price index used as a proxy of the market portfolio.

Thus the downward bias in the covariance estimate caused by thin- trading translates into a downward bias in the estimate of beta.

Several researchers have devised certain techniques for obtaining unbiased estimates of the beta coefficient in infrequently trading environments. Two distinctly different approaches have emerged: The “Trade-to-Trade” estimator (Dimson & Marsh (1979), Bowie & Bradfield (1993)) and the “Cohen” estimators which encompass all methods using non-synchronous coefficients, such as Scholes & Williams(1977), Dimson (1979), Cohen Hawawini, Maier, Schwartz & Whitcomb (1983).

In the “Trade-to-Trade” method, the returns are matched and measured during the last consecutive trading days in each month, whilst the “Cohen” type of estimators are based on aggregating lagged and leading regression coefficients. Bowie & Bradfield (1993) assessed the superiority of these two types of estimators on the JSE and conclusively found that the "Trade-to-Trade" method was superior for application on the JSE, by obtaining substantially smaller standard errors for the "Trade-to-Trade" approach than those of "Cohen" approach.

Nevertheless, Fowler & Rorke (1982) in a previous research had shown that Dimson's estimator ("Trade-to-Trade" approach) is incorrect (i.e not specified correctly) and thus cannot generally be expected to yield consistent beta estimates.

CHAPTER 3:

3.1 Literature review (in chronological order):

In this chapter we are going to review some of the most important previous researches relative to our issue. The following articles are presented **in chronological order**, in order to maintain the actual evolutionary character of the more recent researches based on the previous ones. At the end of the presentation of the articles there is a summary table of all the articles analyzed in the "Literature Review" section.

Blume (1971), *On the assessment of risk.*

M. E. Blume used as a sample the monthly investment relatives, adjusted for dividends and capital changes of all common stocks listed on the NYSE during any part of the period from January 1926 through June 1968. He examined six equal time periods beginning in June 1926 and ending in June 1968. He then regressed the investment relatives for a particular security and a particular period upon the corresponding combination market link relatives, which were originally prepared by Fisher[6] as a measure of the market factor. The number of companies in each of the six periods for which there was a complete history of monthly return data ranged from 415 to 890. The average coefficient of determination (i.e. The proportion of the variance of returns explained by the market) for each of the six periods was 0.51 , 0.49 , 0.36 , 0.32 , 0.25 , 0.28 appearing a steadily declining trend until the last period.

It is important to note that amongst the 4357 betas estimated in all six periods, only seven or 0.16 per cent were negative. This can be interpreted as although the inclusion of a stock which moves counter to the market can reduce the risk of a

[6]Fisher, L. (1966). "Some New Stock-Market Indexes", *Journal of Business,* pp.191-225.

portfolio substantially, there are virtually no opportunities to do this and nearly every stock appears to move with the market.

He then attempted to examine the empirical behaviour (stationarity) of betas over time. He ranked by ascending order the estimates of beta which were derived by using data from the first period (July 1926 through June 1933). He then formed portfolios of “n” securities, with the first one consisted of those securities with the “n” smallest estimates of beta, the second one consisted of those securities with the next “n” smallest estimates of beta and so on until the number of the remaining securities being less than “n”. The “n” was restricted to take values from the sample {1, 2, 4, 7, 10, 20, 35, 50, 75, 100}. The beta of each portfolio was a weighted average of the individual betas of the individual securities consisted it.

After following the same process for the next four periods, he formed a table presenting the product moment and rank order correlation coefficients between:

- The risk measures for portfolios of “n” securities assuming an equal investment in each security estimated in one period and
- The corresponding risk measure for the same portfolio estimated in the next period.

Assuming that the risk measure calculated using the earlier data might be regarded as an assessment of the future risk, while the measure calculated using the later data can be regarded as the realized risk, the estimated correlation coefficients can be interpreted as a measure of the accuracy of the assessments.

The results showed clearly that as the number of securities in a portfolio increases, the correlation between the 2 period’s betas is higher and thus the accuracy of the assessment of future betas using the past ones, is greater.

In the following, by composing portfolios of 100 securities for successive periods and presenting the estimated values and the actual values of their risk parameters, he observed the tendency for the estimated values of the risk parameter change gradually over time, with this tendency being stronger for the lower risk portfolios (for which the estimated risk in the second period is invariably higher than the estimated in the first one) than the higher risk ones (which tend to have lower estimated risk coefficients in the second period than in those estimated in the first).

In order to correct for this tendency, he regressed the estimated values of beta in one period on the values estimated in a previous period and used this estimated relationship in order to modify the assessments of the future.

According to the results, the slope coefficients were all less than one in agreement with the regression tendency, observed above but they were actually changing over time and thus the use of the historical rate of regression in order to correct for the future rate cannot perfectly adjust the assessments and may even overcorrect by introducing larger errors into the assessments than those which were present in the unadjusted data.

Finally, Blume concludes that: *“For individual securities as well as for portfolios of two or more securities, the assessments adjusted for the historical rate of regression are more accurate than the unadjusted or naïve assessments. Thus, an improvement in the accuracy of one’s assessment of risk can be obtained by adjusting for the historical rate of regression even though the rate of regression over time is not strictly stationary”*.

Vasicek (1973), *A Note on Using Cross-Sectional Information in Bayesian Estimation of Security Betas.*

Vasicek’s work starts from the same empirical evidence as in Blume of betas converging towards the unity over time. His proposal for correcting this tendency and providing a more accurate estimate of beta is a weighted average between the overall mean (one) and the stock’s historical beta according to the formula:

$$b_{i,t} = \frac{s^{2}_{b_{i,t-1}}}{s^{2}_{\bar{b}_{t-1}} + s^{2}_{b_{i,t-1}}}\,\overline{b}_{i,t-1} + \frac{s^{2}_{\bar{b}_{t-1}}}{s^{2}_{\bar{b}_{t-1}} + s^{2}_{b_{i,t-1}}}\,b_{i,t-1}$$

Where the weights are a function of the quality of the historical regression when estimating the parameters of the market model. Thus, as the variance of the errors increases, the quality of the historical betas decreases and weight should be given to the overall mean (average beta), while if the opposite happens, weight has to be placed on the stock historical beta. The technique has to be consisted with the tendency of betas to regress towards one and the speed of adjustment depends on the weights which are given to each of the components.

Finally, **Vasicek concludes that the Bayesian**[7] **estimates are preferred to the classical sampling-theory estimates** because:

1. As the Bayesian theory deals with the distribution of the parameters given the available information, while sampling theory deals with the properties of sample statistics given the true value of the parameters, the former procedure provides estimates which minimize the loss due to misestimating, while the latter provides estimates which minimize the error of sampling.
2. Bayesian theory weights the expected losses according to a prior distribution of the parameters and thus incorporating knowledge which is available in addition to the sample information, something which is particularly important in the case of estimating betas of stocks where the prior information is usually sizeable.

Klemkovsky and Martin (1975), *The Effect of Market Risk on Portfolio Diversification.*

Klemkovsky and Martin's work on the Miller and Scholes' evidence that there is a positive correlation between market and residual (nonmarket risk) of individual common stocks, which implies that **the process of diversification should be affected by both the <u>average beta coefficient of the portfolio</u> and the <u>number of securities</u> in it.**

By using data from the NYSE, K&D prove that such a correlation exists not only in case of individual common stocks but also between portfolios' market risk (beta) and residual risk ($Var(\tilde{e}_i)$). As the latter ones are averages of the individual securities betas and residual risk, we call "averaging effect" the effect of higher correlation coefficients for larger portfolios.

Finally they investigated the practical significance of the "beta effect" on the process of portfolio diversification by comparing the residual risk of high and low beta stock portfolios containing from 2 to 25 securities. The comparisons indicated that the levels of diversification achieved for high versus low beta portfolios for a given portfolio size were significantly different as a significantly larger number of

[7] Vasicek's model is an application of Bayes' theory and for this reason is also called the Bayesian model.

securities are required in a high beta portfolio in order to achieve approximately the same level of diversification as with a low beta portfolio.

E.g. In order to achieve the level of diversification reached by a low beta portfolio of 3 (or 4) securities, a high beta portfolio of 17 (24 in the second case) securities is required.

Blume (1975), *Betas and their regression tendencies.*

In this article, Blume moves further the issues of his previous work relative with the consistent tendency for a portfolio with either an extremely low or high estimated beta in one period, to have a less extreme beta as estimated in the next one. In other words, the tendency of the estimated betas to regress towards the overall mean, i.e. one.

Here, the author **presents evidence of this tendency, while trying to detect the possible explanations for this phenomenon**. The first, somehow unclear, explanation is the existence of unstated economic or behavioural reasons, which causes this tendency. Another more rational explanation is that new projects taken on by firms tend to have less extreme risk characteristics than existing projects as a (possible) result of management decision or do limitations on the availability of profitable projects of extreme risk tending to cause the riskiness of firms to regress towards one over time.

An overall conclusion is drawn by realizing that there are real non-stationarities in the underlying values of beta and that the phenomenon of “order bias” although it exists, it is not of major importance.

Klemkovsky and Martin (1975), *The Adjustment of Beta Forecasts.*

Klemkovsky and Martin’s work aimed to investigate the source of forecast errors of extrapolated beta coefficients (i.e. non-stationarity etc.) and three adaptive procedures were recommended by others for improving beta forecasts.

For the first aim (i.e. investigate the sources of prediction errors), he examines the case of Mean Square Forecast Error (MSE) which can be originally presented as follows:

$$MSE = \frac{1}{m}\sum_{j=1}^{m}\left(A_j - P_j\right)^2 \qquad \text{Eq.1}$$

Where: "m" is the number of predictions contained in the forecast, P_j is the prediction of the beta coefficient of security "j" (i.e. the computed beta for the current period used as the predictor of beta for the subsequent period) and A_j is the estimated beta coefficient of security "j" (i.e. the corresponding estimated beta for the subsequent period).

Moreover it can be partitioned into three components of forecast error by the formula:

$$MSE = \left(\overline{A} - \overline{P}\right)^2 + \left(1 - b_1\right)^2 S_p{}^2 + \left(1 - r_{AP}{}^2\right) S_A{}^2 \qquad \text{Eq.2}$$

Where: $\overline{A}$ and $\overline{P}$ are the means of the realizations and predictions respectively, b_1 is the slope coefficient of the regression of A on P, $S_p{}^2$ and $S_A{}^2$ are the sample variances in P and A respectively and $r_{AP}{}^2$ is the coefficient of determination for P and A.

The important thing to note here is that the first term of Eq.2 represents *bias*, while the second represents *inefficiency* and the final one stands as the *random disturbance component of MSE.*

Bias in a forecast indicates that the average prediction was either over or under the average realization, while inefficiency represents a tendency for the prediction errors to be positive at low values of P_j and negative at high values of P_j as measured in Eq.1. Recall that Blume and Levy's observation that beta extrapolations have a tendency to regress towards the mean was evidence of inefficiency in the forecasts. Finally, the third component of Eq.2 is the random disturbance element which contains those forecast errors which are not related to the value of the predictor P_j , or the predicted A_j.

As the results showed, there was a considerable variation in total MSE as well as for its individual components for the different forecasts. **The largest component of MSE's variation was the random error**, with inefficiency component following, while the bias component was almost negligible. **As the portfolio size was increasing, the total MSE was systematically reduced**, mostly as a result of the random error component as the bias and inefficiency components remained virtually unchanged.

In the next section the authors attempted to correct for inefficiency in beta forecasts by adjusting computed beta coefficients, according to Blume's adjustment technique, the Vasicek's one and the technique of Merrill Lynch, Pierce, Fenner & Smith Inc. (MLPFS).

In the reported results all of the 3 adjustment techniques consistently improved upon the unadjusted forecasts as denoted by the reduction in MSE and in the 3 parts of it, **mostly in the inefficiency component**. Amongst the periods 2, 3 and 4, the MLPFS technique was the most successful in period 2, while the Bayesian one achieved the greatest reduction in total MSE in the subsequent periods 3 and 4.

The authors conclude that the accuracy of the simple no-change extrapolative beta forecast can be improved, by using a combination of the Bayesian adjustment technique and a reasonable large portfolio size.

Scholes and Williams (1977), *Estimating betas from nonsynchronous data.*

Scholes and Williams presented a fundamental work for dealing with the problem of non-synchronous data and estimating beta coefficients under such conditions. Especially with the use of daily data the econometric problem of the market model appears more severe as many securities listed on organized exchanges are traded only infrequently, with few securities so actively traded that prices are recorded almost continuously. Thus the OLS estimators for both alphas and betas for almost all securities are biased and inconsistent.

The authors construct computationally convenient, consistent estimators for coefficients in the market model. The sum of betas estimated by regressing the return on the security against returns on the market from the previous, current and subsequent periods is divided by one plus twice the estimated autocorrelation coefficient for the market index, according to the following formula:

$$b_i = \frac{b_i^{-1} + b_i^{0} + b_i^{+1}}{1 + 2 r_m}$$

Where:

b_i^{-1} = The beta estimated with a regression of security returns on market returns for day *t-1*.

b_i^{0} = The beta estimated with synchronous observations.

b_i^{+1} = The beta estimated with a regression of security returns on market returns for day *t+1*.

r_m = The market return autocorrelation coefficient.

And alpha is given by:

$$a_i = \frac{1}{T-2}\sum_{t=2}^{T-1} r_{it} - b_i \frac{1}{T-2}\sum_{t=2}^{T-1} r_{mt}$$

In the following, the above estimators were applied to daily returns from all stocks listed on the New York and American Stock Exchanges between January 1963 through 1975, and by forming 5 portfolios with the first one consisting of the 20% of securities with the lowest trading volume, portfolio 2 with the next 20%, etc.

According to the results, the portfolio of the securities trading at the lowest levels of volume (i.e. portfolio 1) generates consistent estimates of beta which are uniformly larger than the corresponding least squares estimators of beta. This discrepancy is reduced for portfolio 3 and finally the inequality is reversed for the portfolio 5 consisting of the securities trading at the highest levels of volume. Thus we conclude that the result holds if the value-weighted market portfolio is heavily weighted with securities trading on average relatively frequently. In such a case a portfolio has an OLSE for beta asymptotically biased upward.

It is important to note that the relationship between the consistent estimator and the OLSE for alphas couldn't be verified as the standard errors from the results were too large.

Dimson, (1979), "*Risk measurement when shares are subject to infrequent trading.*"

Dimson provided a fundamental, for its time, research, in which he investigated a method for estimating beta coefficients in the case of shares characterized by thin trading.

He criticized earlier methods for dealing with the problem such as the method of lagged market returns being used as additional independent variables in their market model regressions, the method of calculating the returns on a trade-to-trade basis and regressing them on market movements calculated over precisely the same trade-to-trade time intervals and finally the Scholes and Williams method which combined the above ideas and used non-synchronous plus synchronous market returns as explanatory variables for trade-to-trade returns.

His argument against each one is the following:

The first method can only be justified if the constituents of the market index do not suffer from more than a negligible amount of non-trading.

The second one requires each share price to be labelled with a transaction date and needs frequent recordings of market index, having negligible non-trading.

Finally the S&M proposition flaws in that it is unable to make use of share prices which are not preceded or followed by a trade in an immediately adjacent time period. Thus, a return is calculated and used only if a transaction is known to have occurred in consecutive time periods and the market index is defined as the mean of all such returns. Under this definition of the index, simple regression overstates the beta of share which are traded as frequently as the market and thus shares which trade infrequently or very frequently tend to have their risk underestimated.

Dimson's proposal is a development of the lagged market returns approach, overcoming drawbacks such as the above mentioned. According to him, the systematic risk estimate can be obtained by aggregating the coefficient of a multiple regression. In his model the market returns which may be synchronous (R_{Mt}), advanced (R_{Mt+k}) or lagged (R_{Mt-k}), constitute the explanatory variables. In this case a consistent estimator of beta is obtained by the formulas:

$$R_{jt} = a_{jt} + \sum_{k=-N}^{k=N} b_{jk} R_{Mt-k} + e_{jt}$$

$$b_j^* = \sum_{k=-N}^{k=N} b_{jk}$$

Nevertheless, we are not going to present it further, because as we will see later, an article of Fowler and Rorke[8] shows that Dimson's procedure is incorrect and cannot generally be expected to yield consistent beta estimates and it is proven generally to be inferior compared to the Scholes and Williams' method.

Eubank and Zumwalt (1977), *An analysis of the forecast error impact of alternative beta risk adjustment techniques and risk classes.*

Eubank and Zumwalt performed an analytical empirical examination of the relationships among the stability of security and portfolio betas, by testing beta adjustment techniques, beta risk classes and the length of the sample periods used to calculate betas.

More specifically, they tested the adjustment techniques of Blume and Vasicek and one unadjusted (naïve) technique. In order to examine the relationship between different risk classes and the mean squared error and its components, the securities and portfolios for each of the different estimation-prediction periods pairs (12 months, 60 months, 120 months) were ranked in ascending order in period *t* and divided into quintiles (lowest, middle and highest). They performed the tests for individual securities as long as for portfolios of several sizes (i.e. number of securities included).

According to the results, **beta adjustment techniques are more useful for reducing the forecast error associated with higher or lower betas, but they are of limited value for betas near the mean of 1**. The beta adjustment techniques are also more useful in reducing the forecast error for shorter estimation and prediction periods. In addition the MSE was decreasing as we move from single securities to increasing portfolio sizes. In comparing the two adjustment techniques, Blume's model generally outperforms the Vasicek's one.

Their research examines similar issues to those examined by the working paper of Klemkovsky and Martin (1975). Eubank and Zumwalt's result are consistent with Klemkovsky and Martin (1975), on the field of decreasing as a result of increasing portfolio size, but they contradict on the comparing of Blume's and

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[8] Fowler, D.J. & Rorke, H.C (1983) "*Risk measurement when shares are subject to infrequent trading*", *Journal of Finance,* 12, August, pp.279-283.

Vasicek’s techniques. Klemkovsky and Martin (1975) showed a superiority of the Vasicek’s technique against the Blume’s one, while Eubank and Zumwalt showed the opposite.

Fowler and Rorke (1982), “*Risk measurement when shares are subject to infrequent trading”.*

The purpose of this article is to examine the methods of Scholes and Williams (1977) and Dimson (1979) for calculating consistent beta estimates in the case of thin trading. The authors demonstrate that Dimson’s estimator is not specified correctly and thus it is not consistent the Scholes and Williams’ one. Nevertheless, they provide a variant of Dimson’s procedure which can yield results identical to the Scholes and Williams’ and therefore being correct.

First of all, the authors demonstrate the initial forms of Dimson’s procedure and the S & M’s one. But S & M’s method in its original form applies to securities which do not miss an observation between the times “t-1” and “t+1”. Thus the authors extend the technique so as to compute a consisted estimate of beta using two period returns instead of a single period. Thus they are leaded (by proving it) to the following extended Scholes and Williams estimator:

$$p\lim \breve{b}_i = \frac{b_i^{-2} + b_i^{-1} + b_i^{0} + b_i^{+1} + b_i^{+2}}{1 + 2r_1 + 2r_2}$$

Where: r_2 is the 2nd order serial correlation coefficient (i.e. correlation coefficient between the returns of the market index at time t (Rm_t) and the returns at time t-2 (Rm_{t-2}), while the -2 and +2 superscripts of betas imply a lead and lag of 2 respectively.

Obviously the above equation makes better use of the available information than the initial one[9], in the case when a security skips price observations because all the data can be used in the process. Moreover this procedure can be generalized in the case of securities which skip two or more consecutive price observations.

For the same case of securities skipping single orice observations, the initial beta estimators of Dimson, given by the equations:

[9] See the presentation of the article: Scholes and Williams (1977), *Estimating betas from nonsynchronous data.*

$$R_{jt} = a_j + \sum_{k=-m}^{m} b_{j+k} R_{It+k} + m_{jt} \qquad \text{Eq.1}$$

$$p \lim \hat{b}_j = \sum_{k=-m}^{+m} b_{j+k} \qquad \text{Eq.2}$$

are led to the following transformed model:

$$p \lim \hat{b}_j = \frac{(1 + r_1 + r_2)}{(1 + 2r_1 + 2r_2)} b_{j+2} + \frac{(1 + 2r_1 + r_2)}{(1 + 2r_1 + 2r_2)} b_{j+1} + b_{j0} + \frac{(1 + 2r_1 + r_2)}{(1 + 2r_1 + 2r_2)} b_{j-1} +$$

$$+ \frac{(1 + r_1 + r_2)}{(1 + 2r_1 + 2r_2)} b_{j-2} \qquad \text{Eq.3}$$

The equation 3 clearly demonstrates that the original estimator of Dimson (Eq.2) is inconsistent with the S & M's and thus incorrect, as it is required a weighted rather than an unweighted sum of the slope coefficients in order to obtain a consistent beta estimate. However, eq.3 presents a corrected method for Dimson's estimator, which is quite operational as the coefficients have to be weighted by functions of the observable serial correlation coefficients for the index.

Finally, the authors conclude with the question if under this modification Dimson's procedure is more economical than the S & M's one. In the mentioned example with the 2 leads and the 2 lags, the former only requires one multiple regression per security and two for the index, while the latter requires five simple regressions for each security and two for the index. The question which arises therefore is whether one multiple regression is more expensive than several single regressions.

Dimson and Marsh (1983), *"The Stability of UK Risk Measures and the Problem of Thin Trading"*.

In this paper, the inefficiency of the risk measuring estimators and their stability is examined under the conditions of a thin market. It is analytically shown that the conventional approaches which have already been used in previous studies can lead to serious overestimates of the stability of the risk measures, having as a source of the problem not the use of the correlation coefficient as measure of evaluation, but its derivation from beta estimates which are biased. In the next, UK data is used in order to demonstrate practically the nature of this problem. Nevertheless, by using an estimation method (a robust form of the trade-to-trade method designed to overcome thin trading bias, they present reliable evidence on the stability of UK betas. Beta estimates are found to be moderately stable for individual shares and extremely stable for portfolios. The quality of these estimates can be improved by extending the estimation period and by making appropriate adjustments for regression bias.

Brown and Warner (1984), "*Using daily stock returns*".

This working paper examines the properties of daily stock returns and how the particular characteristics of these data affect the several event study methodologies for assessing the share price impact of firm-specific events.

Generally daily data presents difficulties for the event studies, mainly because of the complications caused by the phenomenon of non-synchronous trading which appears to be extremely severe when we use daily data.

Nevertheless, standard procedures are typically well specified even when the special daily data characteristics are ignored. However, the recognition of autocorrelation in daily excess returns and changes in their variance conditional on an event can sometimes be advantageous. Moreover, tests ignoring cross-sectional dependence can be well specified and have higher power than tests which account for potential dependence.

More analytically, by providing relative results in the paper, the authors indicate that the failure to take into account non-synchronous trading in estimating market model coefficients does not result in misspecification of event study methodologies using the OLS market model.

The major reason for this is that by construction OLS residuals for a security sum to zero in the estimation period so that a bias in the estimate of "beta" is compensated for by a bias in "alpha".

The authors also provide a compare of the results by using the classical OLS procedure with the outcomes of the Scholes & Williams and the Dimson's one and prove that the latter two alternative methodologies aiming to deal with the thin-trading problem *"convey no clear-cut benefit in an event study"*. Thus they suggest that **it is**

of no interest to investigate alternative procedures for market model parameter estimation.

Hawawini, Michel and Corhay (1985), “*New evidence on Beta Stationarity and Forecast for Belgian common stocks*”.

This work is an application, in the Belgian market, of the 3 fundamental techniques for adjusting the historical estimates of beta in order to improve its forecasting ability. These adjustment techniques are: the method of Blume (1971), the procedure of Vasicek (Bayesian) (1973), and the method proposed by the brokerage firm of Merrill, Lynch, Pierce, Fenner and Smith (MLPFS). In addition they use as a fourth estimator the unadjusted method of using the preceding period’s beta as a estimator for the next one. Thus the objective is to practically evaluate the predictive ability of the four alternative beta forecasts according to each one of the 4 above techniques.

They used as a data sample 170 securities of the Brussels Stock Exchange which were traded continuously from December 1966 to December 1983. By averaging the estimates of correlation coefficients and Mean Square forecasting Errors (MSE) over common sets of subperiods (2 and 3), they produced correlation coefficients and MSEs for each method.

