

EMPIRICAL TESTING OF CAPITAL ASSET PRICING MODEL

Theriou. N¹

Aggelidis. V.²

Spiridis. T.³

Abstract

The present study examines the CAPM in the Athens Stock Exchange (ASE) using the Black, Jensen and Scholes-BJS approach. Our results show that there is a linear relation between risk and portfolio returns. However, while testing the major hypothesis from the time series tests, that the intercept should be significantly equal to zero, and the hypothesis from the cross-sectional tests, that the intercept should be equal to zero and the beta coefficient should be equal to the mean excess return on the market, we came up with the conclusions that the traditional CAPM is not verified in the ASE for the period between the 1st of July 1992 and the 30th of June 2001. The inferences are quite different when testing Black's two-factor model. Specifically, the hypothesis that the expected excess return on the beta factor should be significantly equal to zero, which would prove a consistency with the traditional CAPM, is not verified for all the periods of the analysis. (JEL G12).

Keywords: CAPM, beta, cross-section of returns, two-factor model.

¹ Associate Professor of Strategic Management, TEI of Kavala, School of Business and Economics, Department of Business Administration, Agios Loukas, 65404 Kavala, Greece, Tel. and Fax : 2510-462156, E-mail: ntheriou@teikav.edu.gr

² Business Administration Dept., TEI of Kavala, Greece

³ Business Administration Dept., TEI of Kavala, Greece

1. Introduction

The Capital Asset Pricing Model (CAPM) has been used, for many decades, as one of the best tools for analyzing the risk-return trade-off of investors and is considered one of the main contributions of academic research to financial managers: The only way an investor can get a higher return for his investment is by taking a higher risk. This intuition is summarized in the CAPM of Sharpe (1964) and Treynor (1961) and was extended further by Lintner (1965), Mossin (1966), and Black (1972). This model, based on the assumption of a positive risk-return tradeoff, asserts that the expected return for any asset is a positive function of only one variable: Its *market beta* (defined as the covariance of asset return and market return). In the present study we examine whether this relationship holds for the period between 1992 and 2001.

Section 2 covers the literature review of CAPM theory, as well as its empirical testing for over three decades. Section 3 describes the methodology used, the data collection and the two-stage data analysis process. Section 4 presents the conclusions from the data analysis and the managerial implications are mentioned. Moreover, there are some comments on the drawbacks of ASE, which are due to the economic and social conditions of Greece, and which caused difficulties during the research. Finally, there is a proposal for future and more effective researches on the risk-return relation.

2. Literature review

The CAPM is based on Markowitz (1959) and Tobin (1958), who developed the “risk-return portfolio theory” based on the utility model of von Neumann and Morgenstern (1953).

The primary implication of the CAPM is the mean-variance efficiency of the market portfolio. The efficiency of the market portfolio implies that there exists a positive linear relationship between ex-ante expected returns and market betas and that variable other than beta should not have power in explaining the expected returns of stocks.

There have been several attempts to test the implications of the CAPM using historical rates of returns of securities and historical rates of return on a market index. The most famous studies according to Diacogiannis (1994) were: Lintner (1965), whose study was reproduced by Douglas (1968), Jacob (1971), Miller and Scholes (1972), and Black, Jensen and Scholes (1972), whose methodology has been adopted for the empirical testing of CAPM in the ASE, Blume and Friend (1973), and Fama and MacBeth (1973).

The CAPM is based on some specific assumptions which have to do with the fact that all investors want to maximize the expected utility of their wealth. An addition to the risk aversion is that they all have homogenous expectations about the returns of the securities. These returns of the securities follow a normal distribution, which characterizes the phenomenon of homoskedasticity. There is also a risk free rate of return which gives the opportunity to an investor to lend or borrow at this rate of return with the lack of risk. Finally, there are no taxes or other restrictions or obstacles which lead to an imperfection of every market.

Sharpe (1964) and Lintner (1965), making a number of assumptions, extended Markowitz's mean-variance framework to develop a relation for expected excess returns (the returns minus the risk-free rate). These returns equal the return of a security with the return on the excess market portfolio times the coefficient beta – the measure of risk in the analysis.

Most tests of the CAPM have been performed by estimating the cross-sectional relation between average return on assets and their betas, over some time interval, and comparing the estimated relationship implied by the CAPM.

In the absence of riskless asset Black (1972) has suggested to use zero beta portfolio, R_z , that is $\text{cov}(R_z, R_m) = 0$, as a proxy for riskless asset. In this case, CAPM depends upon two factors; zero beta and non-zero beta portfolios and it is referred as a two-factor CAPM.

The zero-beta model specifies the equilibrium expected return on asset to be a function of market factor defined by the return on market portfolio R_m and a beta factor defined by the return on zero-beta portfolio which is a minimum variance portfolio and it is uncorrelated with market portfolio. The zero-beta portfolio plays the role equivalent to risk-free rate of return in the Sharpe-Lintner model. If the intercept term is zero, it implies that CAPM holds. During the process of the test and after examining the traditional CAPM, we proceed to the verification of the zero-beta or two-factor model in the ASE.

Initial tests of the CAPM were performed by Black, Jensen and Scholes - BJS (1972) and Fama and MacBeth - FM (1973). As it was mentioned earlier, these tests involved a two-stage procedure. BJS (1972) estimated betas using the monthly returns of each stock on the NYSE, over the 1926-1930 period, and an equally weighted portfolio of all stocks on the NYSE. Their findings showed that CAPM did not hold in the examined period.

Fama and MacBeth (1973) also estimated monthly market returns for all NYSE stocks over 1926-1929, and then they ranked all stocks by beta and formed 20 portfolios. They then estimated their average returns and their betas for the period 1930-1934, exactly the same way as BJS did, and used these betas to predict portfolio returns in the subsequent period 1935-

1938. Their results showed that the coefficient of beta was statistically insignificant and its value remained small for many sub-periods. They also found that the residual risk had no effects on security returns. Their intercept was much greater than the risk-free rate and the results indicated that the CAPM did not hold.

