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AN EMPIRICAL ASSESSMENT OF CAPM, MARKET MODEL AND APT: EVIDENCE FROM THE GREEK STOCK MARKET

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ABSTRACT

This paper uses three models to estimate the financial performance of 33 securities traded on the Athens Stock Exchange (ASE). To estimate the expected returns, this study uses the Capital Asset Pricing Model (CAPM), the Market Model, and the Arbitrage Pricing Theory (APT). There is significant evidence that the APT performs better than the CAPM and the Market Model, while the differences between the CAPM and the Market Model appear not to be significant. The three models are tested for a five-year period from 2000 to 2005. Total risk is significantly negatively related to returns during down markets, while this relationship is positive but not significant in up markets. There is evidence that, apart from the market risk, other risk factors that influence the stock returns are the inflation rate and the exchange rate.

Key words: CAPM, Market Model, APT, Athens Stock Exchange

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INTRODUCTION

The return on assets is closely related to the risk that is inherent. The type of risk is important for all stock market participants and firm stakeholders. The prevailing role of managers is to safeguard the firm's assets and maximize the shareholders' wealth (Arnold 2002). Managers structure their decision-making so as to meet analysts' forecasts and investors' expectations (Levitt 1998). Failing to meet investors' required rate of return would make market participants sceptical about the managerial abilities of managers and the firm future prospects and potential (Fields et al. 2001).

The capital that is needed to finance firms' investment projects and operations is sensitive to price fluctuations and market economic conditions (Siriopoulos 1999). This implies that firm value is significantly influenced by financial risk. Firms with unstable expected cash flows are difficult to take loans or attract new investors, and this might adversely affect their performance. There are multiple ways to measure risk, such as standard deviation and variance, volatility, coefficient of variation, value at risk or beta coefficient. The latter is one of the most widely used measures, and shows the sensitivity of an asset towards the total market movements. The beta coefficient measures the non-diversifiable (systematic) risk, which is vital for capital asset pricing.

The Capital Asset Pricing Model (CAPM), developed by Sharpe (1964) and Lintner (1965), suggests that the beta coefficient is the only relevant risk measure for asset pricing. CAPM and the estimation of expected returns have been widely used for evaluating financial decisions and calculating the cost of capital and the required rate of return (Fletcher 2000). The disadvantage is that the beta may be unstable over time and also that CAPM is a single factor model, focusing only on the market risk (Groenewold and Fraser 1997). An alternative model is the Arbitrage Pricing Theory (APT), developed by Ross (1976). The explanatory power of this model relates to the use of multiple factors that capture the asset risk exposure. The underlying concept is that asset prices are formulated by several factor prices, which have some fundamental and plausible relationship with the underlying company (Maringer 2004). The APT does not itself identify the factors relevant to asset pricing, and therefore, it allows flexibility and judgement. The APT is derived under the usual assumptions of perfectly competitive and frictionless capital markets (Copeland et al. 2005).

A similar model to CAPM is the Single Index Model or Market Model, whereby the single factor is the market. The basic notion underlying the Market Model is that stocks are affected by price movements. The Market Model is a statistical model rather than one derived from financial theory (Gibbons 1982). The deviations from the CAPM have given place to the Market Model, since the restrictions of the CAPM can be relaxed at little cost by using the Market Model (Campbell et al. 1997).

This paper tests whether other risk measures, besides beta, are also important in explaining the expected return of risky assets. It compares the models using three different approaches, the Akaike info criterion, the Schwartz criterion and the Theil's U^2 test. The paper examines the validity of the OLS assumptions, as their violation may lead to biased estimations of the beta coefficients.

The structure of the paper is as follows. Section 2 presents the literature review, Section 3 refers to methodology and the description of data, Section 4 shows the empirical results, and Section 5 concludes the paper.

LITERATURE REVIEW

Several studies have focused on the examination of the validity of CAPM in an effort to explain the relationship between risk and return. Fama and MacBeth (1973) first tested the empirical validity of CAPM, and found a positive trade off between portfolio risk and return. Statistically significant evidence about the relationship between stock and return was found by Pettengill et al. (1995) for the US market, Elsas et al. (2003) for the German market, and Tang and Shum (2003a) for international markets. Different are the results for the Caracas Stock Markets as the beta measure is incapable of assessing the financial performance of the local market, while APT seems to have better explanatory power (Gonzalez 2001). The use of CAPM is found to be significant also in assessing the risk of cash flows of investment projects, and the discount rate of returns (Jagannathan and Wang 1996, Graham and Harvey 2001).

However, empirical evidence such that of Fama and French (1996) and Jegadeesh (1992) show that betas are not significantly related to returns. They argue that the empirical failures of the CAPM are due to bad proxies for the market portfolio, while the beta may have small explanatory power when the tested portfolios are constructed in such a way so that the correlation between firm size and beta is small. Isakov (1999) argues that the beta may not always appear as a useful risk measure in the risk-return relationship, because the CAPM is expressed in terms of expected returns, and the realized excess market return may be too volatile. On the other hand, the use of fundamental measures, such as book to market ratio and price to earnings per share (P/E) ratio, may lead to better informative results regarding expected returns. The literature shows that stocks that have high such ratios tend to have higher expected returns (Chan et al. 1991, Berk 1995, Fama and French 1992).

The APT offers an alternative to CAPM, as it allows more than one generating factor (Roll and Ross 1980). Financial theory suggests that macroeconomic variables systematically affect stock market returns. The inflation rate is the most common factor that influences the returns of a portfolio, and is found to be significant in Chen et al (1986) for the US stock market, and Beenstock and Chan (1988) and Clare and Thomas (1994) for the UK stock market. Other factors that are found to be significant in these studies are industrial production, interest rate, retail index, money supply and fuel and material costs.

The APT is found to be more capable of explaining the financial performance of securities and portfolios than the CAPM, indicating that some other factors, in addition to the market risk, have a critical role in the assessment of returns (Groenewold and Fraser 1997, Sun and Zhang 2001). The CAPM is also preferred to APT in the UK (Beenstock and Chan 1986). Like the CAPM, the APT has been used in various applications, such as the estimation of cost of capital, asset allocation and the performance evaluation of managed funds (Bower et al. 1984, Goldenberg and Robin 1991, Carhart 1997, Busse 1999, Pastor and Stambaugh 2000, Mitchell and Pulvino 2001, Chan et al. 2002). According to the accounting literature, the Market Model seems to be the most popular model for the computation of abnormal returns in event studies (Strong 1992).

The estimation of beta coefficients is associated with some practical problems, such as the instability over time due to the fact that asset returns may not be stationary in practice (Groenewold and Fraser 1999). Various other problems such as heteroscedasticity, autocorrelation and departure from normality of the residuals may also occur. Problems of heteroscedasticity have been found by Brown (1977) for the New York Stock Exchange, Fowler et al. (1979) for the Toronto Stock Exchange, and Karathanasis and Philippas (1993) for the Athens Stock Exchange. Autocorrelation problems and departure from normality when estimating beta coefficients have been found by Praetz (1972), Pettway (1978) and Atchison et al. (1987).

METHODOLOGY AND DATA

Capital Asset Pricing Model

The capital asset pricing model is a set of predictions concerning equilibrium of expected return on risky assets (Bodie et al. 2002). It specifies the relationship between expected return and risk, for all assets and portfolios. For a portfolio with perfect diversification of risk, the systematic risk will be equal to total risk. Equation (1) below shows that the required return for security i, relates to the risk-free rate and the systematic risk β of the security multiplied by the risk premium of the market.

$$E(R_i) - R_f = \beta_i [E(R_m) - R_f] \qquad (1)$$

Based on the model of Fama and MacBeth (1973) that is presented in equation (2) below, this study tests the following hypotheses.

$$\overline{R_{it} - R_f} = \bar{\gamma}_{0t} + \bar{\gamma}_{1t}\, \beta_i + \bar{\gamma}_{2t}\, \beta_i^2 + \bar{\gamma}_{3t}\, S_i + \bar{e}_{it} \qquad (2)$$

H_1 There is unrestricted borrowing and lending at a unique known risk-free rate (Sharpe-Lintner hypothesis). This suggests that the expected value of $\bar{\gamma}_{0t}$ (equation 2) is zero, meaning $E(\bar{\gamma}_{0t})=0$, since the risk free rate is deducted from the market index total returns.

H_2 The market price of risk is positive and equals the average excess return of the market portfolio. This implies that $E(\bar{\gamma}_{1t})=E(R_{mt})>0$ (equation 2).

H_3 The relationship between returns and systematic risk, β, is linear. The linearity of the model should give $E(\bar{\gamma}_{2t})=0$ in equation (2).