From the results, the following conclusions are drawn:

- The correlation coefficients were substantially weaker than those reported in earlier works on the Belgian stock market by Hawawini and Michel (1978, 1979) and by Fabry and Van Grembergen (1978). It is important note that these earlier works had used samples of 30 and 46 common stocks respectively and thus we can attribute the earlier evidence of stronger stationarity to the small and biased samples used and moreover extract a relative general conclusion.
- The value of the correlation coefficient according to the Bayes-adjusted forecasts was higher than that of the unadjusted one while the latter resulted the same values with the Blume’s method and the MLPFS’ one.
- Finally, the MSE were significantly reduced by using the methods of adjusted beta forecasts against the classical one (unadjusted), while none of the 3 former ones exhibits clear superiority against the others. Moreover the

reduction in the MSE appeared to be mostly attributed to the inefficiency component.

Continuing, the authors estimated correlation coefficients and MSEs for portfolios of varying size, constructed by ranking individual securities' betas in decreasing order of value and assigning the first *n*-securities to the first portfolio of size *n* and so on until every security of the sample had been assigned to a portfolio. In this case also, relative conclusions are extracted:

- As the portfolio size increases, the correlation coefficients also rise, while the total MSEs fall. We have to note here that this verifies the results of Klemkovsky and Martin (1975)[10] that draw the same results from their work in the New York Stock Exchange.
- Most of the reduction in the MSEs is caused by the random error component of total MSEs.
- The Bayesian method shows a forecasting superiority against the others.

Berglund. Liljeblom and Löflund (1985), "*Estimating Betas on Daily Data for a small stock market*".

Here we have another application of the several market risk (beta) measures computed on daily data for the case of a thin security market (as the previous one) just as the Helsinki Stock Exchange in Finland. The authors start from the findings of Dimson and Marsh (1983) that betas for small markets appear to be at least as stable as betas estimated in the NYSE data, although the opposite should be expected as a result of the thin trading that the small markets exhibit. In fact this relative stability is indeed caused as a result of the thin trading, because differences in trading frequency between stocks usually are rather persistent through time, causing approximately the same bias to appear in betas for consecutive time periods. Thus the exaggerated impression of stability in the true beta for individual stocks arises.

[10] Klemkovsky, R. & Martin, J. (1975) "*The adjustment of beta forecasts*", *Journal of Finance*, 30, September, pp.1123-1128.

Dimson's proposal for using trade-to-trade betas (i.e. monthly betas estimated exclusively on the prices for actual transactions), although seems to be superior than the other procedures such as his initial proposition, the Scholes and Williams (1977) method and the generalized version of the latter one by Cohen, Hawawini, Mayer, Schwartz and Whitcomb (1983), flaws in that it presupposes that the underlying, sometimes unobservable returns on individual stocks are serially uncorrelated and perfectly synchronized, as we would expect on an informational efficient market. Thus trade-to-trade price changes are supposed to be serially uncorrelated and in addition the market return should also be serially uncorrelated.

However, the argument of this paper is that for small markets the assumption of serial independence seems to be too stringent. Especially in the Helsinki Stock Exchange (HeSE), previous researches [Berglund, Wahlroos, Örnmark (1983)] have shown that daily returns for individual stocks are clearly serially dependent, while this serial dependence is also reflected in the market returns of the HeSE. Moreover the fact that several stocks are traded less frequently than once a day and the existence of non-synchronous price movements not directly related to infrequent trading causes additional market correlation on the HeSE [Berglund, Liljeblom (1986)].

As a consequence the exclusive use of trade-to- trade returns is only likely to solve part of the problems caused by thin trading in beta estimation on a market like the HeSE. In fact it is conceivable that none of the proposed methods for beta estimation as such will prove satisfactory and that ideally some combination of these methods should be used. However, a great deal of care should be applied when such a combination is selected to prevent the introduction of additional complexity not matched by a corresponding increase in accuracy.

After estimating MSEs for several "corrective for thin-trading" beta estimation methods the authors conclude according to the results that none of the correction methods produces much improvement compared to OLS betas.

Diacogiannis, (1989), "*Forecating Stock Betas: Evidence For The London Stock Exchange.*"

Diacogiannis performed a research examining similar issues with those of Klemkovsky & Martin (1975), and Eubank & Zumwalt (1979). He tested an unadjusted technique with the approaches of Blume, Vasicek and the "Merril Lynch, Piece, Fenner and Smith" method (MLPFS). The latter one forecasts beta by employing the following equation:

$$b_{ip,3} = 1 + k_{12}\left(b_{ie,2} - 1\right)$$

Where:

k_{12} = The slope of the regression between the estimated beta over the first and the second subperiod.

He performed the tests for individual securities and also for different size portfolios, constructed by listing 200 securities of the London Stock Exchange in alphabetical order and assigning the first N-securities to the first portfolio of size N, the second N-securities to the second portfolio of size N, etc. He used a total 15-year sample period divided into three consecutive subperiods of equal length (i.e. 60 monthly observations each).

In addition, he estimated the MSEs for alternative risk classes, by ordering the betas of the first and the third subperiod in accordance with the size of the second period betas. The 200 betas of each subperiod were then divided into quintiles and the MSEs were estimated for the lowest, middle and highest quintiles.

According to the findings, beta adjustment techniques provide a better forecast for the systematic risk of individual securities than the unadjusted prediction method. Moreover, beta forecasts can be improved when securities are grouped into portfolios and that the improvement is greater as the portfolio size is increased. Furthermore, the results indicate that beta adjustment techniques are very effective in reducing the forecast errors associated with higher or lower security betas, but less effective for betas near the mean of unity (i.e. 1). Finally, the compare of the three adjustment techniques indicated the superiority of the Vasicek's procedure, while the MLPFS underperforms the other two.

As we can observe, Diacogiannis' results are in accordance with the corresponding ones, deducted by Klemkovsky & Martin (1975), and Eubank & Zumwalt (1979), with only exception that Eubank & Zumwalt (1979) found superiority of the Blume's technique over the Vasicek's, while Diacogiannis and Eubank & Zumwalt (1979) found the opposite.

Handa, Kothari and Wasley (1989), "*The relation between the return interval and betas*".

This paper examines the sensitivity of the **size effect** to the **return measurement interval** (daily, monthly, or longer) used to estimate the beta coefficient of a stock (i.e. beta). By analyzing systematic risk as a function of returns measured over varying intervals, they find that **a security's beta is sensitive to the return interval** used to estimate it, mostly as a result of the fact that an asset return's covariance with the market return and the market return's variance may not change proportionately as the return interval is varied. More specifically they found that **betas of securities riskier than the market increase with the return interval, while the betas of securities which are less risky than the market decrease with the return interval**.

The results stemming from regressions using just one explanatory variable and for different time intervals show that the standard error of beta estimates increases as the return interval is lengthened, thus indicating an as less as possible return interval as identical. This seems rational as a result of the fact that betas estimate during longer interval returns lack statistical precision and thus making them less able to explain return variation.

On the other hand by using the Fama-Macbeth type second-pass cross-sectional regressions, with monthly and annual beta serving as explanatory variables in first place and when moving further adding to the previous two the firm size also as an explanatory variable, only the coefficient of annual beta is significantly positive. Surprisingly, annual betas are incrementally significant notwithstanding their lesser statistical precision resulting from the use of fewer (annual) return observations to estimate them.

Corhay, (1991), "*The intervalling effect bias in beta: A note.*"

Corhay presents another research on the **intervalling effect** (i.e. the sensitivity of a security to the length of the differencing interval used to measure the returns) on estimated betas. The work is undertaken by using as a data stream the daily returns of 250 domestic securities traded on the spot market of the Brussels Stock Exchange (BSE). The total 9-tear period between January 1977 to December 1985 is divided into three-year subperiods of 738 (1977 to 1979), 735 (1980 to 1982) and 740 daily returns (1983 to 1985).

In order to examine the speed of convergence of the beta coefficient of each security *i* when the differencing interval is lengthened, the beta is estimated for a finite set of differencing interval lengths L, according to the equation:

$$R_{iLt} = \hat{a}_{iL} + \hat{b}_{iL} R_{mLt} + \hat{e}_{iLt} \quad \text{for } L = 1,\dots,30 \text{ and } t = 1,\dots,T$$

Where:

R_{iLt} : The returns of security *i*

R_{mLt} : The returns of the market index.

Both of the above were measured over a differencing interval of L days, L varying from one to thirty days.

Following to this, the average beta $\bar{\hat{b}}_{iL}$ as well as the standard deviation $s\left(\hat{b}_{iL}\right)$ of the betas are then calculated, according to the following:

$$\bar{\hat{b}}_{iL} = \frac{\sum_{n=1}^{L} \hat{b}_{iLn}}{L} \qquad s\left(\hat{b}_{iL}\right) = \sqrt{\sum_{n=1}^{L} \frac{\left(\hat{b}_{iLn} - \bar{\hat{b}}_{iL}\right)^2}{L}}$$

Then the speed of convergence of the betas to their asymptotic value is examined. The results are presented for 10 portfolios of with the first one including the 17 stocks with the higher market value while the last one (i.e. number 10) includes the 16 stocks with the lower one. In addition we see a presentation of the results for the individual securities of the portfolios 1 and 10.

From the results, we can observe that there is an intervalling effect for the average betas of the ten size-portfolios, which is quite large for small differencing intervals and it tends to decrease when it is lengthened.

In addition the direction of the intervalling effect is negative for the first portfolio, composed of the largest securities, whereas it is on the average positive for the other nine.

Thirdly, its magnitude is inversely related to the market value of the firms.

Finally, a look at the individual beta coefficients reveals that there are more or less two or three very large securities of the first portfolio having an upward bias.

Thus, only *very* large firms exhibit a slight upward bias whereas all the others, especially the small firms, have a downward bias.

Karathanasis & Philipas (1994), "*Validity tests of the assumptions of the market model in the Athens Stock Exchange*".

Karathanasis and Philipas, by using the 22 most actively traded stocks of the Athens Stock Exchange (ASE) for the period 1/1/1988-31/12/1991, tested the major assumptions of the market model concerning the behaviour of the stochastic/disturbance term U_{it}, which are the following:

- The expected value of the stochastic term U_{it} equals zero.

$$E(U_{it}) = 0 \qquad \forall \ t$$

- There is No-Autocorrelation between the residuals.

$$Cov(U_{it}, U_{i,t+k}) = 0 \qquad \forall \ k \neq 0$$

- The return of the market R_{mt} is independent from the disturbance term U_{it}.

$$Cov(U_{it}, R_{mt}) = 0$$

- The Variance of the residuals is constant (Homoskedasticity).

$$Var(U_{it}) = s_t^2$$

Only if the above assumptions hold, the OLS estimators are unbiased and have the less possible variance amongst all of the linear and unbiased estimators. On the other hand, the violation of those assumptions causes serious problems of credibility in the value of the beta coefficient.

The authors performed the following tests:

- Normality test of the residuals by using the Jarque-Bera criterion.
- Test for the violation of the independence of the stochastic term by using the criterias: Durbin-Watson, Breusch-Godfrey and Box-Pierce.
- Tests for the violation of the Homoskedasticity assumption by using the White's criterion.
- Tests for the existence of autocorrelation under the condition of Heteroskedasticity, by using the ARCH criterion in several forms.
- Tests of specification for the model by using the Ramsey (1969) criterion.

- Tests of stability along time for the model by using the criterias F and LR (Likelihood Ratio).

According to the results there are serious violations of the assumptions of the OLS model for all of the tests (except in the case of using the Box-Pierce criterion) in 5% and 1% levels of significance, for several companies. Thus, bearing in mind, that the authors have chosen the 22 most actively-traded companies, they conclude that the classical OLS method is insufficient for the estimation of the systematic risk of stocks traded in the Athens Stock Exchange.

Brailsford and Joseph (1997), *"The impact of the return interval on the estimation of systematic risk".*

Another research relative to the **interval effect** we have by Brailsford and Joseph who document the impact of the effect in the Australian equity market, with the initial results indicating that **the beta estimates of high (low) capitalised firms fall (rise) as the return interval is lengthened**.

After that they test the model proposed by Hawawini (1983), which provides a prediction of the size and direction of change in the beta estimate as a result of changes in the return interval. In more details, the essence of the model of Hawawini is to first estimate a beta with returns measured over a short (one period) interval. An adjustment is then made based on the relative cross-correlation coefficients between returns on security *i* and the returns on the market index estimated on one period returns, referred to as the q_i ratio and on the cross-correlation coefficient between returns on the market index and itself (i.e. autocorrelation), referred to as the q_m ratio, to arrive at a beta estimate for a longer interval.

The Hawawini's model is described by the following formulas:

$$b_i(T) = b_i(1)\left[\frac{[T + (T-1)q_i]}{[T + (T-1)q_m]}\right] \qquad \text{Eq.1}$$

Where:

$$q_i = \left[\frac{r_{i,m+1} + r_{i,m-1}}{r_{i,m}}\right]$$

$$q_m = \left[\frac{r_{m,m+1} + r_{m,m-1}}{r_{m,m}} \right] = 2\,r_{m,m-1}$$

And (r_i, r_m) is the serial cross-correlation coefficient of returns on security *i* with the returns on the market index.

In order to predict the direction the change implied by the Eq.1 , we take the first differential with respect to T, that is, we measure the response of $b_i(T)$ to a small change in T. Thus the resulting differential equation is:

$$\frac{db_i(T)}{dT} = \frac{b_i(1)[q_i - q_m]}{[T + (T-1)q_m]^2} \qquad \text{Eq.2}$$

The above equation implies that the beta estimates will increase (decrease) as T is lengthened when the security's q_i ratio is greater (less) than the market q_m ratio.

It is important to note here that the Hawawini model is most powerfully tested by using a sample of thinly and frequently traded stocks and thus the sample is chosen to form two extreme beta portfolios of low and high capitalised firms (which proxy for thinly and frequently traded stocks).

According to the results of that working paper, the mean beta from the low-cap portfolio increases as the return interval lengthens, On the other hand, for the high-cap portfolio, the mean beta estimates decline as the return interval lengthens. These results support the claim of Cohen et al. (1980) that **thinly (frequently) traded stocks approach their true betas from below (above), implying that their OLS betas are under-estimated (over-estimated).**

Beer (1997), "*Estimation of risk on the Brussels stock exchange: Methodological issues and empirical results*".

This research makes an attempt to test the adjustment procedures designed by Vasicek (1973), Scholes & Williams (1977) and Dimson (1979) and to appraise their relative ability to forecast the beta parameter in a thin market such as the Brussels Stock Exchange (BSE). The results suggest that the simple **OLS technique may be the best method** to obtain estimates of the systematic risk **when dealing with a thin market** such as the BSE.

As we have already seen, Scholes & Williams tried to correct the observed trend of the beta estimates for securities trading infrequently to be biased downward, while beta estimates for securities trading very frequently are biased upwards.

A consistent estimator of beta according to Scholes & Williams can be obtained by regressing the return on the security against returns on the market from the previous, current and subsequent periods is divided by one plus twice the estimated autocorrelation coefficient for the market index, according to the following formula:

$$b_i = \frac{b_i^{-1} + b_i^{0} + b_i^{+1}}{1 + 2 r_m}$$

where:

b_i^{-1} = The beta estimated with a regression of security returns on market returns for day *t-1*.

b_i^{0} = The beta estimated with synchronous observations.

b_i^{+1} = The beta estimated with a regression of security returns on market returns for day *t+1*.

r_m = The market return autocorrelation coefficient.

And alpha is given by:

$$a_i = \frac{1}{T-2}\sum_{t=2}^{T-1} r_{it} - b_i \frac{1}{T-2}\sum_{t=2}^{T-1} r_{mt}$$

Moreover, according to Dimson (1979), the systematic risk estimate can be obtained by aggregating the coefficient of a multiple regression. In his model the market which may be synchronous (R_{Mt}), advanced (R_{Mt+k}) or lagged (R_{Mt-k}), constitute the explanatory variables. In this case a consistent estimator of beta is obtained by the formulas:

$$R_{jt} = a_{jt} + \sum_{k=-N}^{k=N} b_{jk} R_{Mt-k} + e_{jt}$$

$$b_j^* = \sum_{k=-N}^{k=N} b_{jk}$$

Finally, Cohen et al. (1983) demonstrated the notion that delays in the adjustment of a security price to a change in information cause cross-serial correlation in the security returns and autocorrelation in the market index returns. In addition, thinly traded securities' downward bias in betas increase for small differencing intervals. An enlargement in the differencing interval used to measure the return may lessen the adjustment delay so that beta estimates match asymptotically the true betas.

Thus Cohen et al. proposed the use of a three-pass regression to estimate the asymptotic value that the OLS beta approaches as the differencing interval is lengthened.

The first pass is a standard estimate of beta:

$$R_{jLt} = a_{jL}^1 + b_{jL}^1 R_{MLt}^1 + e_{jLt}^1$$

Where the returns are measured over a differencing interval of L days.

The second and third passes are obtained by computing the following two equations:

$$b_{jL}^1 = a_{jL}^2 + b_{jL}^2 L^{-n} + e_{jLt}$$

$$b_{jL}^2 = a^3 + b^3 LnV_j + e_j^3$$

Where:

Vj is the value of the shares outstanding and is used as an inverse empirical proxy for security *j*'s expected price adjustment delay.

It is important to note here that the procedures of Scholes and Williams and Cohen et al. are weighted while the Dimson's one is unweighted. The former two assume that the only problem to be solved is non-synchronous trading and that a transaction occurs in each measurement period. This hypothesis implies that any information lost due to an interval of non-trading will be observed in the next period. On the contrary, Cohen et al. claimed that this procedure is insuffiecient to capture the whole intervalling effect.

In order to perform the analysis, the author used daily data of the stocks of 181 companies traded without interruption during the whole period from January 1974 until December 1986 (i.e. 13 years). The securities were ranked by their market capitalization forming 10 groups with group 1 including securities having the largest capitalization, i.e. securities trading very frequently.

According to the results we see that there is actually dependence between the risk and the frequency of the transactions as the systematic risk estimates are greater than one for securities frequently traded, whereas these estimates decrease as securities are traded with less regularity. More importantly the proposed correcting procedures, although sophisticated they also provide biased results and thus do not improve the quality of the estimated betas. As a result **we judge as rational the decision of many researchers to use the simple OLS technique in order to obtain estimates of the systematic risk when dealing with a thin market.**

Chawla (2001), "*Testing the stability of Beta in the Indian Stock Market*".

Chawla in his paper tries to **examine the stability of the beta coefficient along time** by using data of the Indian stock market. He uses as a data sample the monthly returns of 36 stocks over a period of 4 years.

More specifically he tests the stability of beta according to the following two methods:

1. *By using time as a variable.*

First of all a variable namely tm_t is used as a separate explanatory variable in the classical OLS single index model where the time variable t takes a value of t=1 for the first period, t=2 for the second and so on. Thus the classical OLS model, after incorporating tm_t as a separate regressor takes the following form:

$$r_{j,t} = a + bm_t + c(tm_t) + v$$

The statistical significance of the coefficient c of the variable tm_t is tested by using the estimated *t-statistic*. If it is found significant at a rational level of significance, it indicates that the beta values are unstable over time.

2. *By using dummy variables to measure the change of the slope over time.*

This alternative method tests the stability of betas by using dummy variables for the slope coefficients according to the form of the following model:

$$r_{j,t} = c + dm_t + g_1 D_1 m_t + g_2 D_2 m_t + g_3 D_3 m_t + ... + v$$

Where:

D_1 = 1, if the data is for period April 1996 to March 1997

D_1 = 0, if otherwise

D_2 = 1, if the data is for period April 1997 to March 1998

D_2 = 0, if otherwise

D_3 = 1, if the data is for period April 1998 to March 1999

D_3 = 0, if otherwise

It is important to note here that because of the fact that we have 4 periods, we are going to use 3 dummy variables, as the inclusion of a 4^{th} dummy would lead to dummy variable trap. The 4^{th} period (i.e. 1999-2000) is treated as the base period.

The hypothesis of stability of betas is accepted if each of g_1, g_2 and g_3 is found to be statistically insignificant according to the corresponding t-statistic. In other words, the null hypothesis of the stability of betas is rejected if any one of the g s is statistically significant.

According to the results, in the first case where we use time as a variable the results indicate that the coefficient *c* is significant in 21 cases (i.e. 10, 9 and 2 times at 1%, 5% and 10% levels of significance respectively). Thus it is observed an overall tendency for accepting the (alternative) hypothesis that the beta coefficient is not stable over time.

On the other hand, according to the results of the second method using dummy variables to measure the change of the slope over time in 23 out of the total of 36 (i.e. almost 64%) cases the hypothesis of stability of the beta coefficient is rejected, thus confirming the results of the previous method.

Overall, in 20 companies out of the total of 36, the hypothesis of stability of beta is rejected according to both the methods.

3.2 Summary table of the analyzed articles.

Research (Year)	Task	Methodology	Results
Blume (1971)	Examine the empirical behaviour of betas over time. Correct this tendency.	Regressed the estimated values of beta in one period on the values estimated in a previous period and used this estimated relationship in order to modify the assessments of the future.	Betas change over time. The assessments adjusted for the historical rate of regression are more accurate than the unadjusted or naïve assessments.
Vasicek (1973)	Correct the tendency of betas towards unity over time.	Estimate beta as a weighted average between the overall mean (one) and the stock's historical beta. Bayes-Vasicek formula.	(Theoretical research)
Klemkovsky & Martin (1975)	Test the relationship between market and residual risk. Assess its significance on diversification.	Cross sectional regression of beta coefficients and residual variances.	Significant and positive association exists. A significantly larger number of securities are required in a high beta portfolio to achieve similar level o a diversification with a low beta portfolio.
Blume (1975)	Present evidence of the tendency of betas. Detect the possible explanations for this phenomenon.	Estimate betas for several portfolios of 100 securities, classified according to the individual betas of the securities.	**Companies of extreme risk (high or low) tend to have less extreme risk characteristics over time**. Possible explanation: New projects taken on by firms tend to have less extreme risk characteristics than existing projects as a result of management decision.
Klemkovsky & Martin (1975)	Investigate the source of error in the forecast of betas & compare the adjustment techniques of Blume, Vasicek and MLPFS.	Estimate MSE for each technique and partition it to its components.	The largest component of MSE's variation was the random error. As the portfolio size was increasing, the total MSE was systematically reduced. Vasiceks technique is superior. Blume's technique follows.
Scholes & Williams (1977)	Calculate consistent estimators of betas, under the conditions of thin-trading.	Formula using 3 betas. One synchronous, one lagged and one leaded.	The result holds if the value-weighted market portfolio is heavily weighted with securities trading on average relatively frequently. In such a case a portfolio has an OLSE for beta asymptotically biased upward.
Dimson (1979)	Calculate consistent estimators of betas, under the conditions of thin-trading.	The beta can be obtained by aggregating the coefficient of a multiple regression. The market returns which may be synchronous, advanced or lagged, constitute the explanatory variables.	Improved beta estimators.
Eubank & Zumwalt (1979)	Examination of the relationships among the stability of security	Use of the MSE in each case.	Beta adjustment techniques are more useful for reducing the forecast error associated with higher

	and portfolio betas, by testing beta adjustment techniques, beta risk classes and the length of the sample periods used to calculate betas.		or lower betas, but they are of limited value for betas near the mean of 1. The beta adjustment techniques are also more useful in reducing the forecast error for shorter estimation and prediction periods. MSE was decreasing as we move from single securities to increasing portfolio sizes. Blume's model generally outperforms the Vasicek's one.
Fowler & Rorke (1982)	Compare the Scholes & Williams' method with Dimson's.	Mathematical approach	Dimson's estimator is inconsistent with the S & M's and thus incorrect, as it is required a weighted rather than an unweighted sum of the slope coefficients in order to obtain a consistent beta estimate. However, a corrected method for Dimson's estimator can be estimated, which is quite operational as the coefficients have to be weighted by functions of the observable serial correlation coefficients for the index.
Dimson & Marsh (1983)	Examine the inefficiency of the risk measuring estimators and their stability under the conditions of a thin market.	Use as estimation method, a robust form of the trade-to-trade method designed to overcome thin trading bias.	Beta estimates are found to be moderately stable for individual shares and extremely stable for portfolios. The quality of these estimates can be improved by extending the estimation period and by making appropriate adjustments for regression bias.
Brown & Warner (1984)	Examine the properties of daily stock returns in the case of a thin-trading market.	Test the correcting procedures of Scholes & Williams and Dimson.	Both of the procedures convey no clear-cut benefit in an event study
Hawawini, Michel and Corhay (1985)	Examine the beta stationarity in the BSE[11].	Tested the MSEs according to the results of the methods of Blume, Vasicek and MLPFS.	Beta forecasts can be generally improved using an adjustment method. The improvement is higher for portfolios of increasing size.
Berglund, Liljeblom and Loflund (1985)	Properties of betas in a thin-trading market such as the HESE[12].	Estimate MSEs for several "corrective for thin-trading" beta estimation methods.	None of the correction methods produces much improvement compared to OLS betas.
Diacogiannis, (1989)	Find the optimum adjustment method and portfolio size for estimating betas.	Compare the results of the adjustment techniques of Blume, Vasicek and MLPFS for individual securities and for different size portfolios according to MSEs. Estimated the MSEs for alternative risk classes.	Beta forecasts can be improved when securities are grouped into portfolios and the improvement is greater as the portfolio size is increased. Beta adjustment techniques are very effective in reducing the forecast errors associated with higher or lower security betas, but less effective for betas near the mean of unity (i.e. 1). Vasicek's method is superior over

			the others.
Handa, Kothari and Wasley (1989)	Examine the sensitivity of the **size effect** to the **return measurement interval.**	Cross-sectional regressions, with monthly and annual beta serving as explanatory variables in first place and when moving further adding to the previous two the firm size also as an explanatory variable.	The size effect becomes statistically insignificant when risk is measured by betas estimated using annual returns.
Corhay, (1991)	Examine the speed of convergence of the beta coefficient of a security *i* when the **differencing interval** is lengthened.	Beta is estimated for a finite set of differencing interval lengths L.	The magnitude of the interval effect inversely related to the market value of the firms.
Karathanasis and Philipas (1994)	Validity tests on the assumptions of the market model in the Athens Stock Exchange.	Performing the tests by using several statistical criterias (i.e. White, Breusch-Godfrey, Jarque-Bera etc.).	There are serious violations of the assumptions of the OLS model. The classical OLS method is insufficient for the estimation of the systematic risk of stocks traded in the Athens Stock Exchange
Brailsford and Joseph (1997)	Impact of the **interval effect** in the Australian equity market	Test the model of Hawawini (1983), which provides a prediction of the size and direction of change in the beta estimate as a result of changes in the return interval.	The beta estimates of high (low) capitalized firms fall (rise) as the return interval is lengthened.
Beer (1997)	Test the adjustment procedures of Vasicek (1973), Scholes & Williams (1977) and Dimson (1979) and appraise their ability to forecast betas in a thin market such as the BSE[13].	Estimate betas according to the techniques tested and compare them with the OLS method's estimates.	The classical OLS technique remains the best method for the beta's estimation in a thin market.
Chawla (2001)	Examine the stability of the beta coefficient along time in the Indian stock market.	Use of two methods. Adding time as a variable in the OLS formula. Adding dummy variables in the OLS formula.	In 20 companies out of the total of 36, the hypothesis of stability of beta is rejected according to both the methods.