Though initial empirical studies support the CAPM (Fama and MacBeth (1973) and Black, Jensen and Scholes (1972)), subsequent research shows that market beta does not carry a risk premium (Reinganum, 1981). Furthermore, empirical variables like the Market Value of Equity ratio (MVE), the Earnings to Stock Price ratio (E/P) and the Book-to-Market Equity ratio (B/M) have been reported to have explanatory power beyond market beta (Banz, 1981; Basu, 1983; Rosenberg, Reid and Lanstein, 1985). All these variables are scaled versions of a firm's stock price and they have no clear role inside established asset pricing models and are now regarded as anomalies.

Later, Fama and French (1992, 1995), Kothari, Shanken and Sloan (1995), and Jagannathan and Wang (1996) have tried to find evidence on whether beta is dead or not in the world of finance. Fama and French (1992) claimed that the CAPM is misspecified in the period between 1963 and 1990 because: a) beta does not explain the cross-section of expected returns, but, b) a combination of size and book-to-market seem to absorb leverage and E/P ratios in explaining average returns.

Based on Black's version of the CAPM, Gibbons (1982), Stambaugh (1982) and Shanken (1985) have tested CAPM by first assuming that the market model is true, that is, the return of the i th asset is a linear function of a market portfolio proxy. Researchers looked at other stock markets searching for additional evidence regarding the misspecification of the CAPM. Among them, we find Cheung, Chung and Kim (1996), who applied FF's method in Hong Kong, and Kubota and Takehara - KT (1996) who extended FF's work using data from the Japanese stock market.

Other studies have examined the impact of the macroeconomic factors (for instance Chen, Roll and Ross - CRR (1986), Antonio, Garret and Priestley (1998) and Poon and Taylor (1992)). An asset pricing model must be robust enough while simultaneously offering economic insight into the determinants of security returns. That is, formulating the relations between returns and economic factors through specifying macroeconomic variables as candidates for pervasive risk factors (e.g. Chen, Roll and Ross, 1986) don't prove that the model is valid.

Maru and Yonezawa (1984) looked at the period between 1956 and 1976 and employed a methodology similar to Fama and MacBeth (1973) but without using their portfolio grouping procedures. Using data from the Japanese Stock Exchange they found that both the systematic and unsystematic risk components can significantly explain Japanese security returns.

3. Methodology

In this section we test the CAPM using the Black, Jensen and Scholes methodology in the ASE. This methodology was used because it is one of the initial empirical studies of the CAPM and it has been the basis for future improvements on the CAPM over the last thirty years.

The main implication of the model is a statement of the relation between the expected risk premium on individual assets and their systematic risk:

$$E(\tilde{R}_i) = E(\tilde{R}_M)\beta_i \quad (1)$$

where

$E(\tilde{R}_i)$ = the expected excess returns of a security

$E(\tilde{R}_M)$ = the expected excess returns of the market portfolio

$\beta_i = \text{cov}(\tilde{R}_i, \tilde{R}_M) / \sigma^2(\tilde{R}_M)$ = the systematic risk of a security.

In our time-series test - first-pass regression - we use the following relation:

$$\tilde{R}_i = \alpha_i + b_i \tilde{R}_M + \tilde{e}_i \quad (2)$$

where

$$\alpha_i = E(\tilde{R}_i) - E(\tilde{R}_M)\beta_i, \quad (3)$$

according to relation (1) of the standard CAPM. The hypothesis for the time-series test is that the intercept α should be equal to zero, a hypothesis that confirms the positive relation between beta and returns based on CAPM. If it is different from zero, the CAPM cannot hold in the ASE.

The results of the tests, which are examined extensively in the next few paragraphs, indicate that the traditional form of the asset pricing model does not provide an accurate description of the structure of security returns.

During the cross-sectional tests - second-pass regression - we use the following equation:

$$\bar{R}_j = \gamma_0 + \gamma_1 \hat{\beta}_j + \tilde{e}_j \quad (4)$$

where

\bar{R}_j = the mean excess returns of a security

γ_0 = the intercept term

γ_1 = the risk premium

$\hat{\beta}_j$ = the estimated betas from the time series analysis

\tilde{e}_j = the disturbance term

If $\gamma_0 = 0$ and $\gamma_1 = \bar{R}_M$ then the CAPM is verified in the ASE.

Alternatively, the theory of the two-factor or zero-beta model implies that, instead of the intercept a being equal to zero, we try to verify the hypothesis of $E(\tilde{R}_z) = 0$. In other words, we examine if the expected excess return on the beta factor is equal to zero. This verification would prove a consistency with the standard unconditional CAPM.

3.1 Data collection

Our data are daily closing prices of common stocks traded in the Athens Stock Exchange. They are row prices in the sense that they do not include dividends but are adjusted for capital splits. These data were taken from the Athens Stock Exchange (ASE) database.

The market return is obtained from the ASE Composite (General) Share Price Index. Time series of excess returns on the market and individual securities are taken over the three-month Government Treasury Bill rate, which is considered to be the short-term interest rate (risk-free interest rate). The Government Treasury bills were taken from the Central Bank of Greece.

Daily returns are calculated using the logarithmic approximation:

$$R_{i,t} = \log\left(\frac{P_{i,t}}{P_{i,t-1}}\right) \quad (5)$$

where $P_{i,t}$ is the closing price of day t for asset i.

Then daily returns are aggregated to compose the monthly returns that are the input of our investigation.

3.2 Data analysis

The selection of stocks was based on the following criteria: **a)** They have continuous values and no penalties during the whole estimation period of analysis **b)** there are, at least, 36 values of each stock in the investigation period, and **c)** from all the stocks that have just entered the ASE, their values of the first month were excluded because of a large variance which causes bias in the analysis of stocks' returns.

The sample period for our study extends from July 1987 to June 2001. The 14 years of our sample period are divided into nine six-year periods. Each six-year period is then subdivided into two subperiods. The first is a five-year period called investigation period and the second is a one-year period called estimation period. Thus, the first six-year period consists of the first six years of the sample period of our study, the second six-year period is formed by subtracting the first year of the sample period, the third six-year period is formed by subtracting the second year of the sample period, and so on. Based on this process we divide the whole period of our study as follows:

Investigation period	Estimation period
July 1987 - June 1992	July 1992 – June 1993
July 1988 - June 1993	July 1993 – June 1994
July 1989 – June 1994	July 1994 – June 1995
July 1990 – June 1995	July 1995 – June 1996
July 1991 – June 1996	July 1996 – June 1997
July 1992 – June 1997	July 1997 – June 1998
July 1993 – June 1998	July 1998 – June 1999
July 1994 – June 1999	July 1999 – June 2000
July 1995 – June 2000	July 2000 – June 2001

Table 1 The investigation and estimation periods for the entire data sample.