H_4 The market only compensates for the systematic risk, implying that other risk factors should have no explanatory power. In equation (2), $E(\bar{\gamma}_{3t})$ should be equal to zero.

H_5 The market price of risk is positive (negative) and equals the average excess return of the market portfolio when the excess market return is positive (negative), so that

$E(\bar{\gamma}_{it})=E(R_{mt})>0$ and $E(\bar{\gamma}_{2t})=E(R_{mt})<0$ *in equation (3)*

$$\overline{Ri-rf} = \bar{\gamma}_{0t} + \delta\bar{\gamma}_{1t}\beta_i + (1-\delta)\bar{\gamma}_{2t}\beta_i + \bar{\mu}_{it} \qquad (3)$$

In hypothesis 5, if a systematic conditional relationship between beta and return exists, then the average excess market return should be positive (see Pettengil et al. 1995). This implies that in equation (3), the risk return relationship is symmetrical between positive and negative excess market returns, which means that higher beta securities incur higher (lower) returns in up (down) markets than lower beta securities. For testing hypothesis 5, a dummy variable, *δ*, is added to produce the conditional effect. *δ*=1 when the excess market returns are positive, and *δ*=0 when the excess market returns are negative (Tang and Shum 2003b). The linearity hypothesis (3) is tested by squaring β_i. The rest hypotheses are investigated by firstly taking the beta coefficients from the OLS regression, and secondly regressing the estimated beta coefficients against the average excess returns of the period under consideration.

The study also examines whether the residuals that come from the OLS regression satisfy the following assumptions (see Siriopoulos 1999):

- $E(\tilde{e}_{it})=0$, *which means that* e_{it} *has zero expectation*
- $E(e_{it}^2)=\sigma^2$, *which means that residuals are homoscedastic*

- $E(\tilde{e}_{it}\ \tilde{R}_{mt})=0$, *that is* e_{it} *is independent of* $\tilde{R}_{mt}$

If the above assumptions are violated, then there may be problems regarding the reliability of the estimated coefficients. For example, the error term should be normally distributed if the confidence intervals are to rely upon the normal distribution tests. If the assumption of homoscedasticity is violated, the estimators that come from the OLS regression will be biased and the statistics t and F will not be valid. Also, if the third condition of autocorrelation is violated, the coefficients will be biased.

Market Model

The form of the Market Model is quite similar to the CAPM. While the CAPM is expressed in terms of expected relationships between risk and return, the single index model represents a return generating process. When the market index is rising, stocks will generally tend to rise in response to the respective market movement (Farrell 1997).

The model is a linear regression, using the return on a security as the dependent variable, and the return on the market index as the independent variable. The model has the following form:

$$R_i = a_i + \beta_i R_m + e_i \tag{4}$$

The beta coefficient measures the responsiveness of the security to the general market, and indicates how the return of the portfolio or security will respond to the changes in the market return. In this model, the basic hypothesis is the linearity between the expected return of asset *i* and its beta coefficient (Stambaugh 1982, Copeland et al. 2005). The study tests the following hypothesis.

H_6 The Model is linear so as the coefficient γ_2 in equation (5) should be zero, while the coefficient γ_1 should be statistically different from zero in equation (6) (see Gonzalez 2001).

$$\overline{R} = \overline{\gamma}_{ot} + \overline{\gamma}_{1t}\beta_i + \overline{\gamma}_{2t}\beta_I^2 + \overline{\mu}_{it} \tag{5}$$

$$\overline{R} = \overline{\gamma}_{ot} + \overline{\gamma}_{1t}\beta + \overline{\mu}_{it} \tag{6}$$

Together with autocorrelation, heteroscedasticity and the departure from normality of the residuals are also examined.

Arbitrage Pricing Theory

The APT is based on fewer assumptions than the CAPM, and generates an equilibrium model that is similar to the CAPM. The underlying notion is the law of one price, which means that two securities that are the same in risk and return class, cannot sell at different prices (Farrell 1997). The APT assumes that security returns are linearly related to a set of factors that influence the returns on stocks and their associated risk exposure. Different portfolios or securities have different sensitivities to those factors. The following equation illustrates the general form of the model, assuming that there are several factors that influence the returns (Bodie et al. 2002):

$$R_i = a_i + \beta_{i1}\Pi_i + \beta_{i2}\Pi_i + \ldots + \beta_{iz}\Pi_z + e_i \tag{7}$$

In equation (7), the return is determined by a number of factors. The beta coefficient shows the sensitivity of the security to each factor. The term e_i is a random variable with $E(e_i) = 0, E(e_i^2) = \sigma_i^2$ and $E(e_i e_k) = 0, i \neq k$ (Hayashi 2000). The model implies the following relationship between the expected return on security *i* and its factor sensitivities, when all arbitrage opportunities are exhausted at an equilibrium state (Groenewold and Fraser 1997):

$$E(R_i - r_f) = \beta_1(\lambda_1 - r_f) + \beta_2(\lambda_2 - r_f) + \ldots\beta_z(\lambda_z - r_f) \tag{8}$$

The term $\lambda 1$ is the excess return that is required following the sensitivity of the security to factor $\Pi 1$. If there is only one factor and that is the market risk, then the APT equals to CAPM. The testing procedure used for the CAPM is also used for the APT. The first step involves the use of time series data to estimate a set of factor sensitivities to each security. The second step involves the cross sectional regression to explain mean asset returns (Chen et al. 1986). To compare the APT with the CAPM, the underlying hypothesis is that in equation (8), the beta coefficients, other than the one relating to the market index, should be zero. This means that if they are zero, then the CAPM is equal to the APT. If they are not, then the APT outperforms the CAPM, and it has better explanatory power (Groenewold and Fraser 1997). The violation of the assumptions of the residuals of the OLS regression is also investigated.

The Data

The data used concerns 33 securities traded on the Athens stock Exchange. These securities belong to four different sectors and constitute a large sample of the total market. The period under analysis is five years, from June 2000 to June 2005. The analysis is based on monthly data. Securities that have not covered an adequate period of trading have been excluded from the sample. The rate of return for each security, r_i, is calculated as $r_i = (P_t - P_{t-1}) / P_{t-1}$. The five-year period is sufficient for the reliable estimation of the systematic risk (Dimson and Marsh 1983). For the analysis of the data and the estimation of parameters, individual securities are used rather than portfolios. The use of portfolios could distort the impact of extreme results (Kim 1995, Kaplanski 2004).

In order to apply the APT, an arbitrary choice of macroeconomic variables has been made that influence the securities in the same degree, implying that all securities operate in the same economic environment and that the particular variables are important to the whole economy. The macroeconomic variables that were used as independent variables in the first step regression are inflation, the Industrial Production Index (IPI), the interest rate (Euribor) and the exchange rate, as it is formulated by the parity between the euro and the U.S. dollar. The risk free rate is the 3-year Greek government bond. The prices of the securities and macroeconomic variables were obtained from 'www.e-net.gr' and the Greek Statistical Service respectively.

Summary statistics for the rates of return regarding securities and macroeconomic variables are reported in Table 1. The means are monthly proportional rates of return and vary from a high of 0.61% per month to a low of –5.6%. Table 1 also reports the results of tests relating to the normality of returns. The test of normality is the Jarque-Bera (JB) test, which follows the χ^2 distribution. The null hypothesis is rejected for high values of JB. The 5% critical value for χ^2 is 5.99 (Groenewold and Fraser, 1997), which shows that 19 out of 33 securities do not follow the normal distribution. The non-normality of the underlying return data does not necessarily imply non-normality of the residuals, however, the distribution of the residuals should be carefully examined (Graves and McDonald 1989).

The test of stationarity of the time series data has been carried out using the Augmented Dickey-Fuller (ADF) test, which has the following form (Dimeli 2003):

$$\Delta Y_t = \beta_1 + \beta_2 T + \delta Y_{t-1} + a_i \sum_{i=1}^{n} \Delta Y_{\tau-1} + e_t \qquad (9)$$

The null hypothesis for non-stationarity is rejected if ADF $|t| > |t_c|$. The critical value is 4.11 at the 1% level of significance (Dimeli 2003). All time series data were found to be stationary at the 1% level of significance.

EMPIRICAL RESULTS

Capital Asset Pricing Model

The first step is to calculate the beta coefficients that occur after applying the OLS regression in equation (1). Table 2 reports the results after accounting for autocorrelation, heteroscedasticity and departure from normality. The estimated market betas are all statistically significant at the 1% level except for one security. All beta coefficients have the expected positive signs. The highest observed price is 2.016 and the lowest is 0.277. There are companies that have a significantly negative alpha parameter, meaning that there might be some other factors, which influence them and lead to losses when the market index does not change.