CHAPTER 4:

4.1 Data:

The data used for our research includes the daily (and in the Section B of the analysis monthly returns also) of the stocks of 83 companies of the Athens Stock Exchange (ASE) having continuously data during the 12-year period between 1-1-1994 to 31-12-2005. It is important to note that during the selection process for the stocks to be included in the sample, we rejected those stocks appearing an excessively large number of zero returns during the examined 12-year period. We are going to perform the analysis of the Section B twice by using **both daily and monthly data** (i.e. daily data for the first time, monthly for the second) in order to have comparable results between the two methods (i.e. of using daily or monthly data) and thus examine the trend of the “interval effect” in the ASE.

As a proxy of the market’s portfolio, we are going to use the General Market Index of the ASE, for the corresponding period. This index includes a total of 60 stocks traded in the ASE, and it weighted according to the stock exchange value of the stocks it includes (i.e. value-weighted index). The stocks included in the index are tested twice each year and its estimation is done at “real-time”.

It is important to note here that the General Market Index of the ASE does not satisfy the criteria of Roll for the portfolios used as a market proxy, but we consider it as the most appropriate for our research compared to all the rest available for the ASE.

Analytically, our sample includes the stocks of the following 83 companies (listed by alphabetical order):

1	A-B VASSILOPOULOS
2	AEGEK
3	AEOLIAN INVESTMENT FUND
4	ALLATINI
5	ALPHA BANK
6	ALPHA LEASING
7	ALUMINIUM OF GREECE
8	ATHENS MEDICAL
9	ATTICA HOLDINGS
10	BALKAN EXPORT
11	BANK OF ATTICA
12	BANK OF GREECE
13	BANK OF PIRAEUS
14	BENRUBI
15	BIOKARPET
16	BIOSSOL
17	CHATZIIOANNOY HDG.
18	COCA-COLA HLC.BT.
19	CROWN HELLAS CAN
20	CYCLON HELLAS
21	DELTA HOLDINGS
22	DIAS
23	EFG EUROBANK ERGASIAS
24	EGNATIA BANK
25	ELAIS-UNILEVER
26	ELFICO
27	ELMEC SPORT
28	ELTRAK
29	EMPORIKI BK.OF GREECE
30	EMPORIKOS DESMOS

31	ETMA RAYON
32	EUROHOLDINGS CAP & INV C
33	FANCO
34	FG EUROPE
35	FINTEXPORT
36	FLR MLS C SARANTOPOULOS
37	FOURLIS HOLDING
38	GEK GROUP OF COMPANIES
39	GENERAL COMMERCIAL & IND
40	GENERAL HELLENIC BANK
41	HELLENIC SUGAR IND.
42	HERACLES
43	HIPPOTOUR
44	INTERINVEST
45	INTRACOM
46	IONIAN HOTEL
47	J BOUTARIS & SON HLDG
48	KALPINIS SIMOS
49	KARELIA TOBACCO
50	KATSELIS SONS
51	KEKROPS
52	KERAMIA ALLATINI
53	KLONATEX GROUP OF COS
54	LAMPSA HOTEL
55	LEVEDERIS
56	LOULIS MILLS
57	METKA
58	MICHANIKI
59	MOUZAKIS
60	MULTIRAMA
61	NATIONAL BK.OF GREECE
62	NEXANS HELLAS

63	PARNASSOS ENTERPRISES
64	PETZETAKIS
65	PG NIKAS
66	PHOENIX METROLIFE
67	PIPE WORKS
68	PROODEFTIKI
69	REDS
70	RIDENCO
71	RILKEN
72	SANYO HELLAS
73	SATO
74	SELECTED TEXTILE
75	SHEET STEEL
76	SHELMAN
77	TITAN CEMENT
78	TRIA ALPHA
79	UNCLE STATHIS
80	VIOTER
81	VIS-CONTAINER
82	XYLEMBORIA
83	ZAMPA

The 83 companies of our sample can be considered as a representative sample of the ASE and the Greek market as they represent in total the following 25 different sectors of the ASE:

- Constructions
- Bank sector
- Insurance companies
- Financial leasing
- House agencies
- Participation companies
- Basic Metals
- Health
- Wholesale trade
- Metallic products
- Investment companies
- Chemicals
- Wood products
- Agricultural products
- Non metallic rocks-Cement
- Personal computer / Information systems
- Cables
- Retail trade
- Plastics
- Paper products
- Food
- Drink making
- Tobacco production & trade
- Hotels
- Textile mills

Normality test of the results:

In this section we are going to present the basic measures of descriptive statistics for the series of the returns of our stock sample. More analytical we are going to present for every series of returns the following:

- ***Mean***

Mean is the mean value of the returns of the examined stocks and denotes the average daily (or monthly[14]) return of each stock *i* during the examined period. It is estimated according to the formula:

$$\overline{X} = \frac{1}{n}\sum_{i=1}^{n} X_i$$

- ***Median***

Median is the middle price of a sample whose prices are classified according to increasing order. Median is a strong measure for estimating the centre of a distribution and it is less sensitive to the extreme values of the sample than the mean value.

- ***Standard Deviation (Std. Dev.)***

Standard Deviation is a measure of the dispersion of a distribution's prices around the mean value and is used in the portfolio theory, developed by Markowitz as a measure of the risk of a security. The greater the standard deviation of the returns of an asset, the greater the risk of this asset.

It is estimated according to the formula:

$$s = \sqrt{\frac{\sum_{i=1}^{n}\left(X_i - \overline{X}\right)^2}{N-1}}$$

- ***Skewness Coefficient***

The Skewness Coefficient is a measure of the asymmetry of a distribution around its mean value. Thus the skewness coefficient of a symmetrical distribution such as the Normal distribution gets the value of zero. A positive value of the Skewness coefficient means that the distribution shows a long right tail, while a negative value for the Skewness coefficient means that the distribution shows a long left tail.

- ***Kurtosis Coefficient***

The Kurtosis Coefficient measures the kurtosis of the distribution of our sample. The Kurtosis Coefficient of the Normal distribution gets the value of 3. If the Kurtosis Coefficient's value exceeds 3, then we say that our distribution is Leptokurtic. In the opposite case, where the Kurtosis Coefficient's value is less than 3, we say that our distribution is Platykurtic.

- ***Jarque-Bera statistic***

Jacque-Bera is a statistical test, used for examining the normality of the distribution of a sample. This statistical test measures the degree of deviation of Skewness and Kurtosis coefficients from the corresponding ones for the Normal distribution. The value of its distribution represents the probability of the statistical Jacque-Bera to exceed (in absolute terms) the observed value of the statistical measure under the Null Hypothesis of Normality. The statistical measure of the Jacque-Bera under the Null Hypothesis is distributed as X^2 distribution with 2 degrees of freedom. In order for our distribution to be normal, the value of the calculated probability must approach the unity (i.e. one). In other words, the probability value being printed in the last column of the table is the probability of being normal the distribution of the corresponding series, which we examine each time (e.g. If the probability value equals 0.35, this means that the probability of being normal the distribution of the series which we examine, equals 35%.

According to the results of **Table 1** (please refer to the Appendix section) we can draw the following conclusions:

- In terms of the mean value criterion, 32 out of the total 83 stocks of the sample (i.e. 38.5%) exhibit negative mean return. The highest mean daily return (0.00108 or 0.108%) during the 12-year period is given by the stock of the

"GEK Group Of Companies", while the smallest one (i.e. the most negative, -0.00090 or -0.09%) is appeared by the stock of the company "Fanco".

- The riskier stock in terms of standard deviation, belongs to the company "Ridenco" having a value equal to 0.0564, while the stock with the smallest figure belongs to the company "Elais-Unilever" and "Titan Cement" (i.e. 0.0199). It is important to note that the riskiness of the most of the stocks can be considered as relatively high.

- For the most of the stocks, the skewness coefficient is relatively high, thus indicating the existence of positive skewness and a right-tailed distribution in the most of the cases.

- For all of the stocks the kurtosis coefficient is greater than 3, thus indicating that the distributions of all of the stocks are Leptokurtic.

- For almost all of the stocks (except for the stock of the company "Biossol"), the probability of the Jarque-Bera statistic equals zero and thus confirming the non-normality of the distributions (i.e. Reject the Null Hypothesis of the normality of the distributions at any level of confidence).

4.2 Methodology:

First of all, we are going to estimate the daily (or monthly) periodical returns for each one of the 83 stocks of our sample according to the formula:

$$R_{it} = \ln\left(\frac{P_{it}}{P_{it-1}}\right)$$

Where: P_{it} : The closing price of the stock *i* at day (or month) *t*

P_{it-1} : The closing price of the stock *i* at day (or month) *t-1*

Correspondingly, the daily (or monthly) periodical returns for the general market index of the Athens Stock Exchange (ASE) are calculated according to the formula:

$$R_{mt} = \ln\left(\frac{P_{mt}}{P_{mt-1}}\right)$$

Where: P_{mt} : The closing price of the general market index of the ASE at day (or month) *t*.

P_{mt-1} : The closing price of the general market index of the ASE at day (or month) *t-1*

By using the above formulas, we calculate the daily (and monthly) returns for our total sample of the 83 companies of the ASE having continuously data during the 12-year period between 1-1-1994 to 31-12-2005. It is important to note here that returns which we used are capitalized and we have not included the possible distributed dividends. This is because the stocks of our sample appeared insufficient payment of dividend during the examined period. Moreover, according to the research of Sharpe and Cooper (1972), examining over 1500 stocks of the New York Stock Exchange (NYSE), they found that the correlation coefficient between the systematic risk coefficients estimated by using returns including the dividends and the systematic risk coefficients by using returns not including the dividends, was equal to 0.99. This can be interpreted as a sign that the 2 price totals of the systematic risk are almost perfectly correlated.

The research we are going to undertake is divided into the following two basic sections:

SECTION A

In *Section A* we are going to **examine the stability of the beta coefficient during time** according to the following two formulas, originally proposed by Chawla (2001):

3. ***By using time as a variable.***

First of all a variable namely tR_{mt} is used as a separate explanatory variable in the classical OLS single index model where the time variable *t* takes a value of t=1 for the first period, t=2 for the second and so on. In its original general form the model is:

$$R_{i,t} = a + bR_{mt} + c(tR_{mt}) + v$$

In our case our sample is going to be divided into 12 subperiods (one for each year) as we examine a 12-year sample. The classical OLS model, after incorporating Rm_t as a separate regressor takes the following form:

$$R_{i,t} = a + b_{it}R_{mt} + e_i$$

$$b_{it} = b + ct$$

$$R_{i,t} = a + bR_{mt} + c(tR_{mt}) + e_i \qquad \text{Eq.1}$$

Where:

t=1 if the data comes from the year 1994

t=2 if the data comes from the year 1995

t=3 if the data comes from the year 1996

t=4 if the data comes from the year 1997

t=5 if the data comes from the year 1998

t=6 if the data comes from the year 1999

t=7 if the data comes from the year 2000

t=8 if the data comes from the year 2001 t=9 if the data comes from the year 2002

t=10 if the data comes from the year 2003

t=11 if the data comes from the year 2004

t=12 if the data comes from the year 2005

The meaning which is attributed to the variable tRm_t is that there is an independent variation in the dependent variable which is represented by the returns of each stock and the coefficient *c* of this extra variable is a measure of this independent variation. In other words, we assume that the constant term of the model increases or decreases at a constant rate, but the coefficient of the independent variable remains constant. If, in addition, there is the information that the coefficient of the independent variable, varies independently during time, we introduce into the model the term tRm_t as an additional independent variable. The assumption of the independent variation of the coefficient (beta) of the variable Rm_t will be decided by the statistical significance test (t-test) of the coefficient *c* of the independent variable tRm_t. If the estimated *t-statistic* is found significant at a rational level of significance, it indicates that the beta values are unstable over time.

It is important to note that the interpretation of the coefficient *c* as a factor of increase does not applies in all of the cases. In certain of them, the coefficient *c* of the independent variable tRm_t does not express an independent variation of the independent variable, but rather the combined effect of certain coefficients which have been omitted from our model.

4. ***By using dummy variables to measure the change of the slope over time.***

This alternative method, tests the stability of betas by using dummy variables for the slope coefficients according to the form of the following model:

$$R_{i,t} = a + bR_{mt} + g_1 D_1 R_{mt} + g_2 D_2 R_{mt} + g_3 D_3 R_{mt} + \ldots + v \quad \text{Eq.2}$$

In our case the general model of the Eq.2 takes the following form:

$$R_{it} = a + b_i R_{mt} + b_1 D_1 R_{mt} + b_2 D_2 R_{mt} + b_3 D_3 R_{mt} + b_4 D_4 R_{mt} + b_5 D_5 R_{mt} + b_6 D_6 R_{mt} + b_7 D_7 R_{mt} + b_8 D_8 R_{mt} + b_9 D_9 R_{mt} + b_{10} D_{10} R_{mt} + b_{11} D_{11} R_{mt}$$

Where:

$D_1 = 1$, if the data comes from the year 1994

$D_1 = 0$, if otherwise

$D_2 = 1$, if the data comes from the year 1995

$D_2 = 0$, if otherwise

$D_3 = 1$, if the data comes from the year 1996

$D_3 = 0$, if otherwise

$D_4 = 1$, if the data comes from the year 1997

$D_4 = 0$, if otherwise

$D_5 = 1$, if the data comes from the year 1998

$D_5 = 0$, if otherwise

$D_6 = 1$, if the data comes from the year 1999

$D_6 = 0$, if otherwise

$D_7 = 1$, if the data comes from the year 2000

$D_7 = 0$, if otherwise

$D_8 = 1$, if the data comes from the year 2001

$D_8 = 0$, if otherwise

$D_9 = 1$, if the data comes from the year 2002

$D_9 = 0$, if otherwise

$D_{10} = 1$, if the data comes from the year 2003

$D_{10} = 0$, if otherwise

$D_{11} = 1$, if the data comes from the year 2004

$D_{11} = 0$, if otherwise

It is important to note here that because of the fact that we have 12 subperiods (12-year sample), we are going to use 11 dummy variables, as the inclusion of a 12th dummy would lead to dummy variable trap. The 12th period (i.e. 2005) is treated as the base period.

The hypothesis of stability of betas is accepted if each of $D_1, D_2, D_3, D_4, D_5, D_6, D_7, D_8, D_9, D_{10}$ and D_{11} is found to be statistically insignificant according to the corresponding t-statistic. In other words, the null hypothesis of the stability of betas is rejected if any one of the Ds is statistically significant.

<u>SECTION B</u>

In *Section B* we are going to attempt of finding the best possible method of **forecasting the coefficients of systematic risk, i.e. beta coefficients**, in a stock market such as the Athens Stock Exchange (ASE), which is strongly characterized by the effect of thin trading, which we have already discussed. Moreover as it is established and confirmed in SECTION A and according to a variety of working papers, the beta coefficients are not stable over time. This matter of fact makes the forecasting of the beta coefficients for a given period a difficult task to perform.

As we have already seen, the most of the previous researches on the issue such as, Klemkovsky and Martin (1975), Eubank and Zumwalt (1979), Hawawini, Michel and Corhay (1985) and Diacogiannis (1989) have established the superiority of two adjusted method techniques amongst all of the others. These techniques are the autoregressive non-weighted Blume's originally proposed by Blume (1971) in model and the autoregressive weighted Vasicek's model based on the findings of Bayes and proposed by Vasicek (1973).

A. <u>The Blume method</u>

According to Blume's method we initially estimate for each security or portfolio in the sample, the beta values of subperiods one and two, $b_{ie,1}$ and $b_{ie,2}$. Then we run the following cross-sectional regression:

$$\tilde{b}_{ie,2} = q_1 + q_2 \tilde{b}_{ie,1} + \tilde{u}_i$$

The estimated regression coefficients q_1 and q_2 are used to produce the predicted beta for the third subperiod as follows:

$$b_{ip,3} = \hat{q}_1 + \hat{q}_2 \tilde{b}_{ie,2}$$

B. <u>The Bayes-Vasicek method</u>

The method proposed by Vasicek (1973) forecasts the beta by using the following formula:

$$b_{ip,t} = \frac{\left(\dfrac{\bar{b}_{e,t-1}}{s^2_{e,t-1}}\right) + \left(\dfrac{b_{ie,t-1}}{s^2_{ie,t-1}}\right)}{\left(\dfrac{1}{s^2_{e,t-1}}\right) + \left(\dfrac{1}{s^2_{ie,t-1}}\right)}$$

Where:

t = 2, 3

$b_{ie,t-1}$ = The beta coefficient of the security or portfolio *i* estimated by using the market model for the subperiod t-1.

$s_{ie,t-1}$ = The standard error of $b_{ie,t-1}$.

$\bar{b}_{e,t-1}$ = The average of the cross-sectional beta estimates in period t-1.

$s_{e,t-1}$ = The standard deviation of the cross-sectional beta estimates in period t-1.

In order to perform the analysis according to the above two methods we are going to divide our 12 year daily data sample for 83 stocks into the following three 4-year periods.

I. <u>Period A</u> : 1-1-1994 up to 31-12-1997
II. <u>Period B</u> : 1-1-1998 up to 31-12-2001
III. <u>Period C</u> : 1-1-2002 up to 31-12-2005

Thus, for the Blume's model we are going to use the periods A & B (i.e. estimate the betas of each period by using the OLS method and then regress the betas of period B on those of period A) in order to forecast the betas for the period C. For the Vasicek's model we are going to estimate by the OLS method the betas for the period A and then by using the Vasicek's formula we will try to predict the betas for the period B. Similarly, we are going to estimate by the OLS method the betas for the period B and then by using the Bayesian formula we will try to predict the betas for the period C.

In each case, we are going to examine the forecasting ability of each method by using the Mean Square Error (MSE) between the estimated beta for the period C according to the OLS method and the predicted according to the Blume's method. Similarly, in the case of the Vasicek's method we are going to estimate the MSE between the estimated beta for the period B according to the OLS method and the predicted according to the Vasicek's method and the MSE between the estimated beta for the period C according to the OLS method and the predicted according to the Vasicek's method.

The MSE is given by the following expression:

$$MSE = \frac{1}{N}\sum_{i=1}^{N}\left(b_{ie} - b_{ip}\right)^{2}$$

Where:

N = The number of securities or portfolios in the sample.

b_{ie} = The estimated beta (according to the OLS method) for the security or portfolio *i*.

b_{ip} = The predicted beta (according to either Blume's either Vasicek's model) for the security or portfolio *i*.

As we have already said in the "DATA" section we are going to perform the analysis twice by using **both daily and monthly data** (i.e. daily data for the first time, monthly for the second) in order to have comparable results between the two methods (i.e. of using daily or monthly data) and thus examine the trend of the "interval effect" in the ASE.

In order to explore further the possibility of finding a substantially efficient method for estimating betas over time, we are going to re-perform all of the above analysis of SECTION 2, by re-estimating the betas, which we are going to use in the Blume's and the Vasicek's model as a base period, by using the Scholes and Williams (1977) method instead of the classical OLS. Thus, for the Blume's model we are going to use the periods A & B (i.e. estimate the betas of each period by using the S&W method and then regress the betas of period B on those of period A) in order to forecast the betas for the period C. For the Vasicek's model we are going to estimate by the S&W method the betas for the period A and then by using the Vasicek's formula we will try to predict the betas for the period B. Similarly, we are going to estimate by the S&W method the betas for the period B and then by using the Bayesian formula we will try to predict the betas for the period C.

This re-performance is going to be **undertaken only for the case of using daily data** because the use of a correcting procedure in the case of monthly data is considered as unnecessary according to Couto & Duque (2001) who after their research suggested that *"Although some stocks trade infrequently, when fortnightly or monthly data is used unobserved trades within these time ranges stop occurring. Stocks are sometimes infrequent but not so infrequent!"*.

The Scholes and Williams (1977) method aims to deal with the problem of thin trading which appears in a stock market such as the ASE which we examine. As we have already seen, Scholes & Williams tried to correct the observed trend of the beta estimates for securities trading infrequently to be biased downward, while beta estimates for securities trading very frequently are biased upwards.

A consistent estimator of beta according to Scholes & Williams can be obtained by regressing the return on the security against returns on the market from the previous, current and subsequent periods is divided by one plus twice the estimated autocorrelation coefficient for the market index, according to the following formula:

$$b_i = \frac{b_i^{-1} + b_i^{0} + b_i^{+1}}{1 + 2 r_m}$$

Where:

b_i^{-1} = The beta estimated with a regression of security returns on market returns for day *t-1*.

b_i^{0} = The beta estimated with synchronous observations.

b_i^{+1} = The beta estimated with a regression of security returns on market returns for day *t+1*.

r_m = The market return autocorrelation coefficient.

The Scholes & Williams' model is considered to be superior over other "correcting for the thin trading-bias" techniques such as Dimson's, according to many researches (i.e. Fowler & Rorke (1982)).

The point of all this is to see whether by employing the best of the "correcting for the thin trading-bias" techniques, may improve the results given by the Blume's and the Vasicek's methods and thus improve their forecasting ability.