Step 1: During the investigation period, we estimate the excess returns of each security from a time series of returns of ASE listed stocks ($R_{it} - R_{ft}$) and the excess return of the general index of ASE (the market premium), which is defined as the proxy for the market portfolio ($R_{mt} - R_{ft}$).

Step 2: During the same period, we estimate the betas of stocks by regressing the excess returns of stocks on the market premium:

$$(\tilde{R}_{it} - R_{ft}) = a_i + b_i (\tilde{R}_{Mt} - R_{ft}) + e_{it} \quad (6)$$

Step 3: We rank the stocks according to their estimated betas (from the second step) and we construct 10 portfolios of equally-weighted stocks: Specifically, the first portfolio contains

stocks with the largest value of betas and the tenth portfolio contains the stocks with the smallest value of betas. We use this technique in order to reduce the error-in-variables (EIV) problem that arises in asset pricing forecasting (Fama and Macbeth, 1973).

Step 4: For the next year (estimation period), we estimate the portfolios' returns for each of the twelve months by averaging the realized stocks excess returns of each portfolio:

$$R_{Kt} = \frac{\sum_{i=1}^N R_{it}}{N} \quad (7)$$

where

R_{Kt} = The excess return of a K portfolio at time t

R_{it} = The excess returns of stock i at time t

N = The number of stocks at each portfolio.

Step 5: Steps 1 – 4 are repeated until we construct the needed time-series of the excess returns of stocks and portfolios for all periods.

Step 6: For the entire 9-year estimation period and for the three subperiods (which cover the periods between July 1992 and June 1995, July 1995 and June 1998 and July 1998 and June 2001, respectively) of analysis, we calculate the mean monthly returns for each of the ten portfolios:

$$\bar{R}_K = \frac{\sum_{t=1}^N R_{Kt}}{N} \quad (8)$$

and the beta coefficients for each of the 10 portfolios:

$$R_{Kt} = a_K + b_K R_{Mt} + e_{Kt} \quad (9)$$

Step 9: After the construction of the time-series we proceed to a cross-sectional test for the entire period and the subperiods. We regress the mean excess returns of the portfolios against the portfolio betas based on the following equation:

$$\bar{R}_{Kt} = \gamma_0 + \gamma_1 \hat{\beta}_{Kt} + \tilde{e}_{Kt} \quad (10)$$

Step 10: The hypothesis during the cross-sectional tests is:

$$H_1 : \gamma_0 = 0 \text{ and } \gamma_1 = \bar{R}_M$$

where \bar{R}_M the mean excess return on the market.

Additionally, after the time-series and cross-sectional procedure based on BJS and under a normal distribution of returns we follow their research based on Black's (1972) model as mentioned in the previous section. Black's (1972) two-factor model has the same assumptions

with the traditional CAPM except from one. In the two-factor model *not* all investors can borrow and lend at a given riskless rate of interest. In this case we have the following equation:

$$E(\tilde{r}_j) = E(\tilde{r}_z)(1 - \beta_j) + E(\tilde{r}_M)\beta_j \quad (11)$$

where

$E(\tilde{r}_z)$ = the expected return on a portfolio that has a zero covariance ($\beta_z = 0$) with the return on the market portfolio, \tilde{r}_M . In order to proceed to an application using excess return data, as in the work of BJS, we define \tilde{R}_{zt} as the difference between the return on the beta factor, \tilde{r}_{zt} and the riskless rate of return, r_{ft} .

In order to test empirically if the expected excess return on the beta factor is equal to zero, $E(\tilde{R}_{zt}) = 0$, we proceed to an examination of the following equation⁴:

$$R^*_{zt} = K' \sum_j (1 - \beta_j)^2 [\tilde{R}_{jt} - \hat{\beta}_j \tilde{R}_{Mt} / 1 - \hat{\beta}_j] \quad (12)$$

where

$$K' = 1 / \sum_j (1 - \beta_j)^2 \text{ and}$$

R^*_{zt} = the estimated mean values of the excess returns on the beta factor for each month t.

In the next section we present our time-series empirical results.

3.3 Time-series statistical inferences.

For the nine years of monthly returns on each of the ten portfolios calculated as explained previously, we have the following overall results: Portfolio number 1 contains the highest-risk securities and portfolio number 10 contains the lowest-risk securities. The estimated risk coefficients range from 1,069 for portfolio 1 to 0,902 for portfolio 10. The critical intercepts, α_K , and the "t" values are given below them. The "P" value, the adjusted R^2 and the "F" significant are also presented. The correlation between the portfolio returns and the market returns, $r(\tilde{R}_K, \tilde{R}_M)$, seems to be quite high, especially for portfolios 1 to 6 (we say that the correlation is quite high, because the results tend to be equal to 1). Finally, the standard

⁴ The analytical explanation of equation (12) is available from BJS's research in 1972.

deviation of the residuals $\sigma(\tilde{\epsilon}_k)$, the average monthly excess returns \tilde{R}_k and the standard deviation of the monthly excess return, σ , are given for each portfolio.

It is important to notice that in all portfolios the intercepts α are negative. This means that the high-risk and the low-risk securities earned less on average over this nine-year period than the amount predicted by the traditional form of the asset pricing model. These results show great departures from the standard model of the CAPM.

Based on a confidence coefficient of 5%, we proceeded on our t-test. According to the theory of statistics, a coefficient of 5% gives a “ t ” value equal to 1,96. If the “ t ” values are less than 1,96 our hypothesis holds i.e. the intercept is significantly equal to zero. If they are greater than 1,96, then the hypothesis does not hold and the model is rejected in the ASE. The results show that, according to the “ t ” values, the model may be applicable for portfolios 2, 6,7,8,9 and 10 but it is definitely rejected for portfolios 1, 3, 4 and 5. The same theory of statistics shows that there is a reversal relationship between the “ t ” values and the “ P ” values. In this case, based on the confidence coefficient of 5%, if the “ P ” values are greater than 0,05, according to the indexes of statistics, the intercept should be significantly equal to zero. If they are less than 0,05, the model does not hold in the ASE as the hypothesis does not hold.