The issues of autocorrelation, heteroscedasticity and departure from normality have been dealt with as follows. Autocorrelation is investigated using the Durbin-Watson test and the Breusch-Godfrey criterion. According to the Durbin-Watson (1950) test, $DW=\sum_{t=2}^{T}(\hat{e}_t-\hat{e}_{t-1})^2/\sum_{t=1}^{T}\hat{e}_t^2$, there is no residual autocorrelation if DW is between 1.62 and 2.38 when the number of observations *T* is 60. The Breusch-Godfrey criterion is based on the Langrange Multiplier test (LM). The null hypothesis of no existence of autocorrelation is rejected when $(N-\varrho)\,R^2 > X^2_{\alpha,\rho}$, which is 5.99 for the 5% level (a=0.05) and two degrees of freedom (ϱ=2). According to the D-W criterion, 5 securities were observed to display autocorrelation, and 3 securities according to the Breusch-Godfrey criterion.

Table 1. Summary Statistics

Asset	Return Mean	Min	Month	Max	Month	Std. Dev.	Skew	Kurt	Jarque-Bera	P-value
Market Index										
ASE index (GI)	-0.39%	-19.40%	Sep.01	17.50%	Sep.00	0.075	-0.02	2.9	**0**	0.99
Risk Factors										
Industrial Production Index (IPI)	0.40%	-21.10%	Aug.01	22.50%	Sep.03	0.085	-0.02	3.8	**1.8**	0.41
Inflation (Infl)	0.28%	-1.90%	Jul.03	2.50%	Mar.02	0.011	0.12	3	**0.1**	0.93
Exchange Rate (Exchr)	0.46%	-4.90%	Mar.01	8.00%	Dec.00	0.03	0.3	2.7	**1.1**	0.57
Interest Rate(Eur)	-1.33%	-12.10%	Sep.01	12.90%	Apr.04	0.056	0.55	3	**3.1**	0.21
Industry Banks										
Alpha	-0.55%	-22.70%	Sep.01	31.80%	Sep.00	0.112	0.47	3.4	**2.6**	0.27
Agrotiki	-1.33%	-50.50%	Jun.05	32.30%	Oct.04	0.118	-0.6	8.5	70.2	0
Aspis	-1.92%	-39.10%	Sep.01	25.00%	Aug.02	0.125	-0.33	3.7	**2.2**	0.34
Attiki	-0.38%	-48.90%	Jan.03	52.10%	Jun.03	0.17	0.48	4.4	7.6	0.02
Geniki	-1.10%	-27.70%	Sep.01	38.20%	Jul.03	0.142	0.47	3	**2.3**	0.32
Egnatia	-1.37%	-23.80%	Sep.02	38.40%	Jun.03	0.125	0.82	4.1	9.8	0.01
Ethniki	-0.18%	-27.60%	Jun.04	38.90%	Apr.03	0.124	0.31	3.7	**2.1**	0.35
Ellados	0.61%	-19.50%	Jan.02	55.50%	Jul.03	0.116	2.04	10.5	184.6	0
Emporiki	-0.45%	-29.10%	Oct.02	39.00%	Apr.03	0.138	0.42	3.2	**2**	0.38
Peireos	0.08%	-33.40%	Sep.01	20.30%	Jul.03	0.102	-0.46	3.5	**2.8**	0.25
Kiprou	-1.04%	-19.90%	Dec.02	28.30%	Oct.02	0.101	0.64	3.9	**5.5**	0.06
Eurobank	0.19%	-19.10%	Nov.00	29.70%	Sep.00	0.096	0.67	3.9	6.6	0.04

Foods										
Allatini	-1.00%	-38.10%	Mar.03	82.20%	Nov.01	0.16	1.8	12.3	250.4	0
B.Stathis	-0.69%	-28.10%	Sep.00	17.60%	Nov.00	0.09	-0.73	4.4	10.3	0.01
Chagikraniotis	-2.75%	-60.70%	Sep.04	46.80%	Feb.01	0.2	0.13	3.6	**1.1**	0.57
Chipita	-2.01%	-25.40%	Sep.02	20.20%	Jan.05	0.09	-0.17	3.1	**0.3**	0.85
Delta	-0.06%	-25.10%	Jun.00	42.30%	Jul.00	0.1	1.02	8.3	82.2	0
Elais	-0.27%	-15.00%	Jan.03	13.80%	Mai.03	0.05	0.05	3.3	**0.2**	0.89
Evrofarma	-2.55%	-45.50%	Jul.01	59.80%	Apr.03	0.17	0.7	5.5	20.2	0
Karamolegos	-3.57%	-51.90%	Jul.00	39.00%	Apr.03	0.17	-0.15	3.9	**2.3**	0.32
Katselis	-1.72%	-48.50%	Dec.03	31.90%	Aug.03	0.12	-0.77	6.3	33.7	0
Kreka	-1.22%	-37.40%	Dec.02	126.20%	Apr.03	0.28	2.76	12.9	326.7	0
Kreta Farm	-2.11%	-51.60%	Dec.02	59.30%	Oct.04	0.16	0	7.1	42.1	0
M.Kerenou	-1.11%	-43.80%	Mar.04	141.10%	Jul.03	0.29	3.08	16.1	359	0
M.Louli	-2.57%	-23.20%	Jun.00	28.20%	Jul.03	0.11	0.57	3.8	**5.1**	0.08
Nikas	-1.14%	-39.10%	Nov.00	31.60%	Jan.05	0.12	-0.48	5.2	15	0
Sarantopoulos	-2.94%	-43.30%	Mar.02	69.00%	Feb.01	0.19	1.43	7.7	76.3	0
Suggar Industry	-1.66%	-37.60%	May.01	38.70%	Apr.04	0.16	0.29	2.7	**1.1**	0.58
Furniture										
Dromeas	-5.49%	-133.90%	Jun.02	26.90%	Apr.03	0.23	-3.46	19.9	762.6	0
Sato	-5.64%	-58.20%	Sep.01	36.00%	Apr.03	0.18	-0.14	3.6	**1**	0.61
Varagis	-5.06%	-49.20%	Sep.01	32.80%	Apr.03	0.16	-0.34	3.1	**1.2**	0.55
Machinery										
Frigoglass	-0.37%	-31.30%	Sep.01	40.00%	Nov.01	0.13	0.54	4.8	11.2	0
Kleeman	-0.88%	-32.20%	Sep.01	39.30%	Jul.03	0.13	0.51	4.5	8.5	0.01

Note: The bold letters show normality according to the Jarque Bera test at the 5% level.

Table 2. Use of Least Squares to estimate the coefficients of CAPM from Eq.(1)

Asset	α_0 Coefficient	t-ratio	β Coefficient	t-ratio	Adjusted R^2	F
Industry Banks						
Alpha	-0.000	(-0.038)	1.300	(13.41) c	0.752	179.84
Agrotiki	-0.010	(-1.17)	0.638	(4.41) c	0.264	19.46
Aspis	-0.000	(-1.188)	1.301	(6.376) c	0.397	40.66
Attiki	0.001	(0.054)	1.349	(5.976) c	0.366	35.70
Egnatia	-0.008	(-0.87)	1.330	(10.86) c	0.639	107.52
Ellados	-0.006	(-1.13)	0.709	(9.156) c	0.587	83.84
Emporiki	0.001	(0.133)	1.463	(10.58) c	0.649	112.09