4.3 Empirical Results:

Now, we are going to interpret the empirical results of the corresponding SECTIONS:

SECTION A

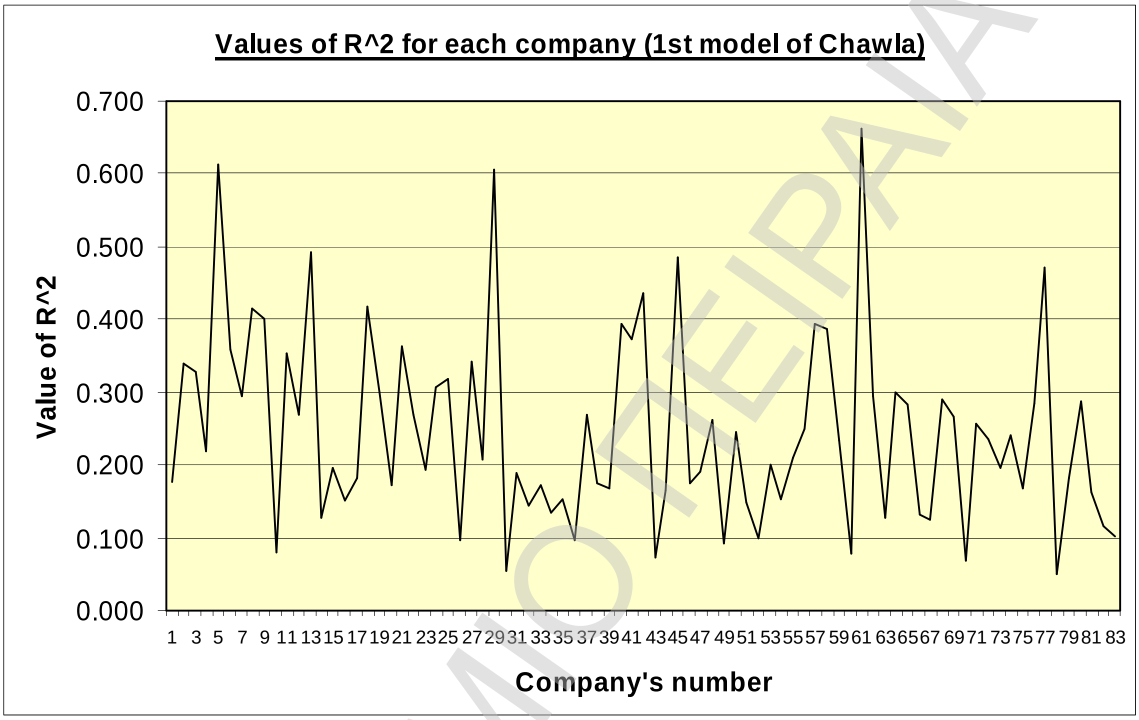
According to the results printed on **Table 2** (please refer to the Appendix section) of the first case where we use time as an additional variable, we can make the following observations.

- The value of the R^2, which is a measure of the goodness of fit of our regression varies from 0.050 to 0.663, thus exhibiting large variation. The average is equal to 0.247. In just 8 out of the 83 regressions its price exceeds 40%, while only for 3 exceeded 50%.

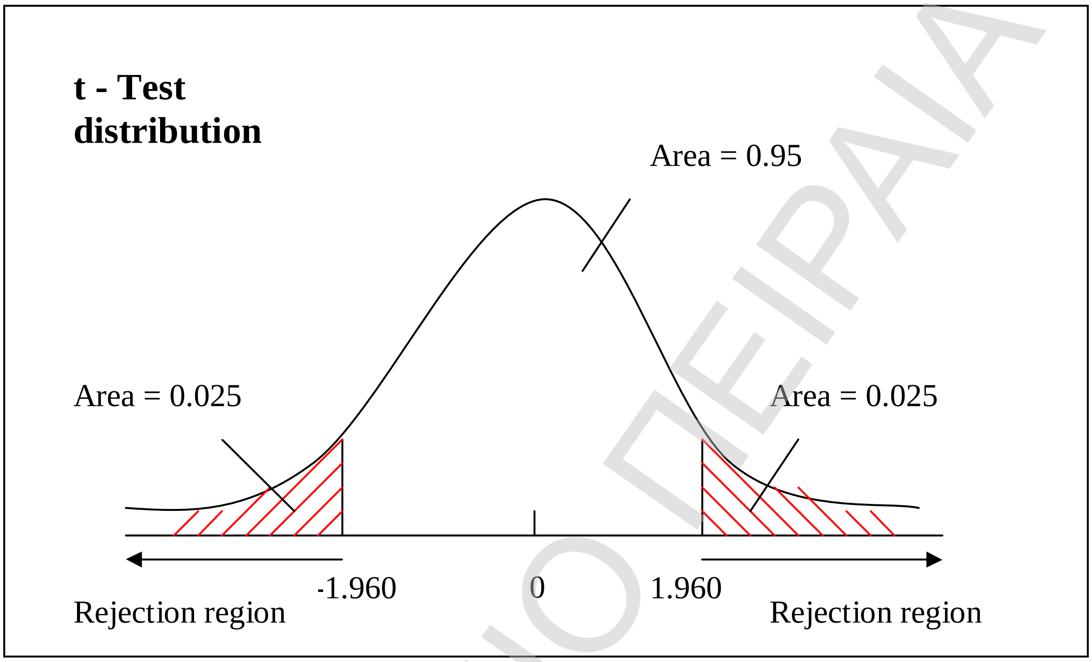
  More specifically the value of R^2 is greater than 40% for the stocks of the following 8 companies:

Name of the company	R^2
ALPHA BANK	0.614
BANK OF PIRAEUS	0.492
COCA-COLA HLC	0.418
EMPORIKI BK.OF GREECE	0.606
HERACLES	0.436
INTRACOM	0.487
NATIONAL BK.OF GREECE	0.663
TITAN CEMENT	0.470

In the following graph we can see the large variation of the values of R^2 for the regression in each company's stock.



- The **tabular t-value** from the t-distribution tables, in 5% level of significance and with *n-k-1 = 3130-2-1 = **3127*** (considered as infinity i.e. →∞) degrees of freedom, is equal to1.960.



The respective tabular t-values from the t-distribution tables, in 1% and 10% level of significance are 2.576 and 1.645 respectively.

Null Hypothesis: The examined coefficient (i.e. parameter estimate) is equal to zero (=0). In other words the corresponding variable is not significant in our model (i.e. it doesn't have significant effect on the estimation of the dependent variable).

Alternative Hypothesis: The examined coefficient is not equal to zero (≠0). (i.e. 2 tailed test). In other words the corresponding variable is significant in our model (i.e. it has significant effect on the estimation of the dependent variable).

The coefficient b of the variable Rm_t is found to be significant in **66** cases at the 1% level of significance, (**4**+66=70 cases in total) at the 5% and (**3**+70=73 cases in total) at the 10% level of significance. **We calculate the values "in total" because when a coefficient is significant at the 1% level of significance it will subsequently be significant at the highest levels of 5% and 10%.**

Thus only in 10 cases the coefficient is statistically insignificant at any of the three levels of significance.

Number of cases with significant t-ratios of the coefficient b of the variable Rm_t at each level of significance.	
Level of significance	**Number of cases with significant t-ratio**
1%	**66**
5%	(**4**+66=70 in total)
10%	(**3**+70=73 in total)

The coefficient c of the variable tRm_t is found to be significant in **60** cases at the 1% level of significance, (**7**+60=67 cases in total) at the 5% and (**5**+67=72 in total) cases at the 10% level of significance. Thus only in 11 cases the coefficient is statistically insignificant at any of the three levels of significance.

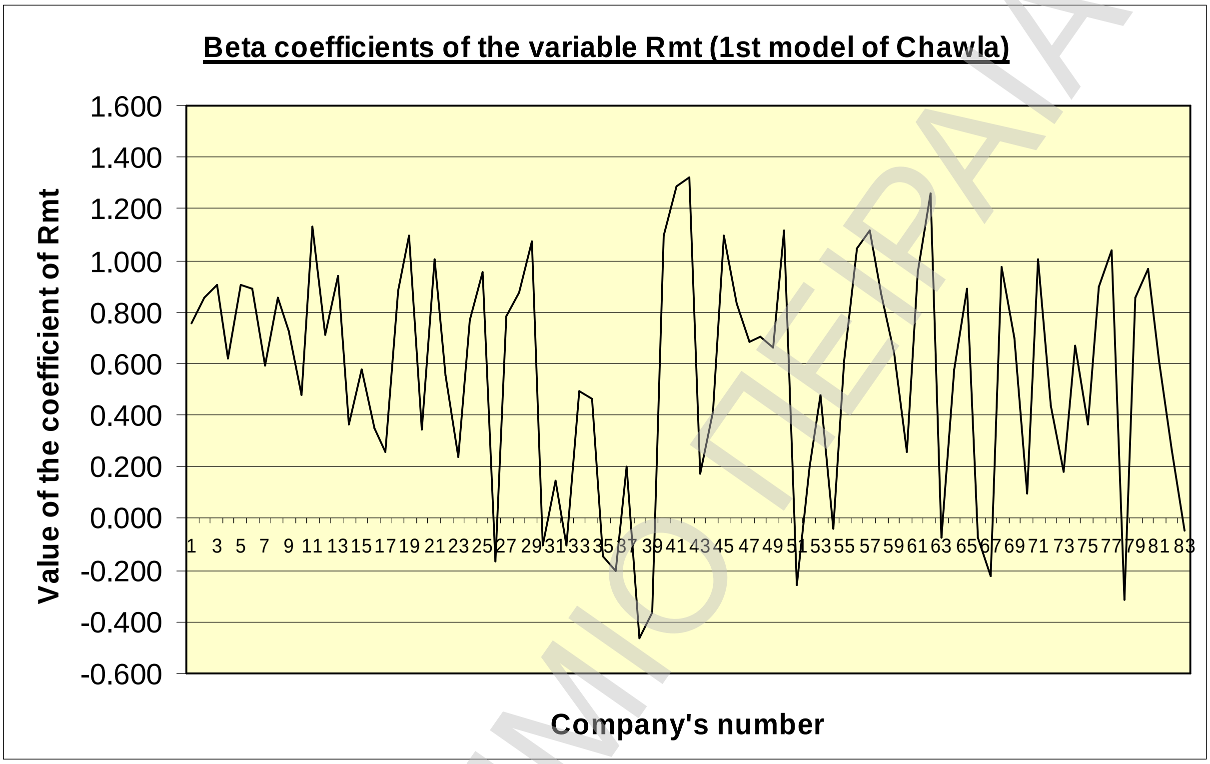
*Number of cases with significant t-ratios of the coefficient **c** of the variable tRm_t at each level of significance.*	
Level of significance	**Number of cases with significant t-ratio**
1%	**60**
5%	(**7**+60=67 in total)
10%	(**5**+67=72 in total)

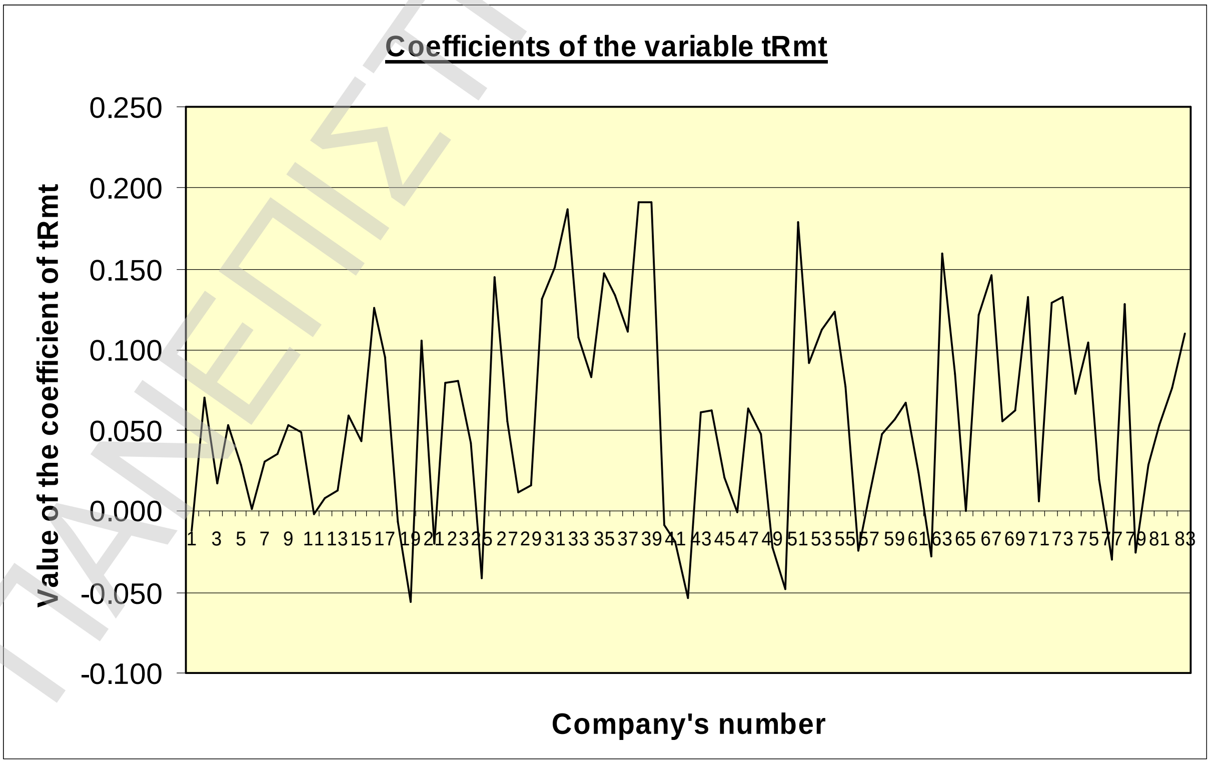
In other words, for 72 stocks (i.e. 87% of the total sample of stocks) we accept the hypothesis of the non-stability of beta at least at one level of significance and **<u>for 60 stocks (i.e. 72% of the total sample of stocks) we accept the hypothesis of the non-stability of beta at all levels of significance.</u>**

The corresponding figure by the research of Chawla (2001) in the Indian Stock market was 58% (accepting the hypothesis of the non-stability of beta at all levels of significance for 21 out of 36 stocks).

The overall tendency according to the results of this test is to **clearly reject the Null Hypothesis of the stability of beta**. Therefore, the findings of Chawla (2001) are confirmed for the ASE and thus leading us to accept with more confidence the notion of the non-stable beta in a thin-trading market such as the ASE and the Indian Stock Market (examined by Chawla).

In the following 2 graphs, we can see the large variation exhibited by the coefficients of the variables Rm_t and tRm_t.





In order to further revalidate the results, let us now turn to the **Table 3** (please refer to the Appendix section) of the second model which uses dummy variables in order to measure the change of the slope over time. Analytically we can make the following observations:

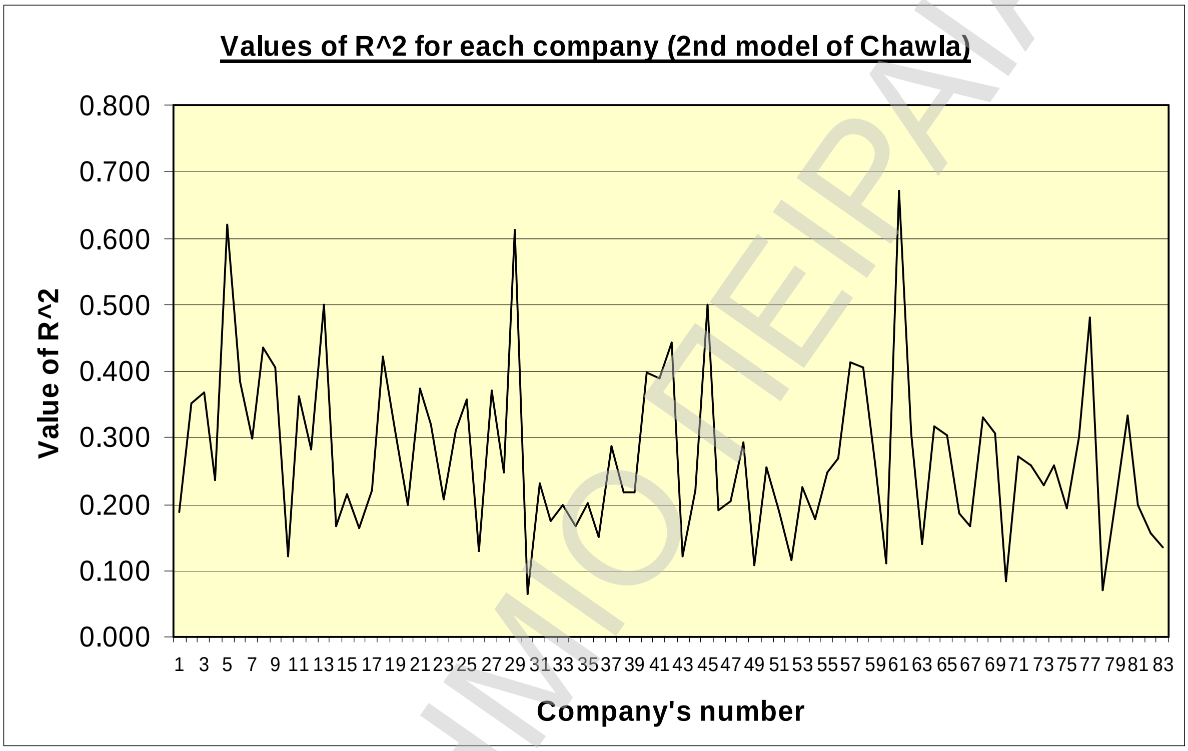
- Firstly, the value of the R^2, which is a measure of the goodness of fit of our regression varies from 0.066 to 0.672, thus exhibiting large variation in this case too. The average is equal to 0.271. It is important to observe here that these three values are very similar to the corresponding ones by using the first method of Chawla (i.e. using time as an additional variable) and thus confirming the validity of the results of the first one

  In just 12 out of the 83 regressions its price exceeds 40%, while only for 5 exceeded 50%. Here again the results as a percentage of the total 83 are very close to the corresponding ones by the first method (i.e. 8 and 3 respectively).

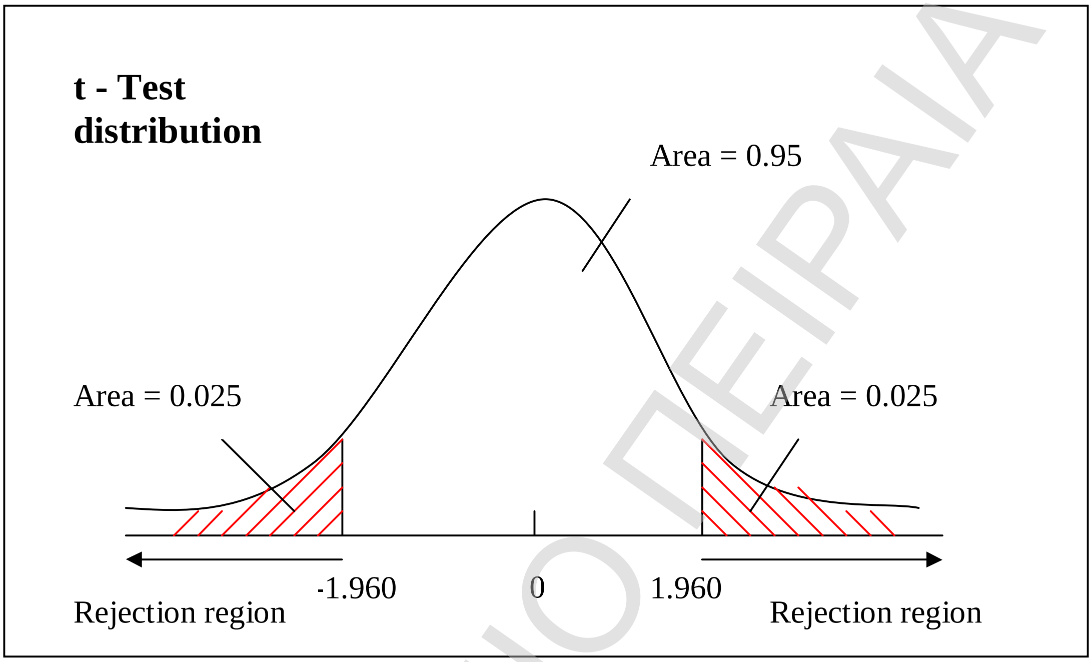
  More specifically the value of R^2 is greater than 40% for the stocks of the following 12 companies:

Name of the company	R^2
ALPHA BANK	0.620
ATHENS MEDICAL	0.434
ATTICA HOLDINGS	0.407
BANK OF PIRAEUS	0.501
COCA-COLA HLC	0.421
EMPORIKI BK.OF GREECE	0.612
HERACLES	0.442
INTRACOM	0.500
METKA	0.415
MICHANIKI	0.405
NATIONAL BK.OF GREECE	0.672
TITAN CEMENT	0.481

In the following graph we can see the large variation of the values of R^2 for the regression in each company's stock.



- The **tabular t-value** from the t-distribution tables, in 5% level of significance and with *n-k-1* = *3130-12-1* = ***3117*** (considered as infinity i.e. →∞) degrees of freedom, is equal to1.960.



The respective tabular t-values from the t-distribution tables, in 1% and 10% level of significance are 2.576 and 1.645 respectively.

Null Hypothesis: The examined coefficient (i.e. parameter estimate) is equal to zero (=0). In other words the corresponding variable is not significant in our model (i.e. it doesn't have significant effect on the estimation of the dependent variable).

Alternative Hypothesis: The examined coefficient is not equal to zero (≠0). (i.e. 2 tailed test). In other words the corresponding variable is significant in our model (i.e. it has significant effect on the estimation of the dependent variable).

As we have already said the Null Hypothesis of the stability of beta over time would be rejected if any one of the coefficients corresponding to the dummy variables D1, D2, D3, …, D11 were found to be statistically significant .

According to the results of the **Table 3** (please refer to the Appendix section), **only** in the case of the stock of the company "Coca-Cola", the Null Hypothesis cannot be rejected at any of our three confidence levels.

More analytically:

- In 76 stocks out of 83 the Null Hypothesis of beta's stability over time is rejected (i.e. at least one dummy is significant) at the 1% level of significance (and subsequently at the 5% and 10% too). Thus **for 76 stocks the Null Hypothesis is rejected at the 1%, 5% and 10% levels of confidence**.
- In 6 cases the Null Hypothesis of beta's stability over time is rejected (i.e. at least one dummy is significant) at the 5% level of confidence (and subsequently at the 10% too), but not at the 1%. Thus **in total** for (6+76=) **82 stocks** out of the 83 the **Null Hypothesis is rejected at the 5 % and 10% level of confidence**.
- Only in the case of the stock of the company "Coca-Cola HLC", there is not any significant dummy variable and thus the Null Hypothesis of betas stability is accepted.

Number of cases with significant t-ratios for at least one of the 11 dummy variables, at each level of significance.

Level of significance	Number of cases with at least one significant dummy
1%	**76**
5%	(**6**+76=82 in total)
10%	82 in total

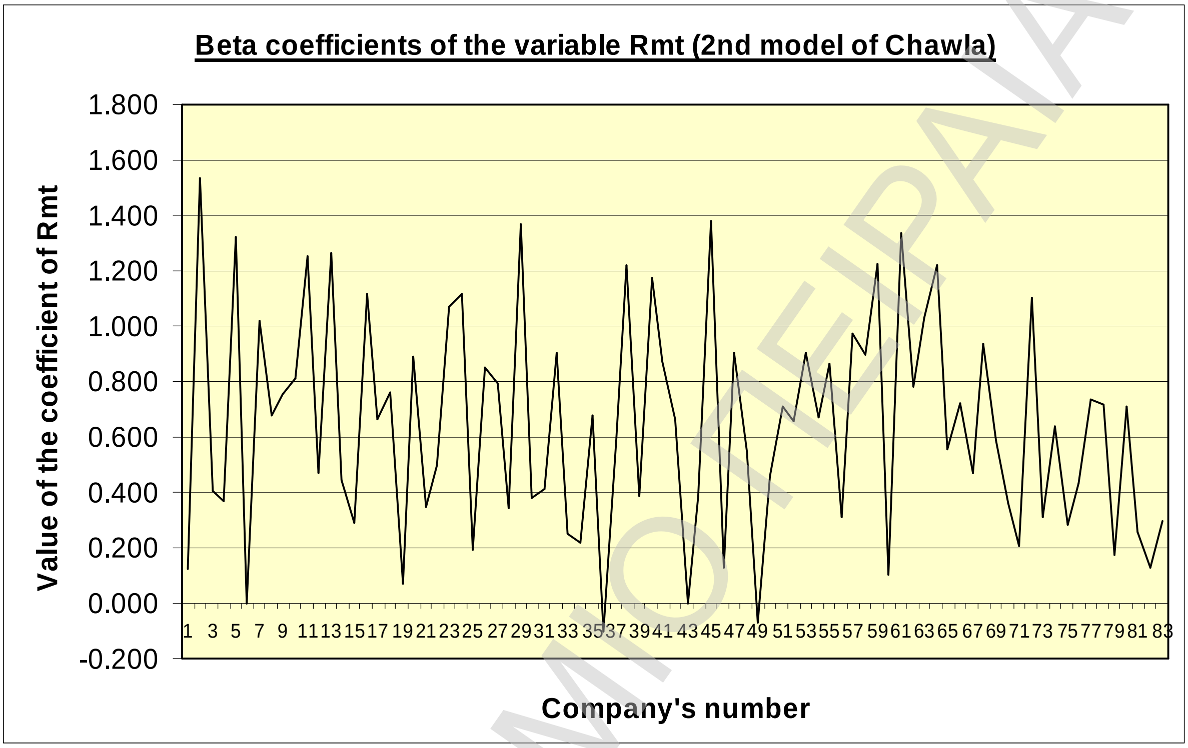
Summarising the above two points we can say that the phenomenon of unstable beta is supported at least at two levels of confidence (i.e. 5% and 10%) for 82 out of the 83 stocks. More importantly, **<u>the phenomenon of the unstable beta is supported at all the levels of confidence for 76 out of the 83 stocks, i.e. for the 92% of the sample</u>**.