The results from the adjusted R^2 , which are all positive, show a significant linearity in the model. The results vary from 0,673 for portfolio 1 to 0,463 for portfolio 10. The adjusted R^2 shows that the independent variable, which is the market premium, can explain the 67,3% of variations for portfolio 1, which is the dependent variable, the 59,2% of variations for portfolio 2, the 56,1% of variations for portfolio 3 etc. As it is obvious, because of the correlation between the returns of the securities and the return on the market, the standard deviation of the mean monthly returns and the standard deviation of the residuals seem to be quite small in all the portfolios.

Finally, the values of the “ F ” statistic mean that the independent variable - the market premium - explain in an efficient way or not the variation in the dependent variables, which are the excess returns of the ten portfolios. Specifically, the “ F ” significance is the crucial value, which help us accept or reject the null hypothesis in the research. Based on a significance level of 5%, if the “ F ” significance is less than 0,05 then we accept that there is linear dependence between the independent and the dependent variable (The null hypothesis is rejected). If it is greater than 0,05 the null hypothesis is accepted, as there is not dependence

between the variables. In our case, all the values are very close to zero ($<0,05$), which means that we cannot accept the null hypothesis.

It is important to say that the five years of investigation cannot adjust properly the risk coefficients of the estimation period. That is why there is a nonstationarity⁵ at the betas of the portfolios. Similar findings are prevalent characteristics of the Athens Stock Exchange. As a conclusion, we can assert that the traditional form of the CAPM does not hold as, for many portfolios, the intercepts are significantly different from zero. **Table 2** summarizes the statistics of the time-series tests for the nine-year estimation period.

Item	Portfolio Number										\tilde{R}_m
	1	2	3	4	5	6	7	8	9	10	
Beta (post)	1,069	0,944	1,020	0,907	0,866	0,908	0,920	0,827	0,896	0,902	1,00
Intercept	- 2,490	- 1,214	- 1,671	- 1,729	- 1,500	- 1,036	- 0,970	- 1,117	- 1,246	- 1,558	
t(Intercept)	- 3,842	- 1,781	- 2,129	- 2,438	- 2,236	- 1,355	- 1,095	- 1,316	- 1,353	- 1,849	
P (value)	0,000	0,078	0,036	0,016	0,027	0,178	0,276	0,191	0,179	0,067	
R ² Adjusted	0,673	0,592	0,561	0,553	0,558	0,516	0,449	0,416	0,416	0,463	
F significant	1,0E- 27	1,4E- 22	7,3E- 21	1,8E- 20	1,1E- 20	1,3E- 18	1,3E- 15	2,9E- 14	2,9E- 14	3,2E- 16	
$r(\tilde{R}, \tilde{R}_m)$	0,822	0,772	0,751	0,746	0,749	0,721	0,674	0,649	0,649	0,684	
$\sigma(\tilde{\epsilon})$	0,067	0,071	0,081	0,073	0,069	0,079	0,092	0,088	0,095	0,087	
\bar{R}	- 2,440	- 1,170	- 1,623	- 1,687	- 1,459	- 0,993	- 0,927	- 1,078	- 1,204	- 1,515	0,047
σ	0,118	0,111	0,123	0,110	0,105	0,114	0,124	0,115	0,125	0,120	0,091

Table 2 Summary of Statistics for Time Series, Entire Period (July 1992 - June 2001)

⁵ High volatility of risk coefficients

In order to test the stationarity of the empirical relations, we divided the nine-year interval into three equal subperiods each containing 36 months. **Tables 3** through **Table 5** present a summary of the regression statistics of equation (9) calculated using the data for each of these periods for each of the ten portfolios.

It is important to notice that the critical intercepts $\hat{\alpha}_K$, were definitely nonstationary through this period⁶. The results of the “*t*” values verify these findings. The negative α ’s for the high-risk portfolios in the first subperiod (July 1992-June 1995) in portfolios 1, 2, 3 and 8 indicate that these securities earned less than the amount predicted by the model and the positive α ’s for the low-risk portfolios, which, in this case, is only portfolio 7, indicate that they earned more than what the model predicted. Again, as with the entire period, we can see significant departures from the model. As it is obvious from the table the departures were not so great in the second subperiod (July 1995-June 1998). The nonstationarity continues in the third subperiod (July 1998-June 2001), where the high-risk portfolios have negative intercepts; the high-risk securities earned less on average over the third subperiod than the amount predicted by the traditional model.

We should mention that the correlation coefficients between \tilde{R}_{Kt} and \tilde{R}_{Mt} like in the entire period tend to be quite high except from portfolio 4 in the first subperiod, portfolios 7 and 8 in the second subperiod and the last three portfolios in the third subperiod. The lowest of the 30 coefficients in the subperiods was 0,584 but none of them were greater than 0,90. As a result, the standard deviation of the residuals from each regression is quite small and so is the standard error of estimate of α . In the three subperiods, as in the examination of the entire period, the “*F*” significance and the adjusted R^2 show significant results and a linearity between the returns and the risk coefficients. As we mentioned before, when the “*F*” significance is less than 0,05, there is a linear dependence between the dependent and the independent variable and the null hypothesis is rejected. For the three subperiods, it is obvious that there is a linear dependence between the market premium and the excess returns of the portfolios. In the case of examination of the “*t*” values and the “*P*” values, especially for the first subperiod, we can see that for portfolios 4, 5, 9 and 10, the model of CAPM is rejected, as the values do not comply with the theory of statistics. **Tables 3** through **Table 5** summarize the coefficients for the subperiods. The results from the time-series tests indicate that we cannot accept the hypotheses of the traditional form of the CAPM, as, according to

⁶As with the risk coefficients, there is a high volatility of the intercepts.

the “*t*” values, the intercepts in many cases are significantly different from zero. There is also a nonstationarity of the risk coefficients and the intercepts in all the portfolios.

Next section presents the cross-sectional tests of the standard CAPM.