Ethniki	0.009	(1.891)	1.396	(21.59) [c]	0.888	480.88
Eurobank	0.005	(0.798)	1.025	(10.46) [c]	0.643	109.48
Geniki	-0.005	(-0.445)	1.443	(9.319) [c]	0.588	86.85
Kiprou	-0.011	(-2.09) [b]	1.085	(9.941) [c]	0.645	98.84
Peireos	0.005	(0.794)	1.163	(12.81) [c]	0.735	164.29
Machinary						
Frigoglass	0.010	(0.109)	1.141	(7.164) [c]	0.457	51.76
Kleeman	-0.001	(-0.954)	1.037	(7.682) [c]	0.493	59.02
Furniture						
Dromeas	-0.036	(-3.252) [a]	1.468	(8.579) [c]	0.573	73.44
Sato	-0.048	(-3.385) [c]	1.795	(9.327) [c]	0.589	87.01
Varagis	-0.044	(-3.050) [c]	1.447	(7.408) [c]	0.473	54.89
Foods						
Allatini	-0.016	(-1.324)	0.872	(5.233) [c]	0.309	27.36
B.Stathis	0.003	(0.443)	0.414	(3.581) [c]	0.165	12.82
Chagikraniotis	-0.012	(-1.050)	1.425	(6.656) [c]	0.376	36.05
Chipita	-0.017	(-1.838) [a]	0.717	(5.700) [c]	0.344	32.49
Delta	-0.001	(-0.112)	0.076	(0.460)	0.013	0.212
Elais	-0.001	(-0.300)	0.277	(3.245) [c]	0.137	10.53
Evrofarma	-0.023	(-1.207)	1.089	(4.177) [c]	0.218	17.45
Karamolegos	-0.025	(-1.807) [a]	1.495	(8.098) [c]	0.511	64.12
Katselis	-0.015	(-0.953)	0.432	(2.837) [c]	0.103	8.054
Kreka	-0.039	(-2.546) [c]	1.368	(6.525) [c]	0.423	42.53
Kreta Farm	-0.017	(-1.222)	0.734	(3.242) [c]	0.144	11.17
M. Kerenou	-0.065	(-3.644) [c]	2.014	(6.815) [c]	0.538	46.81
M.Louli	-0.022	(-2.052) [b]	0.940	(6.559) [c]	0.411	43.03
Nikas	-0.007	(-0.587)	0.955	(5.460) [c]	0.324	29.82
Sarantopoulos	-0.042	(-2.987) [c]	1.099	(5.888) [c]	0.363	34.53
Suggar Ind.	-0.010	(-0.735)	1.569	(8.508) [c]	0.543	72.38

t-student in parenthesis

[a] statistically significant at 10%, [b] statistically significant at 5%, [c] statistically significant at 1%

The null hypothesis of no existence of heteroscedasticity has been tested using the White test and the Autoregressive Conditional Heteroscedasticity (ARCH) test. The White test is a general test, which means that it does not presuppose the residuals to follow the normal distribution. The test is based on the R^2, which is obtained from the regression between the squared residuals and the rest independent variables. The null hypothesis is rejected if $NR^2 > X^2_{\alpha,\rho}$, which is 7.815 for a=5% and ρ=3 (Christou 2002). The ARCH test exists not only in pooled data, but also in the case of time series analysis. In cases where the residuals behave as an ARCH procedure, the residuals tend to exhibit autocorrelation. In reality, the variance of the residuals is a function of their lagged prices. The null hypothesis is rejected when $NR^2 > X^2_{\alpha,\rho}$, which is 5.99 for a=5% and ϱ=2. According to the White test, there are 4 securities that display heteroscedasticity, and 3 securities according to ARCH test. The problem of autocorrelation has been corrected with the application of the Durbin two-step method (Andrikopoulo, 2000). The problem of heteroscedasticity has been dealt with the application of the OLS regression in transformed variables (GLS), provided that the other classical assumptions hold (Andrikopoulos 2000).

The normality test of residuals has been performed using the Jarque-Bera test. To recall, the null hypothesis is rejected if $JB > \chi^2$, which is 5.99 for the 5% level of significance. The assumption of normality is violated in 13 out of 33 securities. To correct this problem, a robust regression has been applied, under which the standardized residuals are minimized (Tomczyk and Chatterjee 1984). The standard errors of the regression after the correction of the problems (i.e. autocorrelation, heteroscedasticity and departure from normality) appeared to be smaller than those that were obtained from the OLS procedure before the corrections, and were found to be significant at the 5% level of significance.

The first hypothesis is that $\gamma_o = R_f$. According to the *Sharpe-Lintner* hypothesis, the intercept should be an estimate of the risk free rate in the market. The coefficient γ_o is not significantly different from zero at the 1% level and is consistent with the *Sharpe-Lintner* hypothesis. The second hypothesis of $E(\overline{\gamma_{1t}})>0$ is rejected, as the results in Table 3 suggest that there is a significantly negative risk premium, $E(\overline{\gamma_{1t}}) <0$, indicating a negative relationship between beta and returns.

Table 3. Regression Results on Beta: $\overline{Ri - rf} = \bar{\gamma}_{ot} + \bar{\gamma}_{1t}\beta_i + \bar{\mu}_{it}$

Market Proxy	γ_o	t (γ_o)	γ_1	t(γ_1)	Adj r^2
GI (monthly data)	-0.00102	-0.224	-0.0138	-3.669*	0.15

t (.), t-statistic

* statistically significant at 1%

The third hypothesis concerns the linearity of the model. Table 4 shows that the hypothesis is not rejected at the 5% level of significance, and the model appears to be linear. The sign of the excess return changes from negative to positive, such as the second hypothesis suggests, but it is insignificant at the 5% level. Similar findings are reported by Tang and Shum (2003a) for international markets when the Value Weighted Index is employed.

Table 4. Regression Results on Beta and Beta-Squared:

$$\overline{Ri - rf} = \overline{\gamma}_{0t} + \overline{\gamma}_{1t} \beta_i + \overline{\gamma}_{2t} \beta_I^2 + \overline{\mu}_{it}$$

Market Proxy	γ_o	t (γ_o)	γ_1	t(γ_1)	γ_2	t(γ_2)	Adj r^2
GI (monthly data)	-0.0077	-0.870	0.00297	0.17	-0.0064	-0.880	0.113

t (.), t-statistic

* statistically significant at 5%

The fourth hypothesis tests the conditional relationship between beta and return. Table 5 shows that γ_o is insignificant at the 5% level. The results indicate that in up markets there is no statistical evidence that the high beta securities experience higher returns. In contrast, in the down markets, there is evidence that higher beta securities experience higher losses. Figure 1 depicts the conditional average returns (see Pettengill et al. 1995). It shows that in up markets the trend line goes downward indicating that higher beta stocks do not gain higher returns. The vertical line is the security with beta almost equal to 1, which is the same with the market index.

Table 5. Regression Results on Beta:

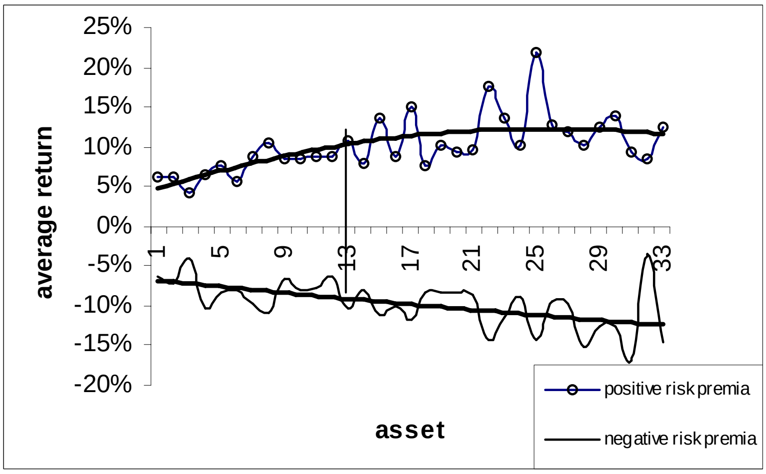
$$\overline{Ri - rf} = \overline{\gamma}_{0t} + \delta \overline{\gamma}_{1t} \beta_i + (1-\delta) \overline{\gamma}_2 \beta_i + \overline{\mu}_{it}$$

Market Proxy	γ_o	t (γ_o)	γ_1	t(γ_1)	γ_2	t(γ_2)	Adj r^2
GI (monthly data)	0.0005	0.076	-0.003	-1.16	-0.012	-2.8*	0.16

t (.), t-statistic

* statistically significant at 1%

Figure 1.



Conditional average returns of the 33 beta securities

The fifth hypothesis is that $\gamma_4 = 0$, and that only the systematic risk influences the returns of securities. Table 6 shows that the hypothesis is rejected at the 10% level, and particularly that there are other factors that also seem to affect the returns of securities. These findings are consistent with previous studies (Gonzalez 2001).

Table 6. Regression Results on Beta and Other Risk Factors:

$$\overline{Ri - rf} = \bar{\gamma}_{ot} + \bar{\gamma}_{1t}\beta_i + \bar{\gamma}_4 Si(e_i) + \bar{\mu}_{it}$$

Market Proxy	γ_o	t (γ_o)	γ_1	t(γ_1)	γ_2	t(γ_2)	Adj r^2
GI (monthly data)	0.0055	1.115	-0.016	-4.318*	-0.312	-2.859*	0.178

t (.), t-statistic

* statistically significant at 1%

Market Model

The corrected beta coefficients that were derived from equation (4) are reported in Table 7. The highest statistically significant beta coefficient is 2.070 and the lowest 0.365. All the estimators are statistically significant at the 1% level, except for one that seems not to be influenced by the market index.