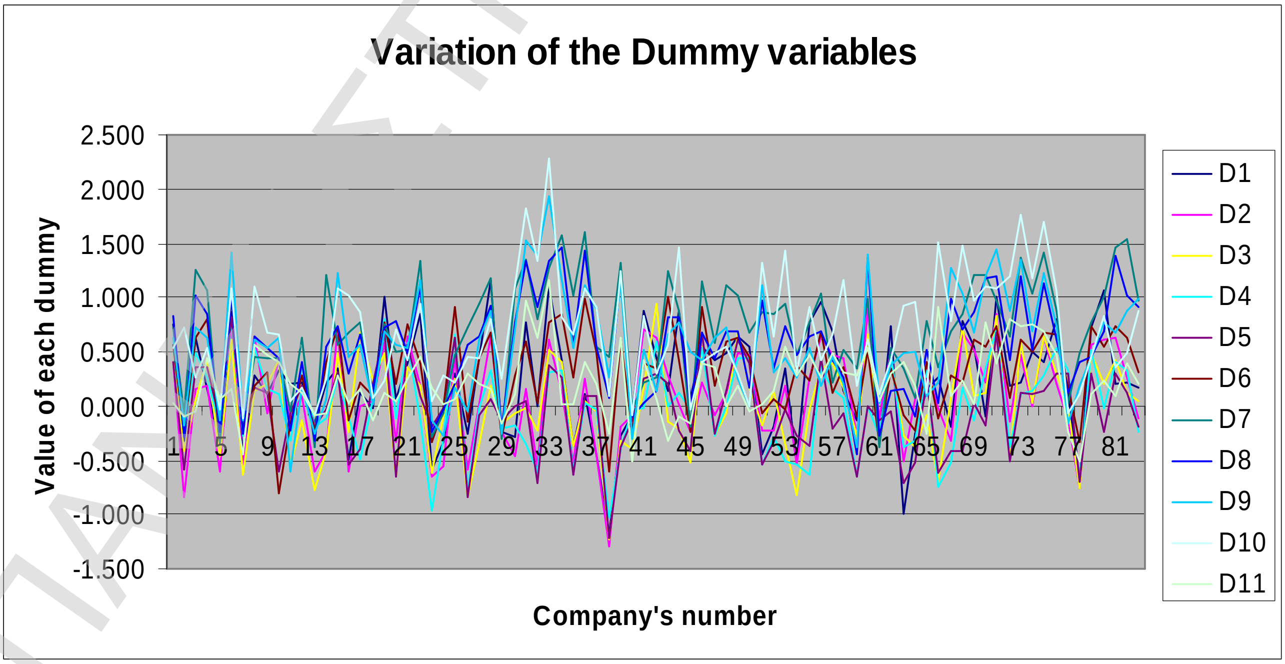
The corresponding figure by the research of Chawla (2001) in the Indian Stock market was 64% (accepting the hypothesis of the non-stability of beta at all levels of significance for 23 out of 36 stocks).

Therefore, the findings of Chawla (2001) are confirmed for the ASE by the second method too, and thus leading us to accept with more confidence the notion of the non-stable beta in a thin-trading market such as the ASE and the Indian Stock Market (examined by Chawla).

By observing also that for the most of the stocks, the Null Hypothesis is rejected for more than 3 of the 11 dummy variables, in at least one of the 3 levels of confidence, we can have stronger opinion supporting the theory of the non-stability of beta over time. Characteristically, in 1 case we have only 1 significant dummy variable, in 4 cases we have only 2 significant dummy variables in 10 cases we have only 3 significant dummy variables. Thus, **for** (83-15=) **68 out of the 83 stocks (i.e. 82% of the sample of stocks)**, there are more than 3 significant dummy variables. Another very strong sign of non-stability of betas over time!

In the following 2 graphs, we can see the large variation exhibited by the coefficients of the variables Rm_t and the dummy variables.





SECTION B

According to the results of the **Tables 4, 5, 6 (daily data)** (please refer to the Appendix section), we can draw the following observations:

- **The Vasicek's technique appears to be better than the Blume's** one, in terms of having smaller value of MSE, at all of the corresponding estimations.

In more details:

- The former has an MSE of 0.14112 while the latter has 0.14939 when predicting the betas of Period C, by using betas estimated under the OLS method.
- Vasicek's technique gives an MSE of 0.14619 while the latter has 0.15499 when predicting the betas of Period C, by using betas estimated under the Scholes & Williams method.

MSE values when predicting the betas of ***period C.***		
	Vasicek's method	**Blume**'s method
By using betas estimated under the **OLS** method.	0.14112	0.14939
By using betas estimated under the **Scholes & Williams** method.	0.14619	0.15499

- The average MSE of the Vasicek's technique (i.e. The average of the MSE when attempting to predict the betas of Period B and the MSE when attempting to predict the betas of Period C) is 0.13956 when using betas estimated under the OLS method and 0.14150 when using betas estimated under the Scholes & Williams method. Again it is lower from the corresponding values of the Blume's technique when predicting the betas of period C (i.e.0.14939 and 0.15499 respectively).

MSE values		
	Vasicek's method. (Average MSE for periods B and C)	**Blume**'s method (MSE for period C)
By using betas estimated under the **OLS** method.	0.13956	0.14939
By using betas estimated under the **Scholes & Williams** method.	0.14150	0.15499

Thus overall it is confirmed the superiority of the Vasicek's technique when compared to the Blume's one. This is consistent with the results of the researches of Klemkovsky & Martin (1975), and Diacogiannis (1989), but contradicts the results of Eubank & Zumwalt (1979) and Hawawini, Michel and Corhay (1985) who found the opposite being true (i.e. Blume's technique outperforming the Vasice's one). Therefore we confirm the results of the former two researches and furthermore we make more robusted the opinion supporting the superiority of the Vasicek's technique.

- **The employment of the Scholes & Williams correcting technique doesn't seem to improve the forecasting ability of the two techniques** (i.e. Blume's and Vasicek's). On the contrary, in the most of the cases leaded to larger MSEs than the OLS technique for the corresponding forecasts. Only in one case improved the results compared to the results when employing the OLS method and thus this can be considered as statistically non-significant. More analytically, according to the **<u>Tables 4, 5, 6 (daily data)</u>** :
  - Only in the case of predicting the betas for the Period B by using the Vasicek's method, the MSE was smaller (i.e. 0.13681) when using betas estimated under the S&W method, than the MSE (i.e 0.13799) when using betas estimated under the OLS method (Table 4).
  - In the case of predicting the betas for the Period C by using the Vasicek's method, the MSE was smaller (i.e. 0.14112) when using betas estimated under the OLS method, than the MSE (i.e 0.14619) when using betas estimated under the S&W method.
  - In the case of predicting the betas for the Period C by using the Blume's method, the MSE was smaller (i.e. 0.14939) when using betas estimated under the OLS method, than the MSE (i.e 0.15499) when using betas estimated under the S&W method.
  - The average MSE for the Period B and Period C by using the Vasicek's method, was smaller (i.e. 0.13956) when using betas estimated under the OLS method, than the MSE (i.e 0.14150) when using betas estimated under the S&W method.

Comparison of the MSEs obtained when using betas estimated under the OLS method with the MSEs when using betas estimated under the Scholes & Williams method.

	Vasicek (for period B)	Vasicek (for period C)	Blume (for period C)	Vasicek (aver. of periods B & C).
By using betas estimated under the **OLS** method.	0.13799	0.14112	0.14939	0.13956
By using betas estimated under the **S & W** method.	0.13681	0.14619	0.15499	0.14150

These results are consistent with the findings of Beer (1997) who found that *"Scholes & Williams' (1977) corrective model, although sophisticated, does not improve the quality of the results"*.

If we compare the results of the **<u>Tables 4, 5, 6 (daily data)</u>** with the corresponding figures of the **<u>Tables 7, 8 (monthly data)</u>** we observe the following:

- ü According to the results the **interval effect is present as it makes significant difference**, in terms of the figures of MSE obtained in each of the two cases: When using **daily** data compared to when using **monthly** data.

  More specifically:

  - § In the case of predicting the betas for the Period B by using the Vasicek's method, the MSE was smaller (i.e. 0.13799) when using daily returns, than the MSE (i.e. 0.22901) (Table 7) when using monthly returns.
  - § In the case of predicting the betas for the Period C by using the Vasicek's method, the MSE was smaller (i.e. 0.14112) when using daily returns, than the MSE (i.e. 0.40510) when using monthly returns.
  - § In the case of predicting the betas for the Period C by using the Blume's method, the MSE was smaller (i.e. 0.14939) when using daily returns, than the MSE (i.e. 0.38217) when using monthly returns.
  - § The average MSE for the Period B and Period C by using the Vasicek's method, was smaller (i.e. 0.13956) when using daily returns, than the MSE (i.e. 0.31705) when using monthly returns.

*Comparison of the MSEs obtained when using **daily** data with the MSEs obtained when using **monthly** data.*

	Vasicek (for period B)	Vasicek (for period C)	Blume (for period C)	Vasicek (aver. of periods B & C).
By using **daily** data (**OLS** method).	0.13799	0.14112	0.14939	0.13956
By using **monthly** data (**OLS** method).	0.22901	0.40510	0.38217	0.31705

- § Finally, the large difference of the corresponding figures between the two data frequencies' results in terms of the MSE, indicate that the "interval effect" is quite large and substantial.

Thus, our results our consistent with the findings of Couto & Duque (2004) who got more significant betas with high frequency data, when compared the results by using different time intervals.

On the other hand, our results contradict the opinion that daily data adds too much noise to the calculations and also the evidence of Handa, Kothari & Wasley (1989), who estimated beta coefficients using several return intervals varying from one day to one year and found that the annual betas were the most significant. Thus the debate on the issue of the direction of the interval effect still "holds on strongly".

CHAPTER 5:

5.1 Conclusion:

In this work, we saw an analytical literature review concerning the relative **instability (non stationarity) along time** as this is revealed by the consistent trend of beta coefficients of a stock or a portfolio of stocks with a low (high) historical beta, calculated for a given time period, to usually show a higher (lower) value for the subsequent time period. Moreover, we analyzed the notion of thin trading and other factors affecting the estimation of the beta coefficient such as the “interval effect”.

Thus the issues, which we used for analysis and the corresponding results and conclusions, are the following:

First of all, we tested if the non-stationarity of betas through time, is still observable in the Athens Stock Exchange (ASE), a small market characterized by thin trading. For this purpose we used the two methods originally proposed by Chawla (2001) of introducing and additional time variable in the classical OLS model and of using dummy variables to measure the change of the slope over time.

According to the results, for the most of the stocks, the null hypothesis of the stability of betas along time is rejected at all levels of significance used (i.e. 1%, 5%, 10%) for both of the Chawla’a methods. Our results are consistent with the findings of Chawla and moreover we have stronger figures than him in terms of greater number of stocks for which the alternative hypothesis of non-stability of betas is accepted. Therefore we provide **more robustness** to this opinion.

After establishing the “non-stationarity” tendency, we tested the forecasting ability of Blume’s and Vasicek’s methods to predict betas along time and compared them.

According to the results, the superiority of Vasicek’s technique is supported in terms of having smaller Mean Squared Error (MSE) values to all the comparable figures with the Blume’s technique. The results confirm the previous findings of the researches of Klemkovsky and Martin (1975) and Diakogiannis (1989) on the issue.

Furthermore, we proposed the use in the Blume's and Vasicek's models of betas estimated by a "correcting for thin-trading" procedure such as the Scholes & Williams' methodology and tested the efficiency of the results.

Unfortunately the results, didn't match our expectations for providing a more efficient tool for predicting future betas. For the most of the cases and with only one exception, the results of the two techniques (i.e. Blume's and Vasicek's) were worst in terms of giving larger values of MSEs, when we employed the Scholes & Williams' methodology for estimating the betas, which the two techniques used, instead of estimating them by the OLS method. We have to note here that the evidence of the non improvement of the results by using the S&W method instead of the OLS is consistent with the findings of Beer (1997) who found that *"Scholes & Williams' (1977) corrective model, although sophisticated, does not improve the quality of the results"*. Thus our proposal has to be rejected, at least as long as no contradicting evidence is deducted.

Finally, we checked whether the frequency of stock data collection has a significant impact (i.e. interval effect) on the forecasting ability of stock betas, by comparing the results achieved with daily and monthly data.

Our results favoured the estimation of betas by using daily data in terms of giving smaller figures for the MSE when compared with the corresponding figures of the estimations when using monthly data. This is consistent with the findings of Couto & Duque (2001) who got more significant betas with high frequency data, when compared the results by using different time intervals. On the other hand, our results contradict the evidence of Handa, Kothari & Wasley, who estimated beta coefficients using several return intervals varying from one day to one year and found that the annual betas were the most significant. Thus the debate on the issue of the direction of the interval effect still "holds on strongly".

Hence, according to our research the positive effect of larger amount of information when using daily data seems to outperforms the negative one of adding much noise to the calculations. In any case the debate is still present on what time interval should we prefer to use and this can be a field for further research.

5.2 Suggestions for further research:

Two major fields for further research can be suggested.

In this work we attempted to provide a more efficient method for predicting the future beta coefficient of a stock or a portfolio, by combining the correcting method of Scholes and Williams (by using it in the estimation process of the past betas instead of the classical OLS) with the forecasting method of Blume and the corresponding one proposed by Vasicek. Unfortunately the results of the two forecasting techniques were not improved by employing this method.

Nevertheless, other similar procedures can be tested by using one of the other correcting procedures and explore the possibility of getting improved results.

Moreover, as we saw the debate on the choice between the optimal return interval still holds as the "interval effect" seemed to be substantial according to the large difference of the corresponding figures between the two data frequencies' results in terms of the MSE. Furthermore, the several researches have not yet shown the superiority of one return interval against another. Although, our results provide clearly the superiority of high frequency data, there are other findings such as those of Handa, Kothari & Wasley (1989), clearly supporting the opposite "side".

Hence as the debate on this issue still holds, further research with several time intervals should be undertaken in order to create a clearer picture, supporting the one or the other opinion.

CHAPTER 6:

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CHAPTER 7:

7. Appendix:

Table 1

Normality tests for the data sample (daily returns):

	Mean	Median	Std. Dev.	Skewness	Kurtosis	Jarque-Bera	Prob.
ATHEX_COMPOSITE	0.00042	0.000	0.0157	-0.056	7.387	2511.596	0.000
A_B_VASSILOPOULOS	0.00046	0.000	0.0257	0.190	5.427	786.906	0.000
AEGEK	-0.00033	0.000	0.0347	0.226	5.522	856.184	0.000
AEOLIAN_INVESTMENT_FUND	0.00011	0.000	0.0277	0.009	6.222	1354.183	0.000
ALLATINI	-0.00019	0.000	0.0320	0.010	5.716	961.807	0.000
ALPHA_BANK	0.00064	0.000	0.0217	-0.198	16.010	22094.950	0.000
ALPHA_LEASING	-0.00003	0.000	0.0236	0.209	7.445	2599.713	0.000
ALUMINIUM_OF_GREECE	0.00049	0.000	0.0226	0.008	7.974	3226.073	0.000
ATHENS_MEDICAL	0.00036	0.000	0.0262	0.197	4.502	314.538	0.000
ATTICA_HOLDINGS	0.00043	0.000	0.0262	0.176	4.739	410.405	0.000
BALKAN_EXPORT	-0.00084	0.000	0.0429	15.664	573.201	42530261.000	0.000
BANK_OF_ATTICA	0.00048	0.000	0.0297	0.391	5.757	1070.929	0.000
BANK_OF_GREECE	0.00099	0.000	0.0231	0.291	7.569	2766.666	0.000
BANK_OF_PIRAEUS	0.00088	0.000	0.0227	0.405	6.124	1358.173	0.000
BENRUBI	-0.00014	0.000	0.0325	-0.032	5.831	1045.873	0.000
BIOKARPET	0.00022	0.000	0.0299	0.036	4.664	361.647	0.000
BIOSSOL	-0.00026	0.000	0.0465	0.042	3.214	6.872	**0.032**
CHATZIIOANNOY_HDG	0.00008	0.000	0.0319	0.211	4.656	380.707	0.000
COCA_COLA_HLC	0.00037	0.000	0.0206	0.077	6.245	1376.625	0.000
CROWN_HELLAS_CAN	0.00001	0.000	0.0222	0.160	6.812	1907.976	0.000
CYCLON_HELLAS	-0.00052	0.000	0.0382	0.043	4.113	162.474	0.000
DELTA_HOLDINGS	-0.00008	0.000	0.0232	0.243	5.953	1168.188	0.000
DIAS	0.00035	0.000	0.0320	0.093	5.566	863.091	0.000
EFG_EUROBANK_ERGASIAS	0.00048	0.000	0.0266	0.152	5.872	1087.638	0.000
EGNATIA_BANK	0.00001	0.000	0.0292	0.425	5.773	1097.100	0.000
ELAIS_UNILEVER	0.00011	0.000	*0.0199*	0.327	7.295	2461.913	0.000
ELFICO	0.00001	0.000	0.0397	0.033	4.318	227.251	0.000
ELMEC_SPORT	0.00047	0.000	0.0303	0.003	5.385	742.062	0.000
ELTRAK	0.00018	0.000	0.0328	0.355	5.964	1211.278	0.000
EMPORIKI_BK_OF_GREECE	0.00058	0.000	0.0236	0.135	5.795	1028.102	0.000
EMPORIKOS_DESMOS	-0.00085	0.000	0.0512	-5.878	141.832	2531702.000	0.000
ETMA_RAYON	-0.00003	0.000	0.0402	0.153	4.052	156.542	0.000
EUROHOLDINGS_CAP	-0.00002	0.000	0.0464	0.097	4.061	151.827	0.000
FANCO	*-0.00090*	0.000	0.0444	0.123	5.122	595.226	0.000
FG_EUROPE	0.00066	0.000	0.0421	4.412	109.978	1502680.000	0.000
FINTEXPORT	0.00002	0.000	0.0331	0.102	5.346	723.202	0.000
FLR_MLS_SARANTOPOULOS	-0.00031	0.000	0.0344	0.267	6.332	1484.961	0.000
FOURLIS_HOLDING	0.00063	0.000	0.0277	0.111	5.316	705.650	0.000
GEK_GROUP_OF_COMPANIES	**0.00108**	0.000	0.0312	-2.386	59.159	414280.100	0.000
GENERAL_COMMERCIAL_IND	0.00005	0.000	0.0353	0.194	14.626	17648.240	0.000
GENERAL_HELLENIC_BANK	0.00042	0.000	0.0261	0.315	5.328	758.602	0.000
HELLENIC_SUGAR_IND	-0.00030	-0.001	0.0303	0.422	4.654	449.641	0.000
HERACLES	0.00021	0.000	0.0240	0.286	11.876	10317.030	0.000
HIPPOTOUR	0.00004	0.000	0.0326	0.128	5.090	578.467	0.000
INTERINVEST	-0.00005	0.000	0.0311	0.031	5.152	604.736	0.000
INTRACOM	0.00003	0.000	0.0275	0.154	4.875	470.986	0.000
IONIAN_HOTEL	0.00035	0.000	0.0312	0.269	4.885	501.320	0.000
J_BOUTARIS___SON_HLDG	-0.00047	0.000	0.0386	0.120	3.452	34.228	0.000
KALPINIS_SIMOS	-0.00005	0.000	0.0309	0.235	4.728	418.243	0.000
KARELIA_TOBACCO	0.00025	0.000	0.0275	-0.063	5.968	1150.768	0.000
KATSELIS_SONS	0.00009	0.000	0.0266	-0.098	6.969	2059.763	0.000
KEKROPS	0.00059	0.000	0.0376	0.193	4.366	262.816	0.000
KERAMIA_ALLATINI	0.00025	0.000	0.0392	-0.202	5.085	588.431	0.000
KLONATEX_GROUP_OF_COS	-0.00038	0.000	0.0417	0.322	5.409	811.229	0.000

LAMPSA_HOTEL	0.00061	0.000	0.0307	0.070	4.924	485.587	0.000
LEVEDERIS	0.00004	0.000	0.0374	0.140	4.000	140.746	0.000
LOULIS_MILLS	-0.00008	0.000	0.0285	0.274	4.751	438.891	0.000
METKA	0.00064	0.000	0.0295	0.145	4.703	389.117	0.000
MICHANIKI	-0.00034	0.000	0.0294	0.208	5.354	745.187	0.000
MOUZAKIS	-0.00028	0.000	0.0322	0.234	4.362	270.296	0.000
MULTIRAMA	0.00023	0.000	0.0386	-0.009	4.322	227.933	0.000
NATIONAL_BK_OF_GREECE	0.00082	0.000	0.0213	0.316	5.795	1071.075	0.000
NEXANS_HELLAS	-0.00069	0.000	0.0318	0.217	4.875	483.118	0.000
PARNASSOS_ENTERPRISES	0.00012	0.000	0.0425	-0.108	4.994	524.730	0.000
PETZETAKIS	-0.00022	0.000	0.0319	0.038	5.716	963.089	0.000
PG_NIKAS	0.00027	0.000	0.0265	0.174	5.964	1161.460	0.000
PHOENIX_METROLIFE	0.00002	0.000	0.0310	0.461	10.280	7023.213	0.000
PIPE_WORKS	-0.00011	0.000	0.0329	0.097	6.651	1743.677	0.000
PROODEFTIKI	-0.00065	0.000	0.0385	0.295	4.027	182.906	0.000
REDS	-0.00015	0.000	0.0329	0.192	4.823	452.726	0.000
RIDENCO	0.00097	0.000	**0.0564**	9.108	282.898	10260461.000	0.000
RILKEN	-0.00014	0.000	0.0323	0.483	4.854	569.724	0.000
SANYO_HELLAS	0.00019	0.000	0.0406	0.679	52.348	317841.100	0.000
SATO	0.00013	0.000	0.0364	0.161	3.995	142.520	0.000
SELECTED_TEXTILE	-0.00037	0.000	0.0359	0.342	4.890	527.136	0.000
SHEET_STEEL	-0.00016	0.000	0.0394	0.053	3.748	74.424	0.000
SHELMAN	-0.00011	0.000	0.0299	0.282	4.370	286.279	0.000
TITAN_CEMENT	0.00078	0.000	*0.0199*	0.249	6.550	1675.846	0.000
TRIA_ALPHA	-0.00003	0.000	0.0386	-0.083	5.249	663.126	0.000
UNCLE_STATHIS	0.00014	0.000	0.0260	0.152	5.509	833.163	0.000
VIOTER	-0.00017	0.000	0.0335	0.336	4.568	379.588	0.000
VIS_CONTAINER	0.00017	0.000	0.0368	-0.029	4.006	132.424	0.000
XYLEMBORIA	0.00050	0.000	0.0343	-0.002	4.206	189.597	0.000
ZAMPA	0.00010	0.000	0.0331	0.170	5.518	841.733	0.000