Item	Portfolio Number										
	1	2	3	4	5	6	7	8	9	10	\tilde{R}_m
Beta (post)	1,064	1,108	1,149	0,736	0,949	0,949	0,998	1,080	0,808	0,678	1,00
Intercept	- 1,121	- 0,109	- 1,397	- 2,299	- 1,458	- 0,204	0,098	- 0,578	- 1,766	- 2,154	
t(Intercept)	- 1,479	- 0,114	- 1,941	- 1,975	- 2,196	- 0,216	0,099	- 0,712	- 1,981	- 2,756	
P (value)	0,148	0,910	0,061	0,056	0,035	0,830	0,922	0,481	0,056	0,009	
R ² Adjusted	0,711	0,625	0,761	0,322	0,718	0,555	0,555	0,688	0,502	0,479	
F significant	6,8E- 11	5,8E- 09	2,6E- 12	1,8E- 04	4,4E- 11	1,1E- 07	1,1E- 07	2,5E- 10	8,2E- 07	1,8E- 06	
$r(\tilde{R}, \tilde{R}_m)$	0,848	0,798	0,876	0,584	0,852	0,754	0,753	0,835	0,718	0,703	
$\sigma(\tilde{e})$	0,044	0,055	0,042	0,068	0,039	0,055	0,058	0,047	0,052	0,045	
\bar{R}	- 2,474	- 1,518	- 2,858	- 3,235	- 2,664	- 1,410	- 1,170	- 1,950	- 2,793	- 3,017	- 1,271
σ	0,083	0,092	0,087	0,083	0,074	0,083	0,088	0,086	0,074	0,064	0,066

Table 3 Summary of Statistics for Time Series, First Subperiod (July 1992 - June 1995)

Item	Portfolio Number										
	1	2	3	4	5	6	7	8	9	10	\tilde{R}_m
Beta (post)	0,879	0,645	0,610	0,673	0,619	0,615	0,556	0,405	0,645	0,572	1,00
Intercept	- 2,765	- 0,856	- 0,471	- 1,496	- 0,578	- 1,136	- 1,540	- 0,689	- 0,365	- 0,808	
t(Intercept)	- 2,712	- 0,925	- 0,548	- 1,821	- 0,780	- 1,429	- 1,376	- 0,870	- 0,399	- 0,852	
P (value)	0,010	0,361	0,587	0,077	0,441	0,162	0,178	0,390	0,692	0,400	
R ² Adjusted	0,679	0,578	0,588	0,656	0,665	0,629	0,406	0,420	0,584	0,506	
F significant	4,1E- 10	4,5E- 08	3,0E- 08	1,3E- 09	8,5E- 10	4,8E- 09	1,8E- 05	1,1E- 05	3,6E- 08	7,1E- 07	
$r(\tilde{R}, \tilde{R}_m)$	0,829	0,768	0,774	0,816	0,821	0,800	0,650	0,661	0,772	0,721	
$\sigma(\tilde{\epsilon})$	0,059	0,054	0,050	0,048	0,043	0,046	0,065	0,046	0,053	0,055	
\bar{R}	- 1,239	- 0,264	- 0,588	- 0,327	- 0,497	- 0,067	- 0,574	- 0,014	- 0,755	- 0,186	1,737
σ	0,106	0,084	0,079	0,083	0,076	0,077	0,086	0,061	0,084	0,080	0,100

Table 4 Summary of Statistics for Time Series, Second Subperiod (July 1995 - June 1998)

Item	Portfolio Number										
	1	2	3	4	5	6	7	8	9	10	\tilde{R}_m
Beta (post)	1,283	1,181	1,359	1,212	1,063	1,198	1,281	1,142	1,169	1,315	1,00
Intercept	- 3,190	- 1,872	- 2,159	- 1,104	- 1,866	- 1,113	- 0,618	- 0,928	- 1,194	- 1,288	
t(Intercept)	- 2,230	- 1,278	- 1,124	- 0,733	- 1,087	- 0,597	- 0,297	- 1,220	- 0,490	- 0,621	
P (value)	0,032	0,210	0,269	0,469	0,285	0,555	0,768	0,669	0,627	0,539	
R ² Adjusted	0,693	0,645	0,582	0,644	0,515	0,534	0,512	0,437	0,385	0,527	
F significant	1,9E- 10	2,2E- 09	3,8E- 08	2,4E- 09	5,1E- 07	2,6E- 07	5,7E- 07	6,9E- 06	3,3E- 05	3,3E- 07	
$r(\tilde{R}, \tilde{R}_m)$	0,838	0,810	0,771	0,809	0,727	0,740	0,725	0,673	0,634	0,735	
$\sigma(\tilde{\epsilon})$	0,085	0,087	0,114	0,089	0,101	0,110	0,123	0,127	0,144	0,123	

\bar{R}	-	-	-	-	-	-	-	-	-	-	-
	3,607	2,256	2,601	1,498	2,211	1,502	1,035	1,299	1,574	1,716	0,325
σ	0,155	0,148	0,178	0,151	0,148	0,164	0,179	0,172	0,186	0,181	0,101

Table 5 Summary of Statistics for Time Series, Third Subperiod (July 1998 - June 2001)

3.4 Cross-sectional statistical inferences

Given the nine years of monthly returns on each of the ten portfolios calculated as explained in the time-series section (**Table 2**), we estimate the new coefficients of the analysis using the cross-sectional equation given by (10) for various holding periods.

Figure 1 is a plot of \tilde{R}_K versus $\hat{\beta}_K$ for the nine-year holding period July 1992 - June 2001. The line represents the least-squares estimate of the relation between \bar{R}_K and $\hat{\beta}_K$. The traditional form of the asset pricing model implies that the intercept γ_0 in (10) should be equal to zero and the slope γ_1 should be equal to \bar{R}_M , the mean excess return on the market portfolio. Over this nine-year period, the average monthly excess return on the market portfolio \bar{R}_M was 0,047 and, according to theory, we should have: $\gamma_0 = 0$ and $\gamma_1 = 0,047$.