To test for autocorrelation, heteroscedasticity and departure from normality, the same tests that were used for the CAPM are applied here too. In particular, 3 securities appear to have autocorrelation under the D-W test, and 4 securities under the Breusch-Godfrey criterion. Heteroscedasticity appears in 5 cases according to the White test, and in four cases according to the ARCH test. The normality hypothesis is violated in 18 cases, many more times than any other assumption. The results are consistent with the findings of Philippas (1999) for the Greek stock market for the period 1991-1995 using the same model. All the beta coefficients have been corrected giving lower standard errors at the 10% level.

Table 7. Use of Least Squares to estimate the coefficients of Market Model from Eq. (4)

Asset	α_0 Coefficient	t-ratio	β Coefficient	t-ratio	Adjusted R^2	F
Industry						
Banks						
Alpha	-0.0004	(-0.066)	1.287	(13.04) ^{c}	0.738	170.25
Agrotiki	-0.011	(-1.191)	0.599	(4.128) ^{c}	0.238	17.60
Aspis	-0.015	(-1.198)	1.043	(6.180) ^{c}	0.382	38.16
Attiki	0.001	(0.088)	1.370	(6.03) ^{c}	0.372	36.30
Egnatia	-0.017	(-2.588) ^{c}	1.271	(13.41) ^{c}	0.753	183.4
Ellados	0.009	(0.872)	0.701	(8.962) ^{c}	0.576	80.29
Emporiki	0.001	(0.131)	1.510	(11.05) ^{c}	0.668	122.3

Ethniki	0.007	(1.898) [a]	1.428	(22.60) [c]	0.890	507.15
Eurobank	0.005	(0.796)	1.025	(10.38) [c]	0.640	107.9
Geniki	-0.005	(-0.462)	1.456	(9.362) [c]	0.590	87.66
Kiprou	-0.015	(-2.091) [b]	1.072	(9.739) [c]	0.635	94.68
Peireos	0.005	(0.777)	1.158	(12.64) [c]	0.725	159.9
Machinary						
Frigoglass	0.000	(0.076)	1.182	(7.285) [c]	0.464	53.07
Kleeman	-0.017	(-1.057)	1.053	(7.761) [c]	0.498	60.29
Furniture						
Dromeas	-0.036	(-3.213) [c]	1.417	(8.139) [c]	0.544	66.91
Sato	-0.049	(-3.402) [c]	1.791	(9.202) [c]	0.582	84.68
Varagis	-0.044	(-3.076) [c]	1.474	(7.534) [c]	0.481	56.77
Foods						
Allatini	-0.018	(-1.434)	1.475	(7.269) [c]	0.461	52.71
B.Stathis	-0.006	(-0.472)	0.365	(3.216) [c]	0.138	10.35
Chagikraniotis	-0.019	(-1.067)	1.441	(6.033) [c]	0.372	36.41
Chipita	-0.017	(-1.828)	0.713	(5.627) [c]	0.338	31.67
Delta	-0.000	(-0.077)	0.094	(0.565)	0.011	0.32
Elais	-0.001	(-0.251)	0.271	(3.154) [c]	0.129	9.95
Evrofarma	-0.023	(-1.207)	1.130	(4.311) [c]	0.229	18.58
Karamolegos	-0.029	(-1.935) [a]	1.475	(7.264) [c]	0.463	52.71
Katselis	-0.015	(-0.932)	0.430	(2.796) [c]	0.100	7.821
Kreka	-0.040	(-2.541) [c]	1.395	(6.433) [c]	0.417	41.38
Kreta Farm	-0.017	(-1.201)	0.680	(3.133) [c]	0.128	9.81
M. Kerenou	-0.060	(-3.621) [c]	2.070	(7.270) [c]	0.571	52.85
M. Louli	-0.022	(-2.050) [b]	0.943	(6.530) [c]	0.409	42.64
Nikas	-0.007	(-0.595)	0.927	(5.267) [c]	0.308	27.74
Sarantopoulos	-0.042	(-3.131) [c]	1.158	(6.214) [c]	0.391	38.62
Suggar Ind.	-0.010	(-0.755)	1.571	(8.446) [c]	0.539	71.33

t-student in parenthesis

[a] statistically significant at 10%, [b] statistically significant at 5%, [c] statistically significant at 1%

The sixth hypothesis that concerns the linearity of the model is presented in Tables 8 and 9. The coefficient γ_2 of the squared beta is not significantly different from zero in Table 8, while the coefficient γ_1 in Table 9 is statistically significant at the 5% level, which means that the model is linear and not quadratic (Gonzalez 2001).

Table 8. Regression results on beta and beta-squared:

$$\overline{R} = \overline{\gamma}_{ot} + \overline{\gamma}_{1t}\beta_i + \overline{\gamma}_{2t}\beta_I^2 + \overline{\mu}_{it}$$

Market Proxy	γ_o	t (γ_o)	γ_1	t(γ_1)	γ_2	t(γ_2)	Adj r^2
GI (monthly data)	-0.0055	-0.535	-0.0056	-0.291	-0.0028	-0.328	0.069

t (.), t-statistic

* statistically significant at 5%

Table 9. Regression results on beta: $\overline{R} = \overline{\gamma}_{ot} + \overline{\gamma}_{1t}\beta_i + \overline{\mu}_{it}$

Market Proxy	γ_o	t (γ_o)	γ_1	t(γ_1)	Adj r^2
GI (monthly data)	-0.0032	-0.57	-0.0118	-2.588*	0.11

t (.), t-statistic

* statistically significant at 5%

Following H_6, the study examines whether the estimated beta coefficients and the adjusted R^2 between the CAPM and the Market Model are the same. Because R^2 is a measure of linear association between dependent and independent variables and both models are linear, it is useful to see if the adjusted R^2 is the same between the two models. If it is, then the CAPM and the Market Model lead to similar results and there is no significant gain if one or another is used. However, some other alternatives for comparing models have been proposed, which are presented in Section 4.4 (see Greene 2003). The hypothesis that the beta coefficients of the two models are not different is depicted in Table 10.

Table 10. Paired T test for the Difference of the Beta Coefficients between Market Model and CAPM

Case	Mean MM	Mean CAPM	T-Value	P-Value
The whole sample	1.114	1.110	0.13	0.898
Banks	1.128	1.189	-0.87	0.405
Machinery	1.344	1.012	1.04	0.488
Furniture	1.616	1.624	-0.23	0.848
Foods	0.981	0.966	1.33	0.203

Statistically significant level 5%

The hypothesis of zero difference is not rejected for both the total sample and each sector separately. It appears that the Market Model and the CAPM give almost the same results with regards to the beta coefficients at the 5% level. The same hypothesis about the equality of the adjusted R^2 between the two models is also investigated. The results in Table 11 report no differences in the two means of the adjusted R^2. This holds for both the total sample and each sector separately. In other words, the mean of the adjusted R^2 of the Market Model is not greater than that of the CAPM.

Table 11. Paired T test for the adj. R^2 between Market Model and CAPM

Case	Mean MM	Mean CAPM	T-Value	P-Value
Total sample	0.461	0.457	-0.57	0.572
Banks	0.600	0.596	-0.43	0.677
Machinery	0.481	0.475	-6.00	0.105
Furniture	0.535	0.545	0.87	0.477
Foods	0.332	0.327	-0.48	0.637

Statistically significant level 5%

Arbitrage Pricing Theory

The Arbitrage Pricing Theory estimates the excess return that results from more than one factor. The factors under analysis are the market factor, the interest rate, the exchange rate, the inflation rate and the Industrial Production Index. Table 12 presents the results of the least squares method. The cross sectional regression of the following equation

$$\overline{R_i - R_f} = \gamma_o + \gamma_{1i}\beta_1 + \gamma_{2i}\beta_2 + \gamma_{3i}\beta_3 + \gamma_{4i}\beta_4 + \gamma_{5i}\beta_5 + \varepsilon_i \qquad (10)$$

where the coefficients $\gamma_1,....\gamma_5$ are the excess return of each risk factor, gives:

$$\overline{R_i - R_f} = -0.0013 - 0.0182\beta_{1i} - 0.0388\beta_{2i} - 0.0013\beta_{3i} - 0.0023\beta_{4i} + 0.0012\beta_{5i}$$

(-0.49) (-7.36) (-7.76) (-0.62) (-2.04) (0.55)

R-squared = 0.288

The variable $\overline{R_i - R_f}$ is the average excess return for security *i*, and β_{ij} shows the sensitivity of security *i* to factor *j*. The figures that are in the parentheses show the *t* statistics. It appears that not all five factors are priced, as not all have explanatory power. Thus, if insignificant factors (low *t*-statistics) are eliminated one at a time, the following three-factor equation will result (see Groenewold and Fraser 1997):

$$\overline{R_i - R_f} = -0.0018 - 0.0176\beta_{1i} - 0.0394\beta_{2i} - 0.0023\beta_{4i}$$

(-0.69) (-7.67) (-7.98) (-2.06)

R-squared = 0.293

The factors that are priced concern the market index, the interest rate and the inflation rate respectively. The negative signs of the coefficients for interest rate and inflation rate seem to be correct, except that of the market index. It is noteworthy, that the coefficient of the market index is also negative under the CAPM model, except that the negative risk premium here is higher. The inflation rate is the most common factor and is also found to be significant in other studies (Chen et al. 1986, Beenstock and Chan 1988, Faff 1988, McElroy and Burmeister 1988, Clare and Thomas 1994, Groenewold and Fraser 1999). Because more than one factor was found to be statistically significant, the APT outperforms the CAPM, which uses a single factor (see Groenewold and Fraser 1997).