Table 2

Estimated coefficients by using the 1st model of Chawla:

$$R_{i,t} = a + bm_t + c(tm_t) + v$$

Name of the company	Estimated coefficients and t-ratios						R^2
	Constant		R_{mt}		tR_{mt}		
	Coef.	t-ratio	Coef.	t-ratio	Coef.	t-ratio	
A-B VASSILOPOULOS	0.000	0.424	0.754	10.939*	-0.012	-1.092	0.176
AEGEK	-0.001	-1.720	0.855	10.277*	0.070	5.460*	0.340
AEOLIAN INVESTMENT FUND	0.000	-0.764	0.904	13.456*	0.018	1.707***	0.328
ALLATINI	-0.001	-1.167	0.621	7.434*	0.054	4.158*	0.219
ALPHA BANK	0.000	0.789	0.904	22.676*	0.029	4.756*	**0.614**
ALPHA LEASING	0.000	-1.193	0.887	15.884*	0.002	0.207	0.358
ALUMINIUM OF GREECE	0.000	0.484	0.594	10.575*	0.030	3.506*	0.294
ATHENS MEDICAL	0.000	-0.249	0.856	14.450*	0.036	3.915*	0.415
ATTICA HOLDINGS	0.000	-0.040	0.729	12.132*	0.053	5.765*	0.401
BALKAN EXPORT	-0.001	-1.577	0.477	3.922*	0.049	2.599*	0.081
BANK OF ATTICA	0.000	0.019	1.134	16.063*	-0.002	-0.155	0.354
BANK OF GREECE	0.001	1.902	0.713	12.222*	0.008	0.904	0.269
BANK OF PIRAEUS	0.000	1.591	0.937	19.588*	0.013	1.718***	**0.492**
BENRUBI	0.000	-0.808	0.365	4.064*	0.059	4.277*	0.126
BIOKARPET	0.000	-0.265	0.578	7.294*	0.043	3.516*	0.196
BIOSSOL	-0.001	-0.955	0.354	2.797*	0.126	6.428*	0.151
CHATZIIOANNOY HDG.	0.000	-0.534	0.258	3.022*	0.096	7.261*	0.181
COCA-COLA HLC.BT.	0.000	0.052	0.881	18.988*	-0.006	-0.823	**0.418**
CROWN HELLAS CAN	0.000	-0.903	1.095	19.921*	-0.056	-6.553*	0.300
CYCLON HELLAS	-0.001	-1.497	0.347	3.374*	0.105	6.643*	0.173
DELTA HOLDINGS	0.000	-1.371	1.006	18.376*	-0.019	-2.295**	0.364
DIAS	0.000	-0.180	0.559	6.895*	0.080	6.371*	0.268
EFG EUROBANK ERGASIAS	0.000	0.401	0.234	3.315*	0.081	7.400*	0.193
EGNATIA BANK	0.000	-0.956	0.767	10.649*	0.043	3.847*	0.306
ELAIS-UNILEVER	0.000	-0.634	0.955	19.650*	-0.041	-5.510*	0.319
ELFICO	0.000	-0.431	-0.169	-1.520	0.145	8.409*	0.096
ELMEC SPORT	0.000	0.002	0.783	10.779*	0.056	4.993*	0.342
ELTRAK	0.000	-0.424	0.878	10.177*	0.012	0.915	0.208
EMPORIKI BK.OF GREECE	0.000	0.359	1.073	24.503*	0.016	2.358**	**0.606**
EMPORIKOS DESMOS	-0.001	-1.284	-0.104	-0.703	0.131	5.778*	0.054
ETMA RAYON	0.000	-0.732	0.143	1.338	0.150	9.100*	0.188
EUROHOLDINGS CAP & INV C	0.000	-0.592	-0.100	-0.791	0.187	9.541*	0.144
FANCO	-0.001	-1.913	0.494	4.135*	0.108	5.848*	0.172
FG EUROPE	0.000	0.370	0.462	3.988*	0.083	4.638*	0.134
FINTEXPORT	0.000	-0.538	-0.142	-1.583	0.147	10.569*	0.152
FLR MLS C SARANTOPOULOS	-0.001	-0.971	-0.202	-2.095**	0.133	8.933*	0.097
FOURLIS HOLDING	0.000	0.610	0.201	2.868*	0.112	10.323*	0.268
GEK GROUP OF COMPANIES	0.001	1.552	-0.465	-5.548*	0.191	14.755*	0.174
GENERAL COMMERCIAL &IND	0.000	-0.501	-0.366	-3.840*	0.192	13.055*	0.167
GENERAL HELLENIC BANK	0.000	-0.041	1.093	18.155*	-0.009	-0.919	0.393
HELLENIC SUGAR IND.	-0.001	-1.824	1.286	18.111*	-0.018	-1.688***	0.372
HERACLES	0.000	-0.621	1.320	24.792*	-0.054	-6.533*	**0.436**
HIPPOTOUR	0.000	-0.344	0.176	1.898***	0.061	4.256*	0.073
INTERINVEST	0.000	-0.748	0.417	4.971*	0.062	4.826*	0.166
INTRACOM	0.000	-1.365	1.094	18.806*	0.021	2.301**	**0.487**
IONIAN HOTEL	0.000	0.011	0.835	9.954*	-0.001	-0.087	0.174
J BOUTARIS & SON HLDG	-0.001	-1.479	0.682	6.643*	0.063	3.990*	0.190

KALPINIS SIMOS	0.000	-0.984	0.709	9.027*	0.048	3.972*	0.261
KARELIA TOBACCO	0.000	0.067	0.660	8.527*	-0.022	-1.809***	0.093
KATSELIS SONS	0.000	-0.613	1.117	16.342*	-0.048	-4.540*	0.246
KEKROPS	0.000	0.396	-0.260	-2.532**	0.179	11.289*	0.149
KERAMIA ALLATINI	0.000	-0.103	0.202	1.832***	0.092	5.405*	0.099
KLONATEX GROUP OF COS	-0.001	-1.292	0.481	4.358*	0.112	6.593*	0.200
LAMPSA HOTEL	0.000	0.616	-0.041	-0.490	0.124	9.617*	0.154
LEVEDERIS	0.000	-0.698	0.612	6.228*	0.077	5.052*	0.209
LOULIS MILLS	0.000	-1.025	1.049	14.386*	-0.024	-2.163**	0.250
METKA	0.000	0.361	1.120	16.517*	0.009	0.898	0.394
MICHANIKI	-0.001	-2.005	0.871	12.803*	0.048	4.566*	0.387
MOUZAKIS	-0.001	-1.363	0.638	7.662*	0.057	4.416*	0.233
MULTIRAMA	0.000	-0.083	0.262	2.389**	0.067	3.959*	0.077
NATIONAL BK.OF GREECE	0.000	1.635	0.957	26.135*	0.025	4.343*	**0.663**
NEXANS HELLAS	-0.001	-2.400	1.259	15.908*	-0.027	-2.238**	0.293
PARNASSOS ENTERPRISES	0.000	-0.368	-0.075	-0.642	0.160	8.847*	0.128
PETZETAKIS	-0.001	-1.416	0.580	7.347*	0.085	6.959*	0.298
PG NIKAS	0.000	-0.252	0.894	13.464*	0.001	0.065	0.283
PHOENIX METROLIFE	0.000	-0.493	-0.075	-0.877	0.121	9.172*	0.131
PIPE WORKS	0.000	-0.714	-0.226	-2.485**	0.146	10.404*	0.126
PROODEFTIKI	-0.001	-2.074	0.975	10.175*	0.056	3.800*	0.290
REDS	-0.001	-1.196	0.696	8.359*	0.063	4.865*	0.267
RIDENCO	0.001	0.612	0.092	0.571	0.132	5.329*	0.069
RILKEN	-0.001	-1.151	1.006	12.201*	0.006	0.492	0.257
SANYO HELLAS	0.000	-0.517	0.440	4.185*	0.129	7.964*	0.235
SATO	0.000	-0.477	0.179	1.853***	0.132	8.854*	0.195
SELECTED TEXTILE	-0.001	-1.498	0.670	7.238*	0.073	5.085*	0.240
SHEET STEEL	-0.001	-0.895	0.366	3.435*	0.104	6.346*	0.166
SHELMAN	-0.001	-1.174	0.901	12.052*	0.019	1.670***	0.286
TITAN CEMENT	0.000	1.615	1.041	24.359*	-0.030	-4.505*	**0.470**
TRIA ALPHA	0.000	-0.334	-0.315	-2.830*	0.128	7.437*	0.050
UNCLE STATHIS	0.000	-0.358	0.853	12.243*	-0.025	-2.345**	0.181
VIOTER	-0.001	-1.277	0.971	11.626*	0.029	2.212**	0.288
VIS-CONTAINER	0.000	-0.368	0.614	6.170*	0.054	3.496*	0.163
XYLEMBORIA	0.000	0.341	0.267	2.800*	0.076	5.151*	0.116
ZAMPA	0.000	-0.296	-0.046	-0.496	0.110	7.713*	0.102
Average	**0.000**	**-0.480**	**0.561**	**8.468**	**0.059**	**3.949**	**0.247**
Variance	**0.000**	**0.777**	**0.197**	**58.793**	**0.004**	**19.199**	**0.017**

Note:

* = statistically significant at 1% level of significance
** = statistically significant at 5% level of significance
*** = statistically significant at 10% level of significance

Table 3

Estimated coefficients by using the 2nd model of Chawla:

$$R_{it} = a + b_i R_{mt} + b_1 D_1 R_{mt} + b_2 D_2 R_{mt} + b_3 D_3 R_{mt} + b_4 D_4 R_{mt} + b_5 D_5 R_{mt} + b_6 D_6 R_{mt} + b_7 D_7 R_{mt} + b_8 D_8 R_{mt} + b_9 D_9 R_{mt} + b_{10} D_{10} R_{mt} + b_{11} D_{11} R_{mt}$$

Name of the company	Estimated coefficients and t-ratios													R^2
	R_{mt}	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11	Constant	
A-B VASSILOPOULOS	0.125	0.752	0.398	0.400	0.555	0.413	0.562	0.718	0.838	0.628	0.529	0.033	0.000	0.189
t-ratio	0.724	3.724*	1.745***	1.651***	2.927*	2.253**	3.068*	3.817*	4.381*	2.860*	2.495**	0.143	0.865	
AEGEK	1.534	-0.320	-0.836	-0.421	-0.249	-0.580	-0.242	-0.059	-0.282	-0.183	0.721	-0.101	-0.001	0.351
t-ratio	7.332*	-1.313	-3.038*	-1.438	-1.089	-2.620*	-1.096	-0.262	-1.221	-0.690	2.818*	-0.358	-1.730	
AEOLIAN INVESTM. FUND	0.403	0.621	0.156	0.066	0.484	0.357	0.627	1.249	1.015	0.717	0.265	-0.054	0.000	0.368
t-ratio	2.443**	3.232*	0.721	0.287	2.679*	2.043**	3.589*	6.974*	5.569*	3.430*	1.312	-0.242	0.115	
ALLATINI	0.365	0.154	0.180	0.421	0.268	0.363	0.801	1.062	0.853	0.629	0.534	0.434	0.000	0.237
t-ratio	1.747***	0.631	0.653	1.439	1.172	1.640	3.622*	4.680*	3.695*	2.375**	2.090**	1.545	-0.758	
ALPHA BANK	1.325	-0.344	-0.601	-0.455	-0.197	-0.153	-0.337	-0.341	-0.245	-0.131	-0.033	0.066	0.000	**0.620**
t-ratio	13.222*	-2.945*	-4.556*	-3.248*	-1.795***	-1.440	-3.179*	-3.139*	-2.217**	-1.029	-0.272	0.487	0.540	
ALPHA LEASING	0.003	0.862	0.688	0.610	0.776	0.818	1.021	1.041	1.015	1.414	1.088	0.157	0.000	0.385
t-ratio	0.020	5.340*	3.776*	3.146*	5.121*	5.580*	6.965*	6.924*	6.635*	8.060*	6.424*	0.843	-0.551	
ALUMINIUM OF GREECE	1.022	-0.458	-0.543	-0.636	-0.277	-0.217	-0.188	-0.169	-0.261	-0.131	-0.109	-0.441	0.000	0.298
t-ratio	7.198*	-2.771*	-2.907*	-3.206*	-1.787	-1.444	-1.253	-1.098	-1.663***	-0.726	-0.629	-2.313**	0.468	
ATHENS MEDICAL	0.679	0.283	0.623	0.141	0.534	0.174	0.178	0.455	0.644	0.615	1.101	0.558	0.000	**0.434**
t-ratio	4.594*	1.648***	3.209*	0.681	3.302*	1.111	1.138	2.841*	3.951*	3.286*	6.100*	2.810*	0.006	
ATTICA HOLDINGS	0.758	0.099	-0.075	0.193	0.158	0.128	0.308	0.435	0.528	0.528	0.671	0.475	0.000	**0.407**
t-ratio	5.001*	0.560	-0.375	0.913	0.955	0.796	1.920***	2.647*	3.159*	2.751*	3.622*	2.335**	0.256	
BALKAN EXPORT	0.815	0.322	0.437	0.423	0.103	-0.606	-0.811	0.437	0.431	0.624	0.658	0.405	-0.001	0.119
t-ratio	2.702*	0.917	1.102	1.004	0.312	-1.899***	-2.544**	1.337	1.297	1.635	1.786***	0.999	-1.083	
BANK OF ATTICA	1.253	0.200	-0.116	-0.561	-0.320	-0.061	-0.157	-0.044	-0.229	-0.595	0.050	0.202	0.000	0.363
t-ratio	7.050*	0.966	-0.496	-2.258**	-1.648***	-0.326	-0.833	-0.230	-1.166	-2.642*	0.232	0.848	-0.139	
BANK OF GREECE	0.474	0.213	0.084	-0.129	0.368	0.180	0.281	0.624	0.402	0.172	0.163	0.121	0.001	0.283
t-ratio	3.230*	1.245	0.437	-0.629	2.293**	1.158	1.812***	3.926*	2.482**	0.926	0.908	0.613	2.232	
BANK OF PIRAEUS	1.267	-0.156	-0.598	-0.775	-0.191	-0.187	-0.238	-0.383	-0.325	-0.259	-0.089	-0.089	0.000	**0.501**
t-ratio	10.540*	-1.115	-3.782*	-4.608*	-1.456	-1.469	-1.874***	-2.941*	-2.452**	-1.702***	-0.605	-0.549	1.290	
BENRUBI	0.443	0.217	-0.410	-0.411	-0.121	-0.035	0.400	1.202	0.541	0.059	0.251	-0.074	0.000	0.166
t-ratio	1.991**	0.838	-1.401	-1.319	-0.496	-0.148	1.701***	4.979*	2.202**	0.209	0.921	-0.249	-0.244	

BIOKARPET	0.289	0.345	0.726	0.482	0.248	0.318	0.724	0.556	0.736	1.227	1.084	0.274	0.000	0.213
t-ratio	1.455	1.491	2.780*	1.735***	1.139	1.515	3.449*	2.580*	3.357*	4.880*	4.467*	1.028	0.085	
BIOSSOL	1.114	-0.488	-0.600	-0.244	-0.102	-0.532	-0.131	0.680	0.300	0.459	1.025	0.031	0.000	0.164
t-ratio	3.495*	-1.316	-1.431	-0.547	-0.292	-1.579	-0.388	1.967**	0.853	1.138	2.633*	0.072	-0.618	
CHATZIIOANNOY HDG.	0.662	0.122	-0.009	0.668	-0.499	-0.390	0.213	0.764	0.651	0.570	0.854	0.153	0.000	0.220
t-ratio	3.132*	0.497	-0.031	2.261**	-2.157**	-1.746***	0.952	3.334*	2.791*	2.131**	3.307*	0.539	0.151	
COCA-COLA HLC.BT.	0.763	-0.019	0.039	0.231	0.056	0.196	0.085	0.018	0.131	0.009	0.075	-0.123	0.000	**0.421**
t-ratio	6.506*	-0.137	0.251	1.410	0.433	1.576	0.684	0.143	1.013	0.062	0.523	-0.779	-0.008	
CROWN HELLAS CAN	0.072	0.998	0.573	0.485	0.804	0.696	0.772	0.756	0.719	0.695	0.235	0.121	0.000	0.311
t-ratio	0.520	6.205*	3.154*	2.507**	5.316*	4.758*	5.281*	5.041*	4.714*	3.969*	1.389	0.653	-0.533	
CYCLON HELLAS	0.892	0.057	-0.331	-0.653	-0.109	-0.648	0.208	0.493	0.778	0.564	0.702	0.037	-0.001	0.200
t-ratio	3.481*	0.190	-0.983	-1.822***	-0.389	-2.388**	0.769	1.775***	2.752*	1.737***	2.242**	0.107	-1.011	
DELTA HOLDINGS	0.349	0.390	0.649	0.355	0.583	0.556	0.745	0.515	0.486	0.525	0.421	0.246	0.000	0.373
t-ratio	2.533**	2.428**	3.580*	1.842***	3.868*	3.809*	5.110*	3.444*	3.192*	3.006*	2.498**	1.328	-1.359	
DIAS	0.497	0.844	0.177	0.182	-0.129	0.091	0.393	1.337	1.094	1.157	0.933	0.448	0.000	0.319
t-ratio	2.507**	3.661*	0.681	0.658	-0.596	0.436	1.874***	6.224*	5.004*	4.611*	3.853*	1.681***	0.910	
EFG EUROBANK ERGASIAS	1.069	-0.584	-0.650	-0.621	-0.969	-0.190	-0.339	-0.293	-0.234	-0.130	0.040	0.174	0.000	0.207
t-ratio	6.013*	-2.823*	-2.778*	-2.498**	-4.984*	-1.009	-1.806***	-1.522	-1.192	-0.580	0.182	0.727	0.426	
EGNATIA BANK	1.118	-0.340	-0.558	-0.094	-0.305	-0.017	-0.017	-0.073	-0.040	-0.265	0.283	0.006	0.000	0.310
t-ratio	6.144*	-1.604	-2.332**	-0.371	-1.533	-0.091	-0.088	-0.369	-0.201	-1.151	1.273	0.024	-1.088	
ELAIS-UNILEVER	0.194	0.298	0.431	0.241	0.651	0.631	0.905	0.461	0.208	0.165	0.221	0.066	0.000	0.356
t-ratio	1.618	2.136**	2.738*	1.439	4.974*	4.984*	7.148*	3.552*	1.573	1.085	1.510	0.412	-1.056	
ELFICO	0.849	-0.258	-0.588	-0.837	-0.782	-0.844	-0.152	0.727	0.571	-0.053	0.451	0.294	0.000	0.129
t-ratio	3.062*	-0.800	-1.611	-2.159**	-2.577*	-2.875*	-0.517	2.416**	1.865***	-0.150	1.332	0.788	0.124	
ELMEC SPORT	0.791	0.430	0.017	-0.345	-0.013	-0.088	0.432	0.944	0.635	0.603	0.433	0.195	0.000	0.371
t-ratio	4.393*	2.051**	0.073	-1.370	-0.065	-0.464	2.267**	4.834*	3.194*	2.646*	1.966**	0.806	0.737	
ELTRAK	0.341	1.166	0.636	0.191	0.328	0.055	0.670	1.179	0.927	0.875	0.794	0.151	0.000	0.246
t-ratio	1.598	4.692*	2.266**	0.641	1.404	0.242	2.966*	5.093*	3.935*	3.235*	3.041*	0.525	0.314	
EMPORIKI BK.OF GREECE	1.365	-0.238	-0.237	-0.160	-0.211	-0.131	-0.281	-0.302	-0.204	-0.259	0.245	-0.158	0.000	**0.612**
t-ratio	12.380*	-1.854***	-1.631	-1.035	-1.753***	-1.123	-2.407**	-2.530**	-1.679***	-1.858***	1.817***	-1.070	0.080	
EMPORIKOS DESMOS	0.378	-0.289	-0.459	-0.060	-0.170	-0.009	0.276	1.076	0.762	0.708	1.122	0.114	-0.001	0.066
t-ratio	1.019	-0.668	-0.940	-0.115	-0.420	-0.022	0.702	2.672*	1.860***	1.506	2.472**	0.229	-0.913	
ETMA RAYON	0.414	0.769	0.158	-0.017	-0.352	0.044	0.587	1.346	1.331	1.527	1.816	0.970	0.000	0.231
t-ratio	1.569	2.504**	0.455	-0.045	-1.221	0.159	2.105**	4.704*	4.571*	4.571*	5.631*	2.735*	0.074	
EUROHOLDINGS CAP & INV	0.906	-0.001	-0.555	-0.217	-0.597	-0.717	0.031	0.800	0.904	1.376	1.329	0.624	0.000	0.174
t-ratio	2.867*	-0.004	-1.336	-0.490	-1.727***	-2.145**	0.092	2.334**	2.592*	3.439*	3.442*	1.471	0.091	
FANCO	0.252	1.096	0.615	0.515	0.314	0.376	0.766	1.277	1.338	1.928	2.284	1.160	-0.001	0.199
t-ratio	0.847	3.160*	1.570	1.237	0.963	1.192	2.432**	3.955*	4.069*	5.112*	6.274*	2.899*	-1.360	
FG EUROPE	0.217	0.415	0.129	0.412	0.321	0.263	0.847	1.572	1.467	1.155	0.815	0.008	0.001	0.165
t-ratio	0.754	1.234	0.339	1.022	1.018	0.860	2.778*	5.024*	4.606*	3.161*	2.311**	0.020	1.096	
FINTEXPORT	0.680	-0.362	-0.516	-0.364	-0.609	-0.637	0.271	1.015	0.553	0.533	0.650	0.009	0.000	0.202

t-ratio	3.071*	-1.406	-1.773***	-1.176	-2.514**	-2.720*	1.158	4.231*	2.264**	1.902***	2.403**	0.031	0.230	
FLR MLS SARANTOPOULO	-0.103	0.103	0.241	0.041	0.028	0.085	0.992	1.603	1.426	1.116	1.078	0.399	0.000	0.152
t-ratio	-0.434	0.372	0.773	0.122	0.109	0.337	3.953*	6.229*	5.444*	3.714*	3.714*	1.251	-0.172	
FOURLIS HOLDING	0.587	-0.444	-0.449	-0.055	-0.041	0.097	0.501	0.555	0.540	0.888	0.915	0.204	0.000	0.286
t-ratio	3.349*	-2.176**	-1.947***	-0.223	-0.214	0.526	2.706*	2.919*	2.794*	4.001*	4.270*	0.865	0.980	
GEK GROUP	1.220	-1.181	-1.295	-1.231	-1.030	-1.212	-0.605	0.458	0.067	0.271	0.092	-0.252	0.001	0.216
t-ratio	5.890*	-4.899*	-4.755*	-4.252*	-4.545*	-5.530*	-2.765*	2.041**	0.293	1.035	0.364	-0.906	2.447	
GENERAL COMMERC. &IND	0.386	-0.266	-0.186	-0.313	-0.395	-0.374	0.618	1.312	1.225	1.147	1.235	0.621	0.000	0.219
t-ratio	1.651***	-0.978	-0.606	-0.957	-1.545	-1.513	2.500**	5.180*	4.751*	3.876*	4.326*	1.977**	0.363	
GENERAL HELLENIC BANK	1.176	-0.081	-0.080	-0.391	-0.034	-0.134	-0.219	-0.030	-0.100	-0.296	-0.087	-0.509	0.000	0.397
t-ratio	7.733*	-0.457	-0.400	-1.836***	-0.202	-0.835	-1.363	-0.182	-0.594	-1.538	-0.469	-2.491**	0.001	
HELLENIC SUGAR IND.	0.870	0.876	0.699	0.172	-0.013	0.242	0.385	0.217	0.027	0.518	0.824	0.419	-0.001	0.389
t-ratio	4.903*	4.241*	2.994*	0.691	-0.067	1.289	2.051**	1.129	0.136	2.306**	3.798*	1.756***	-1.799	
HERACLES	0.666	0.431	0.624	0.937	0.590	0.298	0.346	0.260	0.138	0.136	0.292	0.055	0.000	**0.442**
t-ratio	4.956*	2.756*	3.531*	4.990*	4.016*	2.097**	2.439**	1.783***	0.932	0.797	1.776***	0.306	-0.762	
HIPPOTOUR	0.000	0.139	0.286	-0.146	-0.010	0.200	1.001	1.232	0.815	0.657	0.570	-0.315	0.000	0.120
t-ratio	0.000	0.520	0.950	-0.455	-0.039	0.826	4.135*	4.964*	3.224*	2.267**	2.038**	-1.023	0.195	
INTERINVEST	0.389	0.883	0.007	-0.201	0.118	-0.231	0.415	0.883	0.817	0.766	1.455	-0.100	0.000	0.219
t-ratio	1.889***	3.686*	0.026	-0.700	0.524	-1.062	1.908***	3.959*	3.600*	2.939*	5.786*	-0.362	-0.089	
INTRACOM	1.378	0.067	-0.233	-0.528	-0.032	-0.412	-0.246	-0.195	-0.010	0.500	-0.036	-0.166	0.000	**0.500**
t-ratio	9.466*	0.396	-1.218	-2.595*	-0.204	-2.672*	-1.599	-1.236	-0.064	2.714*	-0.202	-0.850	-1.009	
IONIAN HOTEL	0.131	0.543	0.214	0.545	0.535	0.678	0.911	1.152	0.679	0.423	0.403	0.391	0.000	0.192
t-ratio	0.625	2.219**	0.775	1.854***	2.328**	3.046*	4.097*	5.055*	2.926*	1.588	1.568	1.385	0.267	
J BOUTARIS & SON HLDG	0.905	0.427	-0.080	-0.272	-0.265	-0.262	0.185	0.573	0.443	0.632	0.491	0.359	-0.001	0.205
t-ratio	3.512*	1.423	-0.237	-0.755	-0.938	-0.962	0.680	2.050**	1.558	1.935***	1.559	1.036	-1.028	
KALPINIS SIMOS	0.546	0.479	0.115	-0.073	-0.001	0.135	0.596	1.119	0.696	0.725	0.541	-0.004	0.000	0.292
t-ratio	2.805*	2.111**	0.449	-0.269	-0.004	0.655	2.894*	5.298*	3.237*	2.939*	2.274**	-0.014	-0.277	
KARELIA TOBACCO	-0.070	0.637	0.488	0.671	0.442	0.609	0.632	1.014	0.685	0.246	0.296	0.191	0.000	0.108
t-ratio	-0.359	2.812*	1.906***	2.467**	2.076**	2.957*	3.073*	4.809*	3.190*	0.998	1.244	0.731	0.394	
KATSELIS SONS	0.456	0.544	0.463	0.174	0.440	0.383	0.455	0.680	0.166	0.000	0.002	-0.046	0.000	0.255
t-ratio	2.650*	2.713*	2.046**	0.722	2.335**	2.104**	2.501**	3.645*	0.875	0.001	0.008	-0.198	-0.492	
KEKROPS	0.707	-0.441	-0.220	-0.176	-0.532	-0.542	-0.065	0.855	0.965	1.118	1.323	0.008	0.001	0.188
t-ratio	2.781*	-1.491	-0.658	-0.496	-1.915***	-2.015**	-0.241	3.103*	3.441*	3.475*	4.259*	0.023	1.223	
KERAMIA ALLATINI	0.659	-0.186	-0.221	0.133	-0.286	-0.329	0.059	0.839	0.339	0.317	0.641	0.142	0.000	0.115
t-ratio	2.382**	-0.579	-0.607	0.343	-0.946	-1.126	0.200	2.798*	1.110	0.904	1.896***	0.382	0.320	
KLONATEX GROUP	0.904	0.342	0.190	-0.346	-0.505	-0.040	-0.033	0.940	0.729	0.437	1.433	0.554	-0.001	0.226
t-ratio	3.286*	1.068	0.525	-0.900	-1.678***	-0.138	-0.113	3.151*	2.402**	1.253	4.262*	1.499	-0.808	
LAMPSA HOTEL	0.669	-0.518	-0.542	-0.830	-0.546	-0.274	0.375	0.466	0.475	0.268	0.308	0.278	0.000	0.176
t-ratio	3.206*	-2.131**	-1.973**	-2.844*	-2.392**	-1.243	1.701***	2.061**	2.064**	1.015	1.207	0.991	0.975	
LEVEDERIS	0.864	0.765	0.264	-0.041	-0.626	-0.361	0.237	0.771	0.636	0.534	0.905	0.472	0.000	0.248
t-ratio	3.553*	2.703*	0.826	-0.121	-2.355**	-1.405	0.923	2.924*	2.371**	1.736***	3.045*	1.445	-0.086	