Examining the “t” values for the entire period, we see that:

$$t(\hat{\gamma}_0) = \gamma_0 / s(\hat{\gamma}_0) = 2,723/1,479 = 1,840$$

$$t(\hat{\gamma}_1) = \gamma_1 - \hat{\gamma}_1 / s(\hat{\gamma}_1) = 0,047 - (-4,463)/1,593 = 2,831$$

According to the theory of statistics, while the first part of the hypothesis is accepted i.e. the “t” value of the intercept is less than 1,96, based on the confidence coefficient of 5%, which means that the intercept is insignificantly different from zero, the second part is rejected. Specifically, the slope γ_1 is not equal to \bar{R}_M . This means that the model is rejected in the ASE for the entire period of examination.

Figure 3.1 shows a negative correlation between the excess monthly returns of the portfolios and the betas. As the portfolio returns decrease, the risk increases.

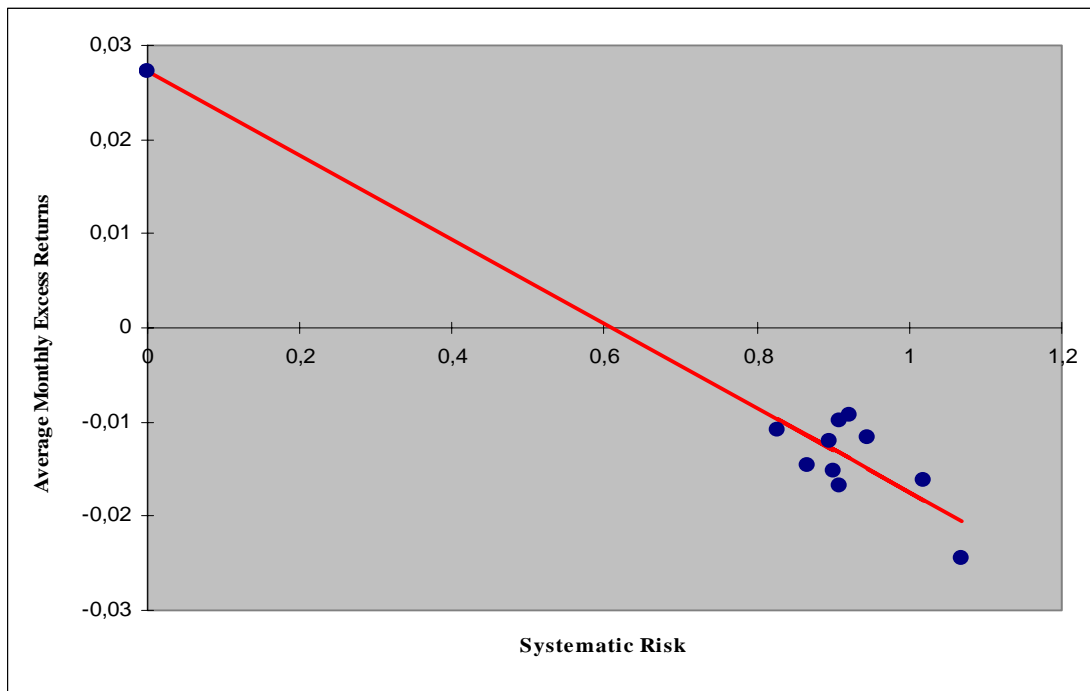


Figure 1 Mean Excess Monthly Returns versus the Systematic Risk for the Entire Period

We have also divided the nine-year interval into three equal subperiods and **Figure 2** through **Figure 4** present the plots of the \bar{R}_K versus the $\hat{\beta}_K$ for each of these intervals. In order to obtain better estimates of the risk coefficients for each of the subperiods, we used the coefficients previously estimated over the entire nine-year period. The graphs indicate that the relation between return and risk is linear but that the slope is related in a nonstationary way to the theoretical slope for each period. It is obvious that there is a linear relation between risk and return but there is also volatility in the values of the coefficients, which was also prevalent during the time-series test.

The coefficients $\hat{\gamma}_0, \hat{\gamma}_1, \gamma_1$ and the “t” values of $\hat{\gamma}_0$ and $\hat{\gamma}_1$ are summarized in Table 6 for the entire period and for each of the three subperiods.

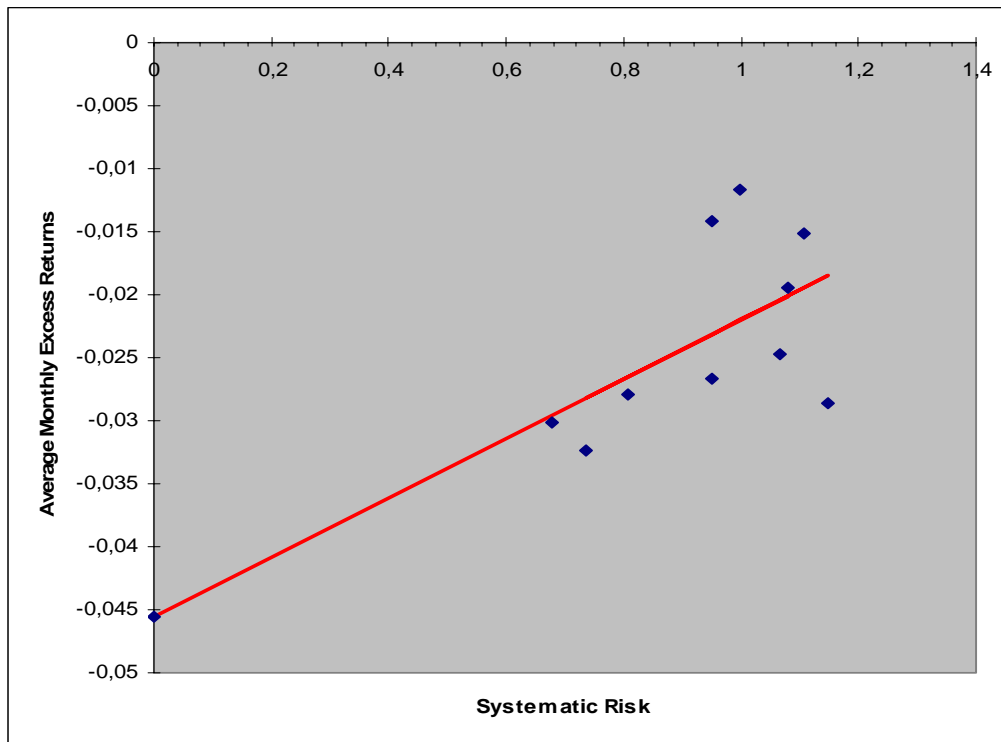


Figure 2 Mean Excess Monthly Returns versus the Systematic Risk for the First Subperiod