Table 12. Use of OLS to estimate additional risk factors according to APT from Eq. (8)

Asset	a_o	GI Beta 1	EUR Beta 2	EXCR Beta 3	INFL Beta 4	IPI Beta 5	adj. R^2	F
Industry Banks								
Alfa	0.00	1.252	0.198	0.348	0.040	0.011	0.751	37.2
	(0.09)	(12.00) [c]	(1.41)	(1.36)	(0.08)	(0.12)		
Agrotiki	-0.019	0.668	-0.18	0.247	-0.218	1.132	0.103	2.20
	(-1.17)	(2.50) [c]	(-0.59)	(0.43)	(-1.12)	(1.01)		
Aspis	-0.014	1.022	-0.04	-0.262	0.477	-0.292	0.398	8.93
	(-1.1)	(5.65) [c]	(-0.17)	(-0.59)	(0.53)	(-1.85) [a]		
Attiki	-0.005	1.434	-0.439	0.129	0.536	-0.209	0.341	7.2
	(-0.27)	(5.63) [c]	(-1.28)	(0.21)	(0.42)	(-0.94)		
Egnatia	-0.008	1.358	-0.166	-0.322	-0.074	-0.069	0.63	21.42
	(-0.85)	(9.67) [c]	(-0.88)	(-0.94)	(-0.11)	(-0.57)		
Ellados	0.007	1.026	-0.201	0.171	-0.415	0.021	0.381	8.40
	(0.61)	(6.14) [c]	(-0.89)	(0.42)	(-0.50)	(0.15)		
Emporiki	0.004	1.501	-0.109	-0.700	-0.515	0.044	0.661	24.36
	(0.37)	(10.22) [c]	(-0.55)	(-1.95) [a]	(-0.70)	(0.35)		
Ethniki	0.001	1.463	-0.173	-0.101	0.586	-0.070	0.744	35.95
	(0.12)	(12.64) [c]	(-1.11)	(-0.36)	(1.01)	(-0.70)		
Eurobank	0.006	1.057	0.018	-0.307	0.100	0.156	0.645	22.81
	(0.87)	(10.00) [c]	(0.13)	(-1.19)	(0.19)	(1.70) [a]		
Geniki	-0.007	1.498	-0.169	0.338	-0.760	0.107	0.586	17.98
	(-0.59)	(8.92) [c]	(-0.75)	(0.82)	(-0.91)	(0.74)		
Kiprou	-0.009	1.04	-0.00	-0.630	-0.089	0.850	0.504	11.99
	(-0.90)	(6.20) [c]	(-0.00)	(-1.82) [a]	(-0.73)	(1.21)		
Peireos	0.005	1.125	0.041	0.253	0.060	-0.125	0.728	33.11
	(0.70)	(11.4) [c]	(0.31)	(1.05)	(0.12)	(-1.46)		

Machinary								
Frigoglass	0.001	1.134	0.053	0.192	-0.204	-0.093	0.43	10.07
	(0.12)	(6.32) [c]	(0.22)	(0.44)	(-0.23)	(-0.60)		
Kleeman	-0.003	1.095	-0.075	-0.831	0.447	0.087	0.358	7.70
	(-0.24)	(5.74) [c]	(-0.29)	(-1.78) [a]	(0.47)	(0.53)		
Furniture								
Dromeas	-0.051	1.615	0.168	-1.311	2.026	0.114	0.206	3.80
	(-1.73)[a]	(3.41) [c]	(0.31)	(-1.34)	(1.02)	(0.33)		
Sato	-0.044	1.761	-0.012	-0.836	-0.240	-0.197	0.596	18.71
	(-2.94)[b]	(8.54) [c]	(-0.04)	(-1.66) [a]	(-0.23)	(-1.10)		
Varagis	-0.036	1.308	0.367	0.154	-1.942	-0.135	0.483	12.22
	(-2.34)b	(6.26) c	(1.30)	(0.30)	(-1.86) a	(-0.74)		
Foods								
Allatini	0.007	1.013	-0.121	-0.70	-0.216	-2.099	0.284	5.77
	(0.04)	(4.02) [c]	(-0.36)	(-1.14)	(-0.99)	(-1.67) [a]		
B. Stathis	-0.010	0.208	0.014	0.457	1.158	-0.169	0.041	1.52
	(-0.82)	(1.24)	(0.06)	(1.12)	(1.38)	(-1.16)		
Chagik/tis	-0.014	1.302	-0.07	-0.875	-1.571	-0.349	0.283	5.73
	(-0.65)	(4.18) [c]	(-0.17)	(-1.15)	(-1.01)	(-1.29)		
Chipita	-0.016	0.706	0.001	0.132	-0.555	-0.021	0.308	6.35
	(-1.62) [a]	(5.06) [c]	(0.01)	(0.39)	(-0.79)	(-0.17)		
Delta	-0.012	-0.038	-0.108	-0.911	0.996	-0.021	0.01	1.01
	(-0.09)	(-0.21)	(-0.45)	(-2.09) [b]	(1.12)	(-0.14)		
Elais	-0.003	0.299	-0.097	0.092	0.110	-0.013	0.088	2.16
	(-0.54)	(3.15) [c]	(-0.76)	(0.40)	(0.23)	(-0.16)		
Evrofarma	-0.010	0.953	0.374	-0.749	-1.725	-0.115	0.229	4.51
	(-0.53)	(3.37) [c]	(1.00)	(-1.11)	(-1.24)	(-0.48)		
Karamolegos	-0.032	1.481	-0.060	0.211	0.775	-0.171	0.424	9.84
	(-1.89)c	(6.34) [c]	(-0.19)	(0.37)	(0.66)	(-0.84)		
Katselis	-0.014	0.304	0.138	0.364	-0.363	-0.193	0.05	1.06
	(-0.89)	(1.38)	(0.47)	(0.68)	(-0.33)	(-1.01)		
Kreka	0.002	2.001	-0.204	-0.867	-2.371	0.003	0.273	5.50
	(0.07)	(4.63) [c]	(-0.35)	(-0.82)	(-1.10)	(0.01)		
Kretafarm	-0.011	0.740	0.362	-0.290	0.158	-0.159	0.116	2.58
	(-0.57)	(2.62) [b]	(0.95)	(-0.42)	(0.11)	(-0.65)		
M. Kerenou	-0.029	2.827	-0.861	-1.423	-0.962	0.816	0.304	4.50
	(-0.70)	(4.20) [c]	(-1.14)	(-0.96)	(-0.36)	(1.84) [a]		
M. Louli	-0.021	0.897	-0.020	0.287	-0.623	-0.186	0.407	9.24
	(-1.89) [a]	(5.77) [c]	(-0.10)	(0.76)	(-0.80)	(-1.38)		
Nikas	-0.017	1.056	-0.494	-0.012	1.750	-0.175	0.342	7.24
	(-1.27)	(5.66) [c]	(-1.96) [a]	(-0.03)	(1.88) [a]	(-1.08)		

Sarantop/los	-0.022	1.216	-0.281	-0.526	-1.959	0.078	0.20	4.00
	(-0.96)	(3.88)	(-0.67)	(-0.69)	(-1.25)	(0.29)		
Suggar I.	-0.009	1.475	-0.008	0.118	-0.260	-0.436	0.568	16.76
	(-0.64)	(7.61) [c]	(-0.03)	(0.25)	(-0.27)	(-2.58)[b]		

t-student in parenthesis

[a] statistically significant at 10%, [b] statistically significant at 5%, [c] statistically significant at 1%

The risk factors for individual securities are far too different from the previous priced factors, i.e. market index, interest rate and inflation rate. Running the OLS regression and omitting the insignificant factors one at a time, the statistically significant beta coefficients are depicted in Table 13. The particular beta coefficients have been corrected for autocorrelation, heteroscedasticity and departure from normality. Of the total sample, 17 out of 33 securities (i.e. 51%) are influenced by risk factors other than the market index. More analytically, the inflation rate constitutes the most common factor as it influences 7 securities, contrary to the exchange rate which influences 6 securities, the Industrial Production Index which influences 4 securities, and the interest rate which influences 2 securities. The market risk is statistically significant for all securities except for one. Finally, two securities are influenced by more than two factors.