LOULIS MILLS	0.310	0.964	0.638	0.348	0.353	0.434	0.683	1.034	0.687	0.189	0.428	0.258	0.000	0.270
t-ratio	1.698***	4.539*	2.658*	1.365	1.768***	2.250**	3.542*	5.231*	3.412*	0.818	1.922***	1.054	-0.631	
METKA	0.971	0.685	0.473	0.388	0.161	-0.216	0.126	0.211	0.415	0.446	0.663	0.488	0.000	**0.415**
t-ratio	5.750*	3.485*	2.127**	1.643	0.872	-1.211	0.703	1.150	2.225**	2.086**	3.211*	2.149**	0.681	
MICHANIKI	0.899	0.137	0.437	0.165	0.080	-0.069	0.353	0.516	0.258	0.205	1.168	0.312	-0.001	**0.405**
t-ratio	5.291*	0.694	1.956***	0.695	0.428	-0.385	1.967**	2.804*	1.378	0.952	5.624*	1.365	-1.909	
MOUZAKIS	1.225	-0.137	-0.272	-0.279	-0.657	-0.653	-0.100	0.338	-0.452	-0.381	0.189	0.278	-0.001	0.258
t-ratio	5.897*	-0.565	-0.997	-0.962	-2.891*	-2.969*	-0.456	1.500	-1.970**	-1.447	0.744	0.997	-1.207	
MULTIRAMA	0.103	0.638	0.894	0.653	-0.005	-0.001	0.516	0.992	1.365	1.395	0.603	0.530	0.000	0.111
t-ratio	0.378	2.007**	2.490**	1.713***	-0.017	-0.002	1.790***	3.353*	4.532*	4.038*	1.807***	1.444	0.675	
NATIONAL BK.OF GREECE	1.334	-0.327	-0.109	-0.364	-0.274	-0.128	-0.354	-0.376	-0.266	0.028	0.100	0.044	0.000	**0.672**
t-ratio	14.570*	-3.072*	-0.908	-2.841*	-2.733*	-1.321	-3.653*	-3.784*	-2.635*	0.238	0.897	0.361	1.425	
NEXANS HELLAS	0.779	0.733	0.520	0.457	0.473	-0.046	0.342	0.533	0.140	0.372	0.416	0.293	-0.001	0.305
t-ratio	3.918*	3.167*	1.987**	1.642	2.175**	-0.218	1.628	2.471**	0.639	1.479	1.712***	1.095	-2.202	
PARNASSOS ENTERPRISES	1.032	-0.993	-0.505	-0.275	-0.377	-0.720	-0.082	0.347	0.148	0.487	0.924	0.407	0.000	0.139
t-ratio	3.495*	-2.889*	-1.299	-0.667	-1.165	-2.304**	-0.263	1.085	0.454	1.301	2.560**	1.026	-0.128	
PETZETAKIS	1.221	-0.263	0.060	-0.386	-0.314	-0.517	-0.220	0.082	-0.096	0.493	0.950	0.180	-0.001	0.316
t-ratio	6.181*	-1.145	0.230	-1.397	-1.453	-2.474**	-1.056	0.383	-0.442	1.973**	3.935*	0.679	-1.179	
PG NIKAS	0.553	0.152	0.346	-0.076	0.334	0.241	0.409	0.778	0.524	0.092	0.117	-0.263	0.000	0.303
t-ratio	3.335*	0.788	1.585	-0.328	1.841***	1.373	2.334**	4.324*	2.858*	0.439	0.578	-1.179	0.120	
PHOENIX METROLIFE	0.722	0.262	-0.022	-0.696	-0.745	-0.621	-0.119	0.366	0.031	0.222	1.510	0.903	0.000	0.186
t-ratio	3.440*	1.072	-0.078	-2.374**	-3.247*	-2.796*	-0.534	1.607	0.132	0.834	5.889*	3.203*	-0.197	
PIPE WORKS	0.469	-0.185	-0.312	0.077	-0.519	-0.421	0.285	0.687	0.991	1.274	0.787	0.085	0.000	0.167
t-ratio	2.081**	-0.706	-1.052	0.245	-2.106**	-1.765***	1.197	2.812*	3.986*	4.466*	2.859*	0.280	0.136	
PROODEFTIKI	0.937	0.783	0.678	0.715	0.162	-0.414	0.214	0.842	0.707	1.038	1.479	0.238	-0.001	0.331
t-ratio	3.974*	2.853*	2.187**	2.169**	0.630	-1.661***	0.858	3.295*	2.719*	3.477*	5.133*	0.753	-1.468	
REDS	0.584	0.548	0.520	0.084	-0.132	0.027	0.609	1.210	0.855	0.667	0.970	0.018	0.000	0.307
t-ratio	2.847*	2.296**	1.929***	0.294	-0.587	0.122	2.810*	5.441*	3.776*	2.570**	3.866*	0.065	-0.472	
RIDENCO	0.364	-0.106	0.216	0.120	0.346	-0.170	0.541	1.204	1.177	1.189	1.102	0.761	0.001	0.082
t-ratio	0.898	-0.224	0.405	0.212	0.780	-0.395	1.264	2.739*	2.631*	2.317**	2.225**	1.398	1.012	
RILKEN	0.204	0.996	0.842	0.827	0.706	0.679	0.729	0.966	1.199	1.443	1.081	0.391	0.000	0.272
t-ratio	0.986	4.138*	3.097*	2.860*	3.119*	3.105*	3.335*	4.309*	5.254*	5.510*	4.277*	1.408	-0.568	
SANYO HELLAS	1.103	0.180	-0.150	-0.473	-0.388	-0.515	0.078	0.634	0.423	0.884	1.201	0.804	0.000	0.258
t-ratio	4.204*	0.589	-0.435	-1.291	-1.353	-1.856***	0.282	2.230**	1.461	2.662*	3.745*	2.281**	-0.035	
SATO	0.308	0.218	0.467	0.582	0.108	0.119	0.604	1.371	1.196	1.355	1.759	0.740	0.000	0.228
t-ratio	1.286	0.782	1.480	1.734***	0.411	0.467	2.382**	5.272*	4.519*	4.460*	6.001*	2.296**	0.232	
SELECTED TEXTILE	0.640	0.492	-0.002	0.032	0.134	0.112	0.503	1.038	0.523	0.686	1.181	0.758	-0.001	0.258
t-ratio	2.760*	1.823***	-0.005	0.097	0.529	0.458	2.052**	4.127*	2.044**	2.336**	4.165*	2.431**	-1.120	
SHEET STEEL	0.281	0.407	0.639	0.640	0.286	0.143	0.675	1.407	1.135	1.230	1.703	0.693	0.000	0.194
t-ratio	1.058	1.317	1.831***	1.723***	0.985	0.510	2.405**	4.890*	3.875*	3.660*	5.250*	1.942***	-0.310	
SHELMAN	0.433	0.804	0.196	0.293	0.524	0.290	0.655	0.883	0.612	0.740	1.044	0.462	0.000	0.301

t-ratio	2.313**	3.686*	0.795	1.117	2.554**	1.463	3.307*	4.343*	2.961*	3.116*	4.556*	1.833***	-0.826	
TITAN CEMENT	0.734	0.111	-0.127	-0.021	0.326	0.290	0.170	0.025	0.120	-0.158	-0.066	-0.244	0.000	**0.481**
t-ratio	6.849*	0.889	-0.902	-0.137	2.782*	2.552**	1.497	0.211	1.012	-1.162	-0.506	-1.696***	1.356	
TRIA ALPHA	0.716	-0.719	-0.763	-0.762	-0.697	-0.700	-0.334	0.478	0.403	0.181	0.098	-0.502	0.000	0.070
t-ratio	2.563**	-2.213**	-2.077**	-1.950***	-2.283**	-2.368**	-1.132	1.578	1.308	0.511	0.288	-1.338	0.214	
UNCLE STATHIS	0.175	0.721	0.564	0.487	0.510	0.296	0.738	0.762	0.448	0.452	0.456	0.113	0.000	0.195
t-ratio	0.998	3.534*	2.448**	1.990**	2.662*	1.600	3.988*	4.011*	2.319**	2.038**	2.132**	0.479	-0.103	
VIOTER	0.709	1.063	0.608	0.206	-0.024	-0.234	0.541	1.010	0.689	0.760	0.824	0.232	0.000	0.333
t-ratio	3.458*	4.453*	2.254**	0.718	-0.107	-1.080	2.495**	4.546*	3.046*	2.928*	3.290*	0.843	-0.554	
VIS-CONTAINER	0.258	0.208	0.623	0.416	0.404	0.288	0.741	1.465	1.383	0.667	0.361	0.091	0.000	0.199
t-ratio	1.047	0.724	1.918***	1.207	1.496	1.102	2.839*	5.474*	5.080*	2.135**	1.198	0.275	0.316	
XYLEMBORIA	0.130	0.219	0.262	0.128	0.331	0.115	0.626	1.545	1.026	0.884	0.488	0.391	0.001	0.155
t-ratio	0.551	0.796	0.843	0.389	1.278	0.459	2.506**	6.029*	3.932*	2.952*	1.688***	1.230	1.108	
ZAMPA	0.299	0.164	-0.120	0.048	-0.233	-0.195	0.315	0.965	0.907	0.986	0.885	0.201	0.000	0.135
t-ratio	1.298	0.612	-0.396	0.149	-0.924	-0.801	1.294	3.859*	3.564*	3.377*	3.142*	0.649	0.464	
Average (without the t-ratios)	**0.645**	**0.213**	**0.071**	**0.005**	**-0.011**	**-0.053**	**0.301**	**0.688**	**0.546**	**0.550**	**0.683**	**0.215**	**0.000**	**0.271**
Variance (without the t-ratios)	**0.152**	**0.246**	**0.215**	**0.197**	**0.177**	**0.164**	**0.161**	**0.252**	**0.224**	**0.260**	**0.260**	**0.103**	**0.000**	**0.015**

Notes:

For each company, in the first line is presented its beta coefficient for each variable, while on the second line is the t-ratio of the corresponding variable.

* = statistically significant at 1% level of significance
** = statistically significant at 5% level of significance
*** = statistically significant at 10% level of significance

Table 4

(Daily Data)

"Please refer at the bottom of the table for explanation of the data included in each of the table's columns"

	Period B	***OLS Vasicek for period B***	***S&W Vasicek for period B***	**MSE** OLS Vas. B	**MSE** S&W Vas. B
A-B VASSILOPOULOS	0.722	0.698	0.656	0.00055	0.00433
AEGEK	1.219	1.162	1.225	0.00327	0.00004
AEOLIAN INVESTMENT FUND	1.145	0.837	0.899	0.09515	0.06041
ALLATINI	1.096	0.609	0.627	0.23681	0.21946
ALPHA BANK	1.060	1.004	1.096	0.00313	0.00130
ALPHA LEASING	0.964	0.774	0.746	0.03624	0.04752
ALUMINIUM OF GREECE	0.816	0.623	0.619	0.03722	0.03886
ATHENS MEDICAL	0.993	1.106	1.066	0.01281	0.00535
ATTICA HOLDINGS	1.075	0.868	0.828	0.04280	0.06102
BALKAN EXPORT	0.541	1.044	1.057	0.25280	0.26646
BANK OF ATTICA	1.137	1.068	0.947	0.00472	0.03603
BANK OF GREECE	0.817	0.710	0.744	0.01125	0.00526
BANK OF PIRAEUS	0.999	0.968	0.987	0.00096	0.00013
BENRUBI	0.902	0.362	0.398	0.29259	0.25458
BIOKARPET	0.855	0.651	0.596	0.04177	0.06713
BIOSSOL	1.103	0.823	0.940	0.07813	0.02661
CHATZIIOANNOY HDG.	0.880	0.524	0.520	0.12716	0.12971
COCA-COLA HLC.BT.	0.876	0.812	0.846	0.00415	0.00091
CROWN HELLAS CAN	0.808	0.864	0.803	0.00316	0.00002
CYCLON HELLAS	0.995	0.742	0.887	0.06395	0.01155
DELTA HOLDINGS	0.943	0.864	0.813	0.00619	0.01682
DIAS	1.116	0.709	0.666	0.16571	0.20211
EFG EUROBANK ERGASIAS	0.802	0.302	0.432	0.25047	0.13744
EGNATIA BANK	1.085	0.788	0.715	0.08842	0.13723
ELAIS-UNILEVER	0.802	0.678	0.658	0.01546	0.02070
ELFICO	0.793	0.250	0.355	0.29438	0.19125
ELMEC SPORT	1.206	0.867	0.824	0.11486	0.14533
ELTRAK	0.973	0.923	0.922	0.00252	0.00262
EMPORIKI BK.OF GREECE	1.138	1.145	1.101	0.00005	0.00134
EMPORIKOS DESMOS	0.817	0.220	0.227	0.35701	0.34832
ETMA RAYON	1.121	0.482	0.485	0.40853	0.40421
EUROHOLDINGS CAP & INV C	1.016	0.529	0.661	0.23726	0.12600
FANCO	1.102	0.837	0.856	0.06996	0.06043
FG EUROPE	1.143	0.557	0.611	0.34379	0.28300
FINTEXPORT	0.877	0.186	0.245	0.47694	0.39873

FLR MLS C SARANTOPOULOS	0.813	-0.003	-0.042	0.66569	0.73212
FOURLIS HOLDING	0.982	0.389	0.355	0.35254	0.39427
GEK GROUP OF COMPANIES	0.766	0.115	0.097	0.42448	0.44793
GENERAL COMMERC. & IND	0.948	0.087	0.133	0.74127	0.66430
GENERAL HELLENIC BANK	1.043	1.080	1.151	0.00133	0.01163
HELLENIC SUGAR IND.	1.114	1.204	1.123	0.00822	0.00009
HERACLES	0.944	1.243	1.177	0.08950	0.05421
HIPPOTOUR	0.772	0.073	0.088	0.48845	0.46783
INTERINVEST	0.773	0.670	0.742	0.01053	0.00095
INTRACOM	1.132	1.286	1.255	0.02377	0.01525
IONIAN HOTEL	0.982	0.631	0.479	0.12338	0.25272
J BOUTARIS & SON HLDG	1.077	0.849	0.693	0.05202	0.14754
KALPINIS SIMOS	1.128	0.687	0.815	0.19503	0.09812
KARELIA TOBACCO	0.644	0.462	0.516	0.03304	0.01636
KATSELIS SONS	0.887	0.898	0.842	0.00011	0.00206
KEKROPS	0.864	0.292	0.244	0.32689	0.38367
KERAMIA ALLATINI	0.810	0.458	0.504	0.12402	0.09324
KLONATEX GROUP OF COS	1.203	0.738	0.608	0.21594	0.35415
LAMPSA HOTEL	0.881	0.118	0.165	0.58168	0.51309
LEVEDERIS	1.098	0.794	0.854	0.09237	0.05938
LOULIS MILLS	0.991	0.864	0.699	0.01591	0.08485
METKA	1.058	1.330	1.249	0.07404	0.03647
MICHANIKI	1.141	1.046	1.113	0.00897	0.00075
MOUZAKIS	0.987	0.798	0.693	0.03555	0.08645
MULTIRAMA	0.705	0.476	0.493	0.05273	0.04508
NATIONAL BK.OF GREECE	1.060	1.055	1.084	0.00002	0.00059
NEXANS HELLAS	1.008	1.314	1.278	0.09370	0.07319
PARNASSOS ENTERPRISES	0.885	0.486	0.463	0.15973	0.17827
PETZETAKIS	0.993	0.959	0.964	0.00120	0.00087
PG NIKAS	1.008	0.798	0.877	0.04426	0.01737
PHOENIX METROLIFE	0.575	0.366	0.472	0.04374	0.01066
PIPE WORKS	0.742	0.142	0.109	0.36068	0.40150
PROODEFTIKI	1.174	1.376	1.428	0.04110	0.06459
REDS	1.184	0.747	0.679	0.19092	0.25427
RIDENCO	0.933	0.572	0.428	0.13026	0.25507
RILKEN	1.047	1.014	0.885	0.00109	0.02637
SANYO HELLAS	1.175	0.885	0.948	0.08369	0.05114
SATO	1.025	0.552	0.612	0.22430	0.17052
SELECTED TEXTILE	1.139	0.842	0.766	0.08826	0.13915
SHEET STEEL	1.025	0.684	0.631	0.11583	0.15506
SHELMAN	1.017	0.958	1.022	0.00350	0.00002

TITAN CEMENT	0.902	0.903	0.877	0.00000	0.00061
TRIA ALPHA	0.565	0.020	-0.029	0.29619	0.35294
UNCLE STATHIS	0.733	0.747	0.709	0.00020	0.00059
VIOTER	1.135	1.085	1.080	0.00254	0.00301
VIS-CONTAINER	1.123	0.641	0.738	0.23223	0.14757
XYLEMBORIA	0.861	0.410	0.412	0.20338	0.20155
ZAMPA	0.695	0.228	0.276	0.21895	0.17560
			MSE	**0.13799**	**0.13681**

Explanations:

- Column **"Period B" :** Includes the beta coefficient of each stock estimated by using the classical OLS model by using **daily data** for Period B (i.e. 1/1/1998 – 31/12/2001).
- Column **"*OLS Vasicek for period B*" :** Includes the predicted beta coefficients of each stock for the Period B (i.e. 1/1/1998 – 31/12/2001), by using the Vasicek's method. In the Vasicek's formula we have used betas of Period A (i.e. 1/1/1994 – 31/12/1997) estimated by the **OLS** method.
- Column **"*S&W Vasicek for period B*" :** Includes the predicted beta coefficients of each stock for the Period B (i.e. 1/1/1998 – 31/12/2001), by using the Vasicek's method. In the Vasicek's formula we have used betas of Period A (i.e. 1/1/1994 – 31/12/1997) estimated by the **S&W** method.
- Column **"*MSE OLS Vas. B*" :** Includes the squared difference between the estimated beta for each stock printed in Column **"Period B"** and the corresponding predicted by using the "OLS-Vasicek" method. which is printed in the Column **"*OLS Vasicek for period B*"**. At the bottom of the table it is estimated the average of the values of this column, which represents the **MSE** by using this method.
- Column **"*MSE S&W Vas. B*" :** Includes the squared difference between the estimated beta for each stock printed in Column **"Period B"** and the corresponding predicted by using the "S&W-Vasicek" method. which is printed in the Column **"*S&W Vasicek for period B*"**. At the bottom of the table it is estimated the average of the values of this column, which represents the **MSE** by using this method.