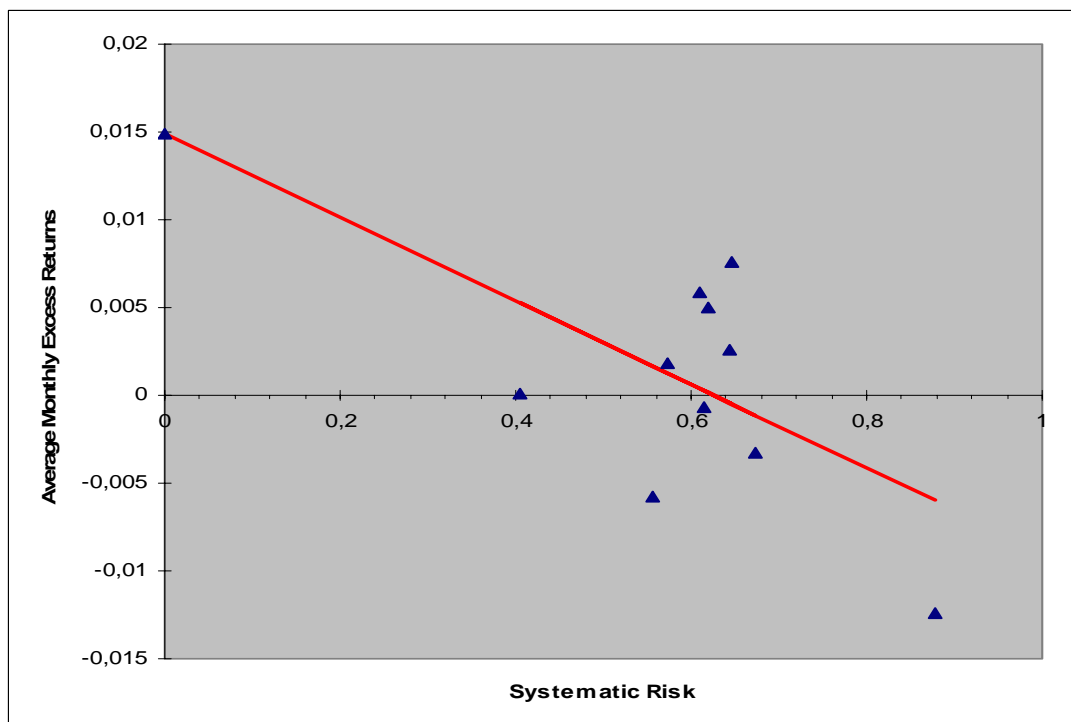


Figure 3 Mean Excess Monthly Returns versus the Systematic Risk for the Second Subperiod

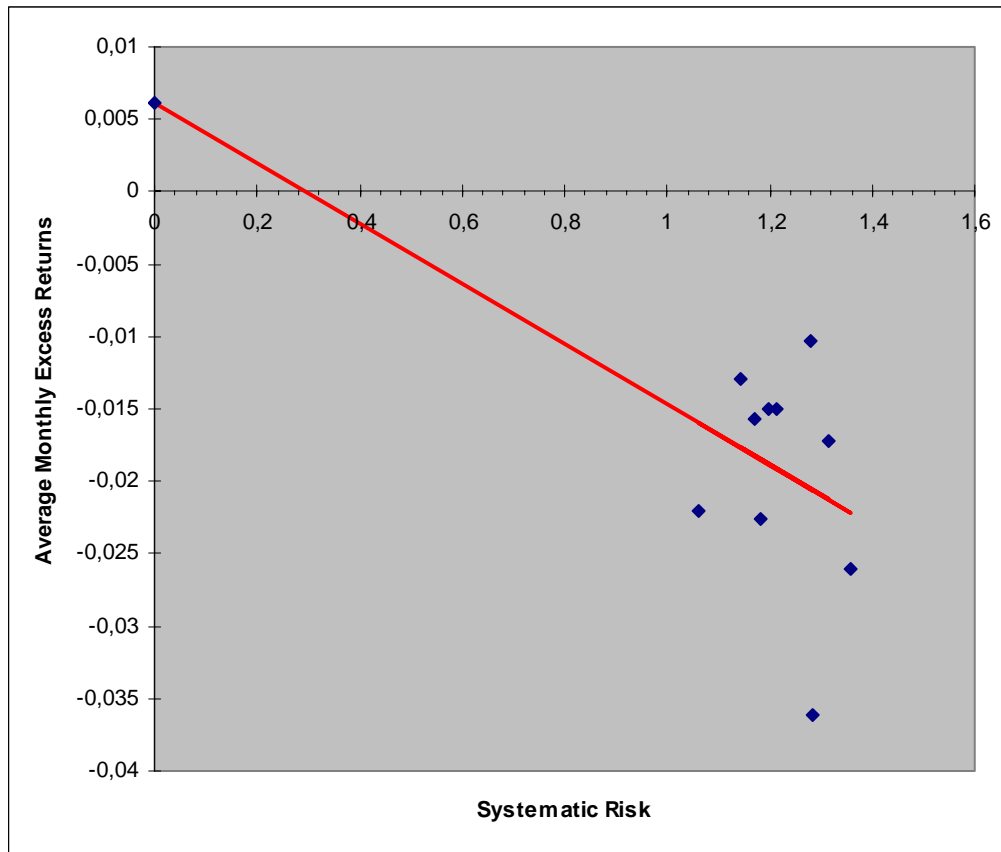


Figure 4 Mean Excess Monthly Returns versus the Systematic Risk for the Third Subperiod