Table 13. Use of Least Squares to estimate additional risk factors using Eq. (8)

Asset	ao	GI Beta 1	EUR Beta 2	EXCR Beta 3	INFL Beta 4	IPI Beta 5	adj. R^2	F
Industry Banks								
Alfa	-0.000	1.287					0.738	170
	(-0.06)	(13.0) [c]						
Agrotiki	-0.014	0.658					0.131	8.85
	(-0.91)	(2.97) [c]						
Aspis	-0.014	1.007				-0.285	0.423	23.03
	(-1.15)	(6.03) [c]				(-1.90) [a]		
Attiki	0.001	1.366					0.358	34.53
	(0.09)	(5.87) [c]						
Egnatia	-0.008	1.330					0.639	107.5
	(-0.37)	(10.86) [c]						
Ellados	0.008	0.922					0.401	41.25
	(0.78)	(6.42) [c]						
Emporiki	0.004	1.469		-0.729			0.66	61.64
	(0.43)	(10.9) [c]		(-2.12) [b]				
Ethniki	0.003	1.429					0.753	84.8
	(0.50)	(13.5) [c]						

Eurobank	0.007	1.080			0.135	0.694	69.04
	(1.08)	(11.7) [c]			(1.69) [a]		
Geniki	-0.005	1.443				0.588	86.95
	(-0.44)	(9.31) [c]					
Kiprou	-0.07	-1.03	-0.395			0.686	59.5
	(-2.21) [b]	(10.7) [c]	(-1.67) [a]				
Peireos	0.005	1.163				0.735	164.3
	(0.79)	(12.8) [c]					
Machinery							
Frigoglass	0.000	1.170				0.463	52.76
	(0.07)	(7.26) [c]					
Kleeman	-0.07	0.967	-0.67			0.483	28.7
	(-0.73)	(7.35) [c]	(-2.05) [b]				
Furniture							
Dromeas	-0.056	1.582				0.213	15.68
	(-2.07) [b]	(3.96) [c]					
Sato	-0.045	1.803	-0.924			0.607	47.33
	(-3.16) [c]	(9.58) [c]	(-1.92) [b]				
Varagis	-0.041	1.434		-1.429		0.487	29.46
	(-2.84) [c]	(7.43) [c]		(-1.66) [a]			
Foods							
Allatini	-0.012	0.907		-1.79		0.314	14.38
	(-0.32)	(4.92) [c]		(-2.06) [b]			
B.Stathis	-0.03	0.428		1.582		0.244	10.75
	(-0.36)	(3.63) [c]		(3.10) [c]			
Chagikran/tis	-0.016	1.355		-2.07		0.295	13.5
	(-0.77)	(4.86) [c]		(-1.72)[a]			
Chipita	-0.017	0.717				0.344	32.49
	(-1.83) [a]	(5.70) [c]					
Delta	0.002		-0.803			0.045	3.79
	(0.18)		(-1.95) [a]				
Elais	-0.001	0.277				0.137	10.53
	(-0.30)	(3.24) [c]					
Evrofarma	-0.019	1.101	-1.018			0.238	10.20
	(-1.00)	(4.28)	(-1.64) [a]				
Karamolegos	-0.029	1.497				0.451	50.38
	(-1.86) [a]	(7.09) [c]					
Katselis	-0.011	0.391				0.054	4.468
	(-0.82)	(2.11)					
Kreka	-0.03	1.342		-1.615		0.429	22.12
	(-2.32) [b]	(6.43) [c]		(-1.73) [a]			

KretaFarm	-0.017	0.859					0.144	11.17
	(-0.92)	(3.34) ^{c}						
M. Kerenou	-0.065	2.110	-0.970			0.51	0.439	11.08
	(-3.34) ^{c}	(5.59) ^{c}	(-3.12) ^{c}			(2.3) ^{b}		
M.Louli	-0.022	0.940					0.411	43.03
	(-2.05) ^{b}	(6.55) ^{c}						
Nikas	-0.016	1.081	-0.451		1.526		0.352	11.86
	(-1.24)	(5.91) ^{c}	(-1.85) ^{a}		(1.74) ^{a}			
Sarant/los	-0.041	1.097			-3.05		0.443	24.83
	(-3.21) ^{c}	(6.39) ^{c}			(-3.09) ^{c}			
Suggar I.	-0.009	1.476				-0.440	0.589	43.99
	(-0.69)	(8.28) ^{c}				(-2.75) ^{c}		

t-student in parenthesis

^{a} statistically significant at 10%, ^{b} statistically significant at 5%, ^{c} statistically significant at 1%

The issues of autocorrelation, heteroscedasticity and departure from normality are revisited and show the following. Autocorrelation exists in 5 out of 17 securities. Three of them display autocorrelation according to the D-W criterion, while the other two securities according to the Breusch-Godfrey criterion. Heteroscedasticity and departure from normality in the residuals appear in 8 cases out of 17, five of which according to the White criterion. The standard errors of the regression after accounting for the above issues are lower than those that come from the OLS regression.

Multicollinearity does not exist because the correlation coefficients among the variables are low. The correlation coefficients among the independent variables are presented in Table 14.

Table 14. Correlation Coefficients among Independent Variables

	GI	Interest	Exchange rate	Inflation
Interest	0.302			
Exch. rate	0.021	-0.046		
Inflation	-0.042	0.402	0.192	
IPI	-0.191	-0.116	0.108	0.177

Comparing the Models

The Akaike information criterion (AIC), the Schwartz criterion (SC) and the Theil's U^2 test are used for comparing the models (Chen 2003, Greene 2003). The AIC and SC criteria are presented below:

$$AIC = \log(\frac{RSS}{n}) + \frac{2(K+1)}{n} \quad (11)$$

$$SC = \log(\frac{RSS}{n}) + \frac{[\log(n)(k+1)]}{n} \quad (12)$$

where *RSS* is the Residual Sum of Square, *K* is the number of independent variables, and *n* is the number of observations. Low AIC and SC show good model performance. Table 15 reports the results. The APT model fits better in 53% of the cases that were found to have statistically significant coefficients according to the AIC criterion, while in 41% of the cases according to the SC criterion. The CAPM was found to fit better in 30% and 33% according to the AIC and SC criteria respectively, and the Market Model in 36% and 39% respectively. Table 16 shows that the differences in the prices of the tests between the CAPM and the Market Model are in most cases very small and not significantly different from zero. Table 17 shows that the differences among the three models are also zero, which means that the three models are essentially not different in terms of performance.

Table 15. Testing for the Performance of the Models according to Akaike Criterion and Schwartz Criterion

Asset	CAPM		Market Model		APT	
	Akaike	Schwartz	Akaike	Schwartz	Akaike	Schwartz
Industry Banks						
Alpha	-2.863*	-2.794**	-2.845	-2.776		
Aspis	-1.884*	-1.815**	-1.869	-1.800	-1.799	-1.695
Agrotiki	-2.324	-2.241	-2.345*	-2.271**		
Attiki	-1.183*	-1.114**	-1.180	-1.112		
Egnatia	-2.975	-2.900	-2.981*	-2.911**		
Ellados	-3.310	-3.240	-3.310	-3.240		
Emporiki	-2.202	-2.133	-2.244*	-2.175**	-2.198	-2.094
Ethniki	-3.634	-3.573	-3.680*	-3.610**		
Eurobank	-3.111*	-3.040**	-3.080	-3.010	-3.030	-2.924
Geniki	-1.928	-1.859	-1.934*	-1.865**		
Kiprou	-2.891	-2.820	-2.891	-2.820	-3.135*	-3.021**
Peireos	-2.997	-2.927	-3.021*	-2.952**		
Foods						
Allatini	-1.797*	-1.728**	-1.730	-1.660	-1.557	-1.452
B. Stathis	-2.595	-2.526	-2.661*	-2.588**	-2.554	-2.441
Chagikraniotis	-1.038	-0.960	-1.040*	-0.970**	-0.745	-0.643
Chipita	-2.342	-2.273	-2.344*	-2.274**		
Delta	-1.786	-1.716	-1.947	-1.878	-2.173*	-2.104**
Elais	-3.114	-3.045	-3.116*	-3.046**		
Evrofarma	-0.929	-0.859	-0.931	-0.861	-1.103*	-0.998**