Table 5
(Daily Data)

"Please refer at the bottom of the table for explanation of the data included in each of the table's columns"

	Period C	OLS Vasicek for period C	S&W Vasicek for period C	Blume OLS Period C	Blume S&W Period C
A-B VASSILOPOULOS	0.491	0.735	0.716	0.964	0.982
AEGEK	1.710	1.201	1.170	1.096	1.068
AEOLIAN INVESTMENT FUND	0.686	1.134	1.184	1.077	1.071
ALLATINI	0.816	1.083	1.074	1.063	1.050
ALPHA BANK	1.291	1.058	1.055	1.054	1.045
ALPHA LEASING	0.805	0.964	0.946	1.028	1.025
ALUMINIUM OF GREECE	0.857	0.822	0.878	0.989	1.013
ATHENS MEDICAL	1.346	0.992	0.986	1.036	1.033
ATTICA HOLDINGS	1.236	1.070	1.083	1.058	1.051
BALKAN EXPORT	1.303	0.628	0.446	0.915	0.914
BANK OF ATTICA	1.147	1.129	1.106	1.074	1.055
BANK OF GREECE	0.603	0.823	0.873	0.989	1.012
BANK OF PIRAEUS	1.146	0.998	1.001	1.038	1.035
BENRUBI	0.531	0.909	0.963	1.012	1.028
BIOKARPET	1.064	0.861	0.852	0.999	1.007
BIOSSOL CR	1.601	1.081	1.075	1.065	1.051
CHATZIIOANNOY HDG.	1.150	0.887	0.950	1.006	1.026
COCA-COLA HLC.BT.	0.765	0.879	0.862	1.005	1.010
CROWN HELLAS CAN	0.372	0.814	0.868	0.987	1.011
CYCLON HELLAS	1.300	0.991	0.998	1.036	1.035
DELTA HOLDINGS	0.690	0.944	0.979	1.023	1.031
DIAS	1.236	1.101	1.247	1.069	1.084
EFG EUROBANK ERGASIAS	1.082	0.810	0.829	0.985	1.003
EGNATIA BANK	1.141	1.079	1.086	1.061	1.052
ELAIS-UNILEVER	0.328	0.808	0.759	0.985	0.991
ELFICO	1.055	0.813	0.800	0.983	0.995
ELMEC SPORT	1.151	1.186	1.154	1.093	1.065
ELTRAK CR	0.891	0.972	1.012	1.031	1.038
EMPORIKI BK.OF GREECE	1.344	1.134	1.161	1.075	1.065
EMPORIKOS DESMOS CR	0.986	0.841	0.797	0.989	0.993
ETMA RAYON	1.668	1.098	1.198	1.070	1.077
EUROHOLDINGS CAP & INV C	1.886	1.008	1.041	1.042	1.044
FANCO	1.826	1.083	1.131	1.065	1.062
FG EUROPE	0.824	1.115	1.216	1.076	1.081
FINTEXPORT	1.058	0.886	1.076	1.005	1.050

FLR MLS C SARANTOPOULOS	0.665	0.832	0.983	0.988	1.032
FOURLIS HOLDING	1.188	0.981	0.977	1.033	1.031
GEK GROUP OF COMPANIES	1.280	0.785	0.820	0.976	1.000
GENERAL COMMERC. & IND	1.263	0.950	1.003	1.024	1.036
GENERAL HELLENIC BANK	0.958	1.040	1.005	1.049	1.036
HELLENIC SUGAR IND.	1.386	1.105	1.091	1.068	1.053
HERACLES	0.816	0.944	0.918	1.023	1.020
HIPPOTOUR	0.318	0.790	0.801	0.977	0.997
INTERINVEST	1.083	0.788	0.784	0.977	0.994
INTRACOM	1.476	1.126	1.068	1.073	1.048
IONIAN HOTEL	0.470	0.980	1.083	1.033	1.051
J BOUTARIS & SON HLDG	1.328	1.063	1.068	1.059	1.049
KALPINIS SIMOS	0.934	1.113	1.113	1.072	1.058
KARELIA TOBACCO	0.140	0.673	0.831	0.943	1.003
KATSELIS SONS CR	0.447	0.892	0.904	1.008	1.017
KEKROPS	1.482	0.876	0.921	1.001	1.020
KERAMIA ALLATINI	1.003	0.826	0.911	0.987	1.018
KLONATEX GROUP OF COS	1.638	1.173	1.160	1.092	1.068
LAMPSA HOTEL	0.908	0.890	0.886	1.006	1.013
LEVEDERIS	1.425	1.082	1.109	1.064	1.057
LOULIS MILLS	0.565	0.989	1.015	1.035	1.038
METKA	1.425	1.052	0.983	1.053	1.032
MICHANIKI	1.418	1.130	1.165	1.075	1.067
MOUZAKIS	1.245	0.985	1.077	1.034	1.050
MULTIRAMA	0.814	0.746	0.774	0.959	0.988
NATIONAL BK.OF GREECE	1.386	1.058	1.088	1.054	1.051
NEXANS HELLAS	1.090	1.005	1.061	1.040	1.047
PARNASSOS ENTERPRISES	1.571	0.898	0.966	1.007	1.028
PETZETAKIS	1.724	0.991	1.006	1.036	1.037
PG NIKAS	0.562	1.006	1.070	1.040	1.049
PHOENIX METROLIFE	1.495	0.599	0.620	0.925	0.964
PIPE WORKS	1.117	0.764	0.841	0.969	1.004
PROODEFTIKI	1.788	1.151	1.095	1.084	1.055
REDS	1.107	1.164	1.132	1.087	1.061
RIDENCO	1.239	0.940	1.023	1.020	1.042
RILKEN	1.063	1.039	1.021	1.050	1.040
SANYO HELLAS	1.933	1.158	1.102	1.084	1.055
SATO	1.446	1.018	1.028	1.045	1.041
SELECTED TEXTILE	1.398	1.124	1.178	1.075	1.070
SHEET STEEL	1.358	1.017	1.118	1.044	1.059
SHELMAN	1.095	1.014	1.029	1.043	1.041

TITAN CEMENT	0.617	0.903	0.905	1.012	1.018
TRIA ALPHA	0.701	0.613	0.695	0.922	0.975
UNCLE STATHIS	0.481	0.747	0.741	0.967	0.986
VIOTER	1.253	1.117	1.074	1.074	1.050
VIS-CONTAINER	0.591	1.104	1.065	1.071	1.049
XYLEMBORIA	0.630	0.873	0.988	1.001	1.033
ZAMPA	0.925	0.722	0.736	0.957	0.984

Explanations:

- Column **"Period C" :** Includes the beta coefficient of each stock estimated by using the classical OLS model by using **daily data** for Period C (i.e. 1/1/2002 – 31/12/2005).
- Column **"*OLS Vasicek for period C*" :** Includes the predicted beta coefficients of each stock for the Period C (i.e. 1/1/2002 – 31/12/2005), by using the Vasicek's method. In the Vasicek's formula we have used betas of Period B (i.e. 1/1/1998 – 31/12/2001) estimated by the **OLS** method.
- Column **"*S&W Vasicek for period C*" :** Includes the predicted beta coefficients of each stock for the Period C (i.e. 1/1/2002 – 31/12/2005), by using the Vasicek's method. In the Vasicek's formula we have used betas of Period B (i.e. 1/1/1998 – 31/12/2001) estimated by the **S&W** method.
- Column **"*Blume OLS period C*" :** Includes the predicted beta coefficients of each stock for the Period C (i.e. 1/1/2002 – 31/12/2005), by using the Blume's method. In the Blume's method we have used betas of Period A (i.e. 1/1/1994 – 31/12/1997) and Period B (i.e. 1/1/1998 – 31/12/2001) estimated by the **OLS** method.
- Column **"*Blume S&W period C*" :** Includes the predicted beta coefficients of each stock for the Period C (i.e. 1/1/2002 – 31/12/2005), by using the Blume's method. In the Blume's method we have used betas of Period A (i.e. 1/1/1994 – 31/12/1997) and Period B (i.e. 1/1/1998 – 31/12/2001) estimated by the **S&W** method.

Table 6
(Daily Data)

"Please refer at the bottom of the table for explanation of the data included in each of the table's columns"

	MSE OLS Vas. C	**MSE** S&W Vas. C	**MSE** OLS Blume C	**MSE** S&W Blume C
A-B VASSILOPOULOS	0.05950	0.05063	0.22358	0.24130
AEGEK	0.25884	0.29188	0.37675	0.41202
AEOLIAN INVESTMENT FUND	0.20044	0.24854	0.15267	0.14807
ALLATINI	0.07151	0.06652	0.06123	0.05474
ALPHA BANK	0.05408	0.05572	0.05622	0.06041
ALPHA LEASING	0.02525	0.01992	0.04977	0.04837
ALUMINIUM OF GREECE	0.00126	0.00044	0.01734	0.02419
ATHENS MEDICAL	0.12506	0.12967	0.09586	0.09806
ATTICA HOLDINGS	0.02765	0.02350	0.03190	0.03447
BALKAN EXPORT	0.45584	0.73521	0.15016	0.15121
BANK OF ATTICA	0.00032	0.00165	0.00525	0.00839
BANK OF GREECE	0.04813	0.07293	0.14866	0.16674
BANK OF PIRAEUS	0.02196	0.02086	0.01173	0.01219
BENRUBI	0.14268	0.18676	0.23124	0.24713
BIOKARPET	0.04129	0.04516	0.00421	0.00323
BIOSSOL	0.27089	0.27756	0.28751	0.30271
CHATZIIOANNOY HDG.	0.06941	0.03989	0.02081	0.01548
COCA-COLA HLC.BT.	0.01302	0.00946	0.05776	0.06017
CROWN HELLAS CAN	0.19526	0.24582	0.37807	0.40827
CYCLON HELLAS	0.09605	0.09168	0.06969	0.07045
DELTA HOLDINGS	0.06431	0.08350	0.11065	0.11649
DIAS	0.01814	0.00013	0.02795	0.02302
EFG EUROBANK ERGASIAS	0.07382	0.06398	0.00940	0.00621
EGNATIA BANK	0.00383	0.00292	0.00638	0.00790
ELAIS-UNILEVER	0.22972	0.18504	0.43134	0.43876
ELFICO	0.05890	0.06510	0.00531	0.00360
ELMEC SPORT	0.00129	0.00001	0.00335	0.00725
ELTRAK	0.00654	0.01457	0.01953	0.02155
EMPORIKI BK.OF GREECE	0.04406	0.03330	0.07254	0.07788
EMPORIKOS DESMOS	0.02113	0.03590	0.00001	0.00005
ETMA RAYON	0.32421	0.22042	0.35707	0.34934
EUROHOLDINGS CAP & INV C	0.77070	0.71295	0.71131	0.70788
FANCO	0.55085	0.48240	0.57847	0.58251
FG EUROPE	0.08477	0.15429	0.06369	0.06631
FINTEXPORT	0.02969	0.00031	0.00281	0.00006

FLR MLS C SARANTOPOULOS	0.02773	0.10081	0.10412	0.13440
FOURLIS HOLDING	0.04294	0.04455	0.02406	0.02476
GEK GROUP OF COMPANIES	0.24484	0.21138	0.09261	0.07820
GENERAL COMMERC. & IND	0.09834	0.06797	0.05729	0.05167
GENERAL HELLENIC BANK	0.00674	0.00225	0.00843	0.00618
HELLENIC SUGAR IND.	0.07942	0.08713	0.10129	0.11137
HERACLES	0.01658	0.01052	0.04296	0.04180
HIPPOTOUR	0.22296	0.23378	0.43491	0.46104
INTERINVEST	0.08690	0.08922	0.01116	0.00794
INTRACOM	0.12217	0.16578	0.16207	0.18284
IONIAN HOTEL	0.26020	0.37595	0.31684	0.33785
J BOUTARIS & SON HLDG	0.06987	0.06763	0.07252	0.07762
KALPINIS SIMOS	0.03184	0.03201	0.01896	0.01522
KARELIA TOBACCO	0.28351	0.47682	0.64443	0.74371
KATSELIS SONS	0.19743	0.20833	0.31412	0.32459
KEKROPS	0.36782	0.31440	0.23103	0.21392
KERAMIA ALLATINI	0.03146	0.00844	0.00026	0.00021
KLONATEX GROUP OF COS	0.21605	0.22812	0.29810	0.32459
LAMPSA HOTEL	0.00033	0.00047	0.00967	0.01103
LEVEDERIS	0.11790	0.09996	0.13039	0.13508
LOULIS MILLS	0.17951	0.20221	0.22116	0.22374
METKA	0.13906	0.19564	0.13823	0.15456
MICHANIKI	0.08321	0.06409	0.11753	0.12344
MOUZAKIS	0.06790	0.02832	0.04445	0.03800
MULTIRAMA	0.00454	0.00158	0.02119	0.03050
NATIONAL BK.OF GREECE	0.10725	0.08858	0.11012	0.11184
NEXANS HELLAS	0.00723	0.00084	0.00248	0.00184
PARNASSOS ENTERPRISES	0.45370	0.36641	0.31810	0.29468
PETZETAKIS	0.53722	0.51511	0.47328	0.47267
PG NIKAS	0.19629	0.25751	0.22817	0.23634
PHOENIX METROLIFE	0.80405	0.76673	0.32572	0.28242
PIPE WORKS	0.12457	0.07622	0.02183	0.01270
PROODEFTIKI	0.40629	0.48037	0.49540	0.53796
REDS	0.00329	0.00065	0.00040	0.00206
RIDENCO	0.08903	0.04657	0.04787	0.03890
RILKEN	0.00056	0.00175	0.00015	0.00054
SANYO HELLAS	0.60128	0.69115	0.72050	0.77090
SATO	0.18277	0.17453	0.16088	0.16377
SELECTED TEXTILE	0.07518	0.04850	0.10445	0.10755
SHEET STEEL	0.11638	0.05753	0.09822	0.08908
SHELMAN	0.00648	0.00435	0.00275	0.00294

TITAN CEMENT	0.08214	0.08334	0.15620	0.16112
TRIA ALPHA	0.00760	0.00003	0.04893	0.07507
UNCLE STATHIS	0.07059	0.06733	0.23543	0.25497
VIOTER	0.01862	0.03215	0.03223	0.04128
VIS-CONTAINER	0.26335	0.22463	0.22977	0.20920
XYLEMBORIA	0.05887	0.12787	0.13747	0.16235
ZAMPA	0.04094	0.03555	0.00102	0.00348
MSE	**0.14112**	**0.14619**	**0.14939**	**0.15499**
			OLS	**S&W**
	Average Vasicek MSE for Periods B&C		**0.13956**	**0.14150**

Explanations:

- Column **“*MSE OLS Vas. C*” :** Includes the squared difference between the estimated beta for each stock printed in Column **“Period C”** of the Table 5 and the corresponding predicted by using the “OLS-Vasicek” method. which is printed in the Column **“*OLS Vasicek for period C*”** of the Table 5. At the bottom of the table it is estimated the average of the values of this column, which represents the **MSE** by using this method.
- Column **“*MSE S&W Vas. C*” :** Includes the squared difference between the estimated beta for each stock printed in Column **“Period C”** of the Table 5 and the corresponding predicted by using the “S&W-Vasicek” method. which is printed in the Column **“*S&W Vasicek for period C*”** of the Table 5. At the bottom of the table it is estimated the average of the values of this column, which represents the **MSE** by using this method.
- Column **“*MSE OLS Blume C*” :** Includes the squared difference between the estimated beta for each stock printed in Column **“Period C”** of the Table 5 and the corresponding predicted by using the “Blume-OLS” method. which is printed in the Column **“*Blume-OLS period C*”** of the Table 5. At the bottom of the table it is estimated the average of the values of this column, which represents the **MSE** by using this method.
- Column **“*MSE S&W Blume C*” :** Includes the squared difference between the estimated beta for each stock printed in Column **“Period C”** of the Table 5 and the corresponding predicted by using the “Blume-S&W” method. which is printed in the Column **“*Blume-S&W for period C*”** of the Table 5. At the bottom of the table it is estimated the average of the values of this column, which represents the **MSE** by using this method.

<u>**Table 7**</u>

(Monthly Data)

"Please refer at the bottom of the table for explanation of the data included in each of the table's columns"

	Period B	***OLS Vasicek for period B***	**MSE** OLS Vas. B
A-B VASSILOPOULOS	0.678	0.559	0.01421
AEGEK	1.239	1.346	0.01149
AEOLIAN INVESTMENT FUND	1.183	0.764	0.17584
ALLATINI	1.158	0.769	0.15110
ALPHA BANK	1.112	0.991	0.01467
ALPHA LEASING	1.059	0.804	0.06491
ALUMINIUM OF GREECE	1.022	0.838	0.03380
ATHENS MEDICAL	1.051	0.829	0.04917
ATTICA HOLDINGS	0.927	0.856	0.00505
BALKAN EXPORT	0.701	0.793	0.00837
BANK OF ATTICA	1.157	0.919	0.05648
BANK OF GREECE	0.857	0.618	0.05730
BANK OF PIRAEUS	1.261	1.089	0.02980
BENRUBI	1.026	0.160	0.75058
BIOKARPET	0.941	0.653	0.08330
BIOSSOL	1.054	0.851	0.04102
CHATZIIOANNOY HDG.	0.862	0.215	0.41851
COCA-COLA HLC.BT.	0.798	0.860	0.00374
CROWN HELLAS CAN	0.885	0.766	0.01404
CYCLON HELLAS	0.835	0.581	0.06428
DELTA HOLDINGS	1.005	0.778	0.05188
DIAS	1.378	0.512	0.74992
EFG EUROBANK ERGASIAS	0.470	0.548	0.00599
EGNATIA BANK	0.912	0.842	0.00487
ELAIS-UNILEVER	0.644	0.782	0.01895
ELFICO	0.763	0.414	0.12197
ELMEC SPORT	1.007	0.541	0.21691
ELTRAK	1.362	0.662	0.48953
EMPORIKI BK.OF GREECE	1.181	1.038	0.02050
EMPORIKOS DESMOS	1.114	0.764	0.12241
ETMA RAYON	1.294	0.327	0.93439
EUROHOLDINGS CAP & INV C	1.926	0.645	1.64084
FANCO	0.951	0.687	0.06992
FG EUROPE	1.143	0.468	0.45518

FINTEXPORT	1.543	0.729	0.66323
FLR MLS C SARANTOPOULOS	1.175	0.151	1.04793
FOURLIS HOLDING	1.094	0.357	0.54434
GEK GROUP OF COMPANIES	0.973	0.214	0.57578
GENERAL COMMERCIAL & IND	1.416	0.607	0.65478
GENERAL HELLENIC BANK	1.005	1.086	0.00661
HELLENIC SUGAR IND.	1.389	0.868	0.27210
HERACLES	0.789	1.056	0.07160
HIPPOTOUR	0.994	0.267	0.52720
INTERINVEST	0.954	0.739	0.04655
INTRACOM	0.973	1.338	0.13320
IONIAN HOTEL	0.922	0.620	0.09095
J BOUTARIS & SON HLDG	0.772	0.452	0.10228
KALPINIS SIMOS	0.868	0.505	0.13235
KARELIA TOBACCO	0.711	0.455	0.06527
KATSELIS SONS	0.984	0.564	0.17557
KEKROPS	0.815	0.634	0.03270
KERAMIA ALLATINI	0.890	0.618	0.07427
KLONATEX GROUP OF COS	1.391	0.192	1.43978
LAMPSA HOTEL	1.312	0.492	0.67316
LEVEDERIS	1.144	0.605	0.29022
LOULIS MILLS	0.809	0.536	0.07454
METKA	1.043	0.942	0.01032
MICHANIKI	1.428	1.330	0.00960
MOUZAKIS	0.955	0.372	0.34010
MULTIRAMA	0.775	0.444	0.10989
NATIONAL BK.OF GREECE	1.317	1.135	0.03337
NEXANS HELLAS	1.018	1.515	0.24772
PARNASSOS ENTERPRISES	1.029	0.422	0.36884
PETZETAKIS	0.720	0.653	0.00456
PG NIKAS	1.214	0.784	0.18522
PHOENIX METROLIFE	0.489	0.428	0.00379
PIPE WORKS	0.845	0.381	0.21480
PROODEFTIKI	1.271	1.017	0.06417
REDS	0.939	0.828	0.01217
RIDENCO	1.121	0.563	0.31095
RILKEN	0.587	0.640	0.00282
SANYO HELLAS	1.096	0.709	0.15006
SATO	1.307	0.938	0.13628
SELECTED TEXTILE	1.126	0.248	0.77061
SHEET STEEL	1.222	0.505	0.51323

SHELMAN	1.055	0.801	0.06455
TITAN CEMENT	0.840	0.900	0.00366
TRIA ALPHA	0.749	0.342	0.16604
UNCLE STATHIS	0.665	0.482	0.03332
VIOTER	1.142	0.846	0.08796
VIS-CONTAINER	1.159	0.783	0.14127
XYLEMBORIA	0.839	0.367	0.22288
ZAMPA	0.723	0.330	0.15454
		MSE	**0.22901**

Explanations:

- Column **"Period B" :** Includes the beta coefficient of each stock estimated by using the classical OLS model by using **monthly data** for Period B (i.e. 1/1/1998 – 31/12/2001).
- Column **"*OLS Vasicek for period B*" :** Includes the predicted beta coefficients of each stock for the Period B (i.e. 1/1/1998 – 31/12/2001), by using the Vasicek's method. In the Vasicek's formula we have used betas of Period A (i.e. 1/1/1994 – 31/12/1997) estimated by the **OLS** method.
- Column **"*MSE OLS Vas. B*" :** Includes the squared difference between the estimated beta for each stock printed in Column **"Period B"** and the corresponding predicted by using the "OLS-Vasicek" method. which is printed in the Column **"*OLS Vasicek for period B*"**. At the bottom of the table it is estimated the average of the values of this column, which represents the **MSE** by using this method.

Table 8

(Monthly Data)

"Please refer at the bottom of the table for explanation of the data included in each of the table's columns"

Period C	***OLS Vasicek for period C***	**Blume OLS Period C**	**MSE** OLS Vas. C	**MSE** OLS Blume C
0.607	0.756	1.021	0.02235	0.17149
1.797	1.154	1.099	0.41335	0.48782
0.974	1.116	1.091	0.02031	0.01376
0.790	1.093	1.088	0.09167	0.08828
1.165	1.105	1.081	0.00356	0.00704
0.930	1.047	1.074	0.01366	0.02078
1.067	1.021	1.069	0.00212	0.00000
1.503	1.041	1.073	0.21382	0.18547
1.610	0.952	1.055	0.43310	0.30777
1.985	0.877	1.024	1.22649	0.92327
1.703	1.117	1.087	0.34389	0.37917
1.169	0.897	1.046	0.07413	0.01525
1.175	1.199	1.102	0.00059	0.00527
0.577	1.022	1.069	0.19843	0.24244
1.641	0.970	1.057	0.45073	0.34102
2.616	1.032	1.073	2.51091	2.38176
1.627	0.924	1.046	0.49405	0.33710
0.785	0.839	1.038	0.00293	0.06401
0.483	0.913	1.050	0.18541	0.32121
2.094	0.924	1.043	1.36914	1.10621
1.103	1.009	1.066	0.00894	0.00135
1.352	1.185	1.118	0.02777	0.05465
0.975	0.758	0.992	0.04735	0.00028
1.621	0.936	1.053	0.46924	0.32267
0.464	0.738	1.016	0.07531	0.30478
1.521	0.931	1.033	0.34832	0.23852
0.766	1.013	1.067	0.06084	0.09027
0.951	1.194	1.116	0.05922	0.02727
1.861	1.153	1.091	0.50066	0.59270

1.590	1.056	1.081	0.28529	0.25865
2.031	1.122	1.106	0.82589	0.85383
2.314	1.288	1.194	1.05204	1.25408
2.362	0.992	1.059	1.87673	1.69820
0.668	1.062	1.086	0.15500	0.17400
1.165	1.259	1.141	0.00869	0.00059
0.671	1.068	1.090	0.15742	0.17516
1.870	1.058	1.079	0.65880	0.62544
1.640	1.006	1.062	0.40292	0.33477
1.328	1.192	1.123	0.01836	0.04168
1.553	1.009	1.066	0.29566	0.23644
1.936	1.276	1.120	0.43543	0.66678
0.988	0.831	1.036	0.02466	0.00234
0.889	1.005	1.065	0.01355	0.03105
1.538	0.976	1.059	0.31562	0.22922
1.709	0.986	1.062	0.52268	0.41821
0.698	0.961	1.055	0.06913	0.12748
1.315	0.907	1.034	0.16632	0.07900
0.873	0.936	1.047	0.00398	0.03044
0.100	0.789	1.025	0.47423	0.85651
0.481	0.996	1.063	0.26463	0.33893
1.827	0.959	1.040	0.75376	0.61996
1.657	0.962	1.050	0.48352	0.36788
2.441	1.161	1.120	1.64074	1.74614
0.765	1.145	1.109	0.14387	0.11816
1.753	1.078	1.086	0.45501	0.44534
1.120	0.875	1.039	0.06050	0.00662
1.661	1.034	1.072	0.39269	0.34687
1.724	1.294	1.125	0.18520	0.35898
0.990	0.983	1.059	0.00006	0.00476
1.507	0.943	1.034	0.31853	0.22339
1.518	1.285	1.110	0.05439	0.16682
1.485	1.018	1.068	0.21819	0.17394
1.953	1.022	1.070	0.86517	0.77945
2.589	0.844	1.027	3.04250	2.43956
0.350	1.130	1.095	0.60847	0.55635
2.250	0.719	0.995	2.34472	1.57602
1.465	0.930	1.044	0.28724	0.17760
1.857	1.152	1.103	0.49613	0.56766
1.381	0.972	1.057	0.16667	0.10466
1.405	1.045	1.082	0.12989	0.10427

1.366	0.808	1.008	0.31119	0.12806
2.255	1.056	1.079	1.43843	1.38259
1.896	1.149	1.108	0.55875	0.62055
1.431	1.086	1.083	0.11921	0.12135
1.796	1.104	1.096	0.47940	0.48984
1.270	1.044	1.073	0.05141	0.03884
0.647	0.858	1.043	0.04463	0.15715
1.215	0.946	1.031	0.07194	0.03380
0.463	0.776	1.019	0.09805	0.30886
1.121	1.084	1.085	0.00135	0.00127
0.867	1.076	1.088	0.04361	0.04872
0.869	0.949	1.043	0.00630	0.03029
1.128	0.891	1.027	0.05606	0.01015
			0.40510	**0.38217**
			OLS	
		Average Vasicek MSE	**0.31705**	

Explanations:

- Column **"Period C" :** Includes the beta coefficient of each stock estimated by using the classical OLS model by using **monthly data** for Period C (i.e. 1/1/2002 – 31/12/2005).
- Column **"*OLS Vasicek for period C*" :** Includes the predicted beta coefficients of each stock for the Period C (i.e. 1/1/2002 – 31/12/2005), by using the Vasicek's method. In the Vasicek's formula we have used betas of Period B (i.e. 1/1/1998 – 31/12/2001) estimated by the **OLS** method.
- Column **"*Blume OLS period C*" :** Includes the predicted beta coefficients of each stock for the Period C (i.e. 1/1/2002 – 31/12/2005), by using the Blume's method. In the Blume's method we have used betas of Period A (i.e. 1/1/1994 – 31/12/1997) and Period B (i.e. 1/1/1998 – 31/12/2001) estimated by the **OLS** method.
- Column **"*MSE OLS Vas. C*" :** Includes the squared difference between the estimated beta for each stock printed in Column **"Period C"** and the corresponding predicted by using the "OLS-Vasicek" method which is printed in the Column **"*OLS Vasicek for period C*"**. At the bottom of the table it is estimated the average of the values of this column, which represents the **MSE** by using this method.
- Column **"*MSE OLS Blume C*" :** Includes the squared difference between the estimated beta for each stock printed in Column **"Period C"** and the corresponding predicted by using the "Blume-OLS" method which is printed in the Column **"*Blume-OLS period C*"**. At the bottom of the table it is estimated the average of the values of this column, which represents the **MSE** by using this method.