	Time Period			
	Total period (1/7/92-30/6/01)	1 st subperiod (1/7/92-30/6/95)	2 nd subperiod (1/7/95-30/6/98)	3 rd subperiod (1/7/98-30/6/01)
$\hat{\gamma}_0$	2,723	-4,549	1,486	0,610
$\hat{\gamma}_1$	-4,463	2,353	-2,373	-2,082
$\gamma_1 = \bar{R}_M$	0,047	-1,271	1,737	-0,325
$t(\hat{\gamma}_0)$	1,840	-3,422	1,466	0,171
$t(\gamma_1 - \hat{\gamma}_1)$	2,831	-2,627	2,562	0,600

Table 6 Summary of Cross-sectional Regression Coefficients and their “t” values

Figure 2 shows a positive correlation between risk and return for the first subperiod (the risk increases as the excess monthly returns increase), while **Figures 3 and 4** show that in the second and third subperiod there is a negative correlation again. The results from the cross-sectional tests for the entire period and the subperiods showed that the hypotheses are rejected which means that the traditional CAPM is not applicable in the ASE. We saw that, for the entire period, the slope γ_1 is not equal to \bar{R}_M . In the first subperiod, the hypothesis is rejected i.e. the “ t ” value of the intercept is greater than 1,96, which means that the intercept is significantly different from zero, and the slope γ_1 is also not equal to \bar{R}_M . In the second subperiod the model of CAPM is rejected, as the slope γ_1 is, once again, not equal to \bar{R}_M .

3.5 Zero-beta model statistical inferences

Table 7 presents the R_{z}^* for the entire period and the three subperiods of examination, their “ t ” values and the standard deviation of the excess returns on the beta factor.

Period	\bar{R}_z^*	$\sigma(R_z^*)$	$t(\bar{R}_z^*)$
1/7/92-30/6/2001	-0,062	0,522	-1,240
1/7/92-30/6/95	-0,018	0,042	-2,582
1/7/95-30/6/98	-0,007	0,044	-0,976
1/7/98-30/6/01	0,001	0,036	0,203

Table 7 Estimated Mean Values of the Excess Returns on the Beta Factor over the Entire Period and the Subperiods

It is obvious that the “ t ” value of the beta factor for the first subperiod is greater than 1,96, which means that the mean excess return on the beta factor is significantly different from zero and the CAPM is rejected. In contrast, during the other subperiods and the entire period the “ t ” values are less than 1,96, which shows some validity for the standard CAPM.

In this case, the inferences support the zero-beta model and the traditional CAPM should be rejected as \bar{R}_z^* should be insignificantly different from zero (i.e. very close or equal to zero) in *all* subperiods of estimation.

4. Conclusions and discussion

After the time-series and the cross-sectional tests, we can confirm that the standard CAPM is not verified in the ASE during the period between the 1st of July 1987 and the 30th of June 2001. In the case of the two-factor model, by releasing the assumption that all investors can borrow and lend at a given riskless rate of interest, the model appears to have some explanatory power but not a valid effect on stocks' returns.

The evidence discussed above does not prove that the CAPM is invalid since only stocks were included in the analyses. The market portfolio contains all of the capital assets. We will never be able to observe the returns on the "true" market portfolio. Therefore, the CAPM is simply not a testable theory.

Here we can also mention that estimated betas are very sensitive to the market index being used. In risk-return space, indices can be close to each other and close to the efficient set, and still produce different relationships (positive and negative) between return and beta.

It is important to know that the main reason that we test the CAPM is to analyze the relation between the risk and return of the securities and - in our case - the risk and return of the portfolios. The testable implications of the CAPM show that all investors hold risky assets in the same proportion and, in particular, every investor hold the same proportion of stocks. In order to achieve the desired balance of risk and return, investors simply vary the fraction of their portfolios made up of the riskless assets.

Testing the CAPM using the BJS approach we noticed that there could be many implications in financial companies from the rejection of the CAPM in the ASE. We should recall that there are many implications on the cost of capital of these companies. Because of the rejection of the CAPM in the ASE, the companies should try to use another model - maybe a multi-factor one - in order to understand the risk-return relation of the Greek securities with the market index. In this way they could proceed to a decrease in their cost of capital, which means a decrease in the discount factor. Here, we should mention that the cost of capital of companies is the cost that a firm sustains when it borrows capital from different sources for its activities. The discount factor is the return that is required from the risk that the firm sustains.

If the model was accepted in the ASE, managers could be able to use the BJS model in the analysis of the securities and to understand a way to increase their returns with the least cost. The truth is, and it is obvious, that in order to apply a financial model in the market, this

model should have already been accepted in this particular market. Otherwise, new financial problems may occur for managers. It is true that managers should be able to understand and analyze investment and risk in different facilities when the investment involves the common circumstances of uncertainty.

5. Limitations on the analysis and proposal for future research

In this test there were drawbacks, especially during the data collection. There were many incidents that caused these drawbacks, like the war in the Iraq in 1990, which had a great impact in the price of oil barrels and it affected the Greek oil companies.

The analysis on the ASE using the BJS approach was a time-consuming research. We tried to be as accurate as we could during our numeric results.

The route of the returns of the Greek securities was obliged on the Greek market, which belonged, a few years ago, at the emerging markets of the world. It became a developing market since May 2001. All these economic changes had as a result great changes in the return of the securities in the ASE, on the risk-free rate of return and other variables, whose collection was necessary for the completion of this work.

For a better and more complete analysis of the ASE - as it was mentioned earlier in the introduction - more databank is needed. The lack of data is obliged on the fact that most of the ASE data wasn't computerized.

In this test of the CAPM, we didn't use other variables than the market return and the risk-free rate of return in order to have the risk premium for the analysis of the securities' excess returns. Further researches, specially the research of Fama and French - FF (1992), used other variables, like the market value (MVE) of securities. Of course, FF's tests lead to the examination of multifactor models (the APT).

We can understand that there were enough drawbacks during our data analysis. And the results showed that the CAPM is rejected in the Greek Stock Exchange. That is why more empirical tests on the ASE should be applied, using alternative financial models. In our opinion, a test on the ASE using the APT model, would give more complete results, as it could include different variables like the inflation rate and the market value of securities. Thus, further researches and more tests on the APT should be applied, in order for the researchers - and the managers of firms - to have more accurate results and understand the risk-return tradeoff of the ASE securities. Another proposal would be to release other

assumption and to tests the models based on different hypotheses. In this way we might have results that would lead to new theories on asset pricing models.

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