Karamolegos	-1.553*	-1.484**	-1.410	-1.343		
Katselis	-1.947	-1.870	-1.947	-1.870		
Kreka	-1.354*	-1.285**	-1.340	-1.268	-1.347	-1.244
Kreta Farm	-1.185	-1.116	-1.201*	-1.126**		
M. Kerenou	-1.375	-1.291	-1.401*	-1.314**	-1.218	-1.041
M. Louli	-2.085*	-2.014**	-2.083	-2.013		
Nikas	-1.684	-1.614	-1.686	-1.616	-1.692*	-1.623**
Sarantopoulos	-1.550	-1.481	-1.581	-1.511	-1.671*	-1.570**
Suggar Industry	-1.578	-1.509	-1.576	-1.507	-1.668*	-1.564**
Machinary						
Frigoglass	-1.900*	-1.830**	-1.850	-1.781		
Kleeman	-2.175	-2.106	-2.175	-2.106	-2.253*	-2.142**
Furniture						
Dromeas	-2.013*	-1.940**	-1.954	-1.921		
Sato	-1.493	-1.424**	-1.486	-1.417	-1.522*	-1.418
Varagis	-1.591	-1.522	-1.678	-1.608**	-1.692*	-1.588

The symbols (*) and (**) indicate the smallest number of AIC and SC respectively.

Table 16. Paired *T* test: CAPM vs. Market Model

Akaike Case	Mean MM	Mean CAPM	T-Value	P-Value
Total sample	-2.076	-2.072	0.47	0.645
Banks	-2.615	-2.609	0.97	0.355
Machinery	-2.196	-2.196	-0.01	0.995
Furniture	-1.777	-1.722	1.04	0.408
Foods	-1.713	-1.720	-0.57	0.576
Schwartz Case	**Mean MM**	**Mean CAPM**	**T-Value**	**P-Value**
Total sample	-2.007	-2.001	0.63	0.535
Banks	-2.545	-2.538	1.10	0.297
Machinery	-2.124	-2.127	-0.05	0.971
Furniture	-1.707	-1.650	1.10	0.385
Foods	-1.644	-1.649	-0.45	0.661

Statistically significant level 5%

Table 17. Paired *T* test: APT vs. CAPM and Market Model

	Akaike			Schwartz		
Case	Mean	T-Value	P-Value	Mean	T-Value	P-Value
APT	-1.845			-1.739		
CAPM	-1.825	0.46	0.648	-1.755	-0.37	0.719
MM	-1.842	0.07	0.946	-1.771	-0.87	0.398

Statistically significant level 5%

The Theil's U^2 test assesses whether the three models constitute an improvement over a naïve model, and determines which of the three models represents a greater improvement. This test measures the ability of the three models to forecast turning points in the observed asset returns (Chen 2003). The Theil's U^2 is computed for each security for each model. The test uses the sum of the squared forecasting errors from a particular model (i.e. CAPM, Market Model or APT) divided by the sum of the squared forecasting errors from the naïve model. The test is:

$$U_i^2 = \frac{\sum_{t=1}^{61}(R_{i,t} - R_{i,t}^{model})^2}{\sum_{t=1}^{61}(R_{i,t} - \bar{R}_i)^2} \qquad (13)$$

where R_{it} is the historical return for asset *i* in month *t*, $R_{i,t}^{model}$ is the forecast return for asset *i* in month *t* according to CAPM, Market Model and APT, and $\bar{R}_i$ is the monthly average historical return for asset *i* over the examined period. The smaller the ratio, the better the model forecast is relative to the naïve model. A ratio with a value greater than one would indicate the inappropriateness of the model. This model has been used also in other studies (Bower et al. 1984, Chen and Jordan 1993, Sun and Zhang 2001).

Table 18 reports the results. The APT outperforms the CAPM and the Market Model in 16 out of 17 cases. The CAPM gives more reliable results in 7 cases, while the Market Model in 9 cases. The differences among the three models are presented in Tables 19 and 20. The APT outperforms the CAPM and the Market Model at the 5% level, while the other two models perform in a similar way. Thus, the APT gives a better forecasting ability over the CAPM and the Market Model.

Table 18. Testing the Models using Theil's U^2

Asset		Theil's U^2	
	CAPM	Market Model	APT
Industry Banks			
Alpha	**0.253**	0.257	
Agrotiki	0.895	**0.885**	
Aspis	0.608	0.611	**0.584**
Attiki	0.663	**0.660**	
Egnatia	0.395	**0.393**	
Ellados	**0.632**	0.637	
Emporiki	0.338	0.326	**0.315**
Ethniki	0.253	**0.251**	
Eurobank	0.376	0.376	**0.348**
Geniki	0.406	**0.404**	

Kiprou	0.537	0.538	**0.521**
Peireos	**0.271**	0.272	
Foods			
Allatini	0.799	0.797	**0.666**
B. Stathis	1.028	**0.996**	1.001
Chagikraniotis	0.743	0.742	**0.699**
Chipita	**0.761**	0.776	
Delta			**0.930**
Elais	0.859	**0.857**	
Evrofarma	0.778	0.776	**0.733**
Karamolegos	**0.581**	0.587	
Katselis	0.964	**0.961**	
Kreka	0.756	0.742	**0.699**
Kretafarm	0.873	**0.870**	
M.Kerenou	0.735	0.731	**0.701**
M. Louli	0.580	0.580	
Nikas	0.685	0.684	**0.650**
Sarantopoulos	0.809	0.808	**0.739**
Suggar Industry	0.456	0.457	**0.403**
Machinery			
Frigoglass	**0.545**	0.546	
Kleeman	0.655	0.656	**0.635**
Furniture			
Dromeas	**0.785**	0.792	
Sato	0.408	0.411	**0.383**
Varagis	0.515	0.511	**0.493**

The bold numbers indicate better performance

Table 19. Paired T test: CAPM vs. Market Model

Case	Mean MM	Mean CAPM	T-Value	P-Value
Total sample	0.621	0.623	1.19	0.242
Banks	0.467	0.469	0.95	0.362
Machinery	0.601	0.600	0.00	0.999
Furniture	0.571	0.569	-0.62	0.597
Foods	0.757	0.760	1.11	0.287

Statistically significant level 5%

Table 20. Paired T test: APT vs. CAPM and Market Model

Case	Mean	T-Value	P-Value	Difference
APT	0.598			
CAPM	0.639	5.69	0.000	0.041
MM	0.635	4.84	0.000	0.037

Statistically significant level 5%

CONCLUSIONS

This study explores and identifies the risk factors that influence the performance of individual securities. The CAPM identifies the systematic factor that comes from the market, while the application of the APT makes clear that there are other factors as well, such as inflation, interest rates, exchange rates and the Industrial Production Index, that affect the securities. Almost half of the securities that are traded on the ASE are influenced by these factors.

Comparing the CAPM, the Market Model and the APT, it is found that, under the Theil's U^2 test, the APT outperforms the CAPM and the Market Model at the 5% level. The differences in the performance between the CAPM and the Market Model are significant neither under the Theil's U^2 test nor under the Akaike and Schwartz criteria. It is noteworthy, that under the previous two criteria, no significant difference was observed among the three models.

When the relationship between beta and return is investigated under the CAPM, a negative relationship is observed between the two. In down markets, there is a significant negative relationship, while in up markets the relationship between beta and return is positive, but not statistically significant. Thus, the higher beta securities do not always earn higher returns in up markets compared to the lower beta securities, but in the down markets they experience higher losses. The CAPM and the Market Model are linear models, while other risk factors that influence the securities, such as interest rates and inflation rates, were also found to be significant.

This study has significant implications. The performance of securities is closely dependent upon the economic and market conditions that prevail within the marketplace (Ceglowski 1989). It follows thus, that price movements can significantly affect securities' behaviour. This study provides significant insight about the behaviour of securities in association with the respective models of capital asset pricing. This information is important for firms, investment banks, financial analysts and investors in assessing securities' performance or making predictions about firms' future performance. The ability of the above interested parties to understand the issues surrounding security valuation and respond to the rapid economic and financial changes would tend to enhance the quality of financial reporting and reduce speculation and earnings manipulation. Therefore, the security valuation models that are used should lead to correct and reliable security pricing, reflect the true and fair picture of firms' financial performance, and reinforce the stock market efficiency.

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