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Macroeconomic vs. Statistical APT Approach in the Athens Stock Exchange

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ABSTRACT

The study is focused on the examination of the Arbitrage Pricing Theory (APT) with the application of the macroeconomic and the statistical APT model. Data of stock returns and macroeconomic indices in the Athens Stock Exchange (ASE) were used for the period between 1989 and 2010. After a review of the models the methodology is extensively presented in order to examine the models. The results are mixed for the whole period as well as for the sub-periods. The results of the macroeconomic APT model indicated that there are observed factors that may have an effect on the behavior of stock returns but their significance seems to be partial. Moreover, the results of the statistical APT model indicated that there are (unobserved) factors that could influence stocks, but these factors should be appropriately determined. All the results seem to be evidence of a weak-form inefficiency of the ASE.

JEL Classifications: *G12, G14*

Keywords: *APT; macroeconomic variables; ASE; risk; market efficiency*

I. INTRODUCTION

The aim of the study is to examine whether there are factors that could affect the behavior of stock returns in the ASE during the period between January 1989 and May 2010. The motive for this analysis is the need nowadays to examine the way that different economic indices behave in order to understand their influence on individual stocks and portfolios. Investors have to be more prepared now than in the past decades, so as to face new challenges while investing in specific securities. There are many (economic) events that can happen very fast, on a domestic and international level, and the markets have to survive in extreme cases, such as the economic crisis of the last few years. The study aims to explore the relationships between a number of economic and artificial factors using the macroeconomic and the statistical APT model, and, then, their influence on the returns of specific portfolios. As the Greek stock exchange is one of the capital markets which proved to be extremely attractive over the last two decades, investors and analysts have tried to acquire profits from possible abnormal returns. The reforms in the ASE, that is capital market liberalization, automated trading system and a relative political stability (Chortareas *et al.*, 2000) made the ASE a place of financial interest. Although several studies have been conducted in the ASE depending on the goal of each study, focusing mostly on the behavior of stocks, the efficiency of the market and the reaction to announcements (Niarchos and Alexakis, 2000; Siourounis, 2002) none of these have combined a selected number of macroeconomic and financial data with the two forms of the APT model in order to reach some robust inferences regarding the behavior of stock returns in Greece. Specifically, we decided to employ the statistical version of the APT model (Chen, 1983) so as to examine if there are any (artificial) factors that may explain the behavior of stocks in the ASE. No similar empirical studies are evident for Greece, at least during this period under examination. The same holds for the application of the macroeconomic APT model (Chen *et al.*, 1986). We used a number of macroeconomic variables and applied the model for the same period, and as there are no similar studies in Greece, we compared our results with those of other stock markets. Furthermore, after the application of the APT models, we proceeded to the comparison of the models. Specifically, we examined the relationship between the macrovariables and the artificial factors generated from the methodology of the statistical APT model. The methods used, like the Davidson and Mackinnon (1981) test for specification error and the canonical correlation analysis (Chen and Jordan, 1993; Cheng, 1995) have not been used in similar studies for the ASE. The empirical results are very interesting for the ASE as there is evidence that the ASE general index is the most significant of the factors used on portfolio returns, an inference that it is in agreement with several prior empirical studies and holds even in the case of the turbulent period for the Greek economy during the last few years.

The APT was originally proposed by Ross (1976) and can be considered as an alternative concept to the CAPM for explaining risk and return in the market. It assumes that security returns are generated by a "multi-factor" model, which is linear. In other words, it is believed that all security returns depend on the movements in these factors. The main question regarding the APT model is to define the exact factors that influence stock returns. There are at least two major approaches: The statistical and the macroeconomic approach. It is important to mention that there is no good way to associate any of the estimated factors with any underlying theoretical constructs. This means that there is no clear economic interpretation for any of the empirical results (Campbell *et al*., 1997). The macroeconomic approach hypothesizes that certain factors are important, based on theoretical considerations, and uses these factors to price the variation of stock returns. The problem with this approach is that it is difficult to know if someone has *a priori* chosen the right factors, no matter how interesting the results of the model might be.

The study is organized as follows: Section II presents the literature review on arbitrage pricing theory with the application of the macroeconomic and the statistical APT model. Section III presents the methodology that is followed in order to test the models. Furthermore, Section IV presents the data collection process, while Section V presents the empirical results and, finally, Section VI concludes the study.

II. LITERATURE REVIEW

In this section we present past and recent studies which are based on the theory of arbitrage pricing. Roll and Ross (1980) investigated the US stock market using the statistical specification of the APT model. The data sample included daily stock returns and the period of analysis extended from 1962 to 1972. The results showed that there were at least three priced factors for the period under examination. Chen (1983) also examined the US stock market for the period 1963−1978 by applying the statistical APT model. The data sample included daily stock returns and, after the application of the APT model, it was compared with the CAPM. The results showed that the APT model performed quite well. Alternatively, Chen *et al.* (1986) used a number of macroeconomic factors so as to examine the validity of the model for the US stock market. The period used for the analysis extended between 1953 and 1983. The results gave evidence of several priced macroeconomic variables, which means that they played a significant role in the explanation of the behavior of stock returns. Faff (1988) employed a statistical APT model in the Australian stock market so as to examine possible derived factors. Principal components analysis was used for the derivation of factors. After the application of the APT model, it was compared with the standard CAPM and the results were mixed for the period between 1974 and 1985. Additionally, Chen and Jordan (1993) examined the power of the statistical and the macroeconomic APT model in the US stock market using monthly returns for the period between 1971 and 1986. The results of the analysis exhibited small differences between the models but it is important to mention that, during the application of the Davidson and MacKinnon (1981) method for the comparison between the models, the results of Chen and Jordan (1993) were similar to the results of our study, that is the statistical APT is a better model compared to the macroeconomic APT model. Furthermore, Clare and Thomas (1994) investigated the cross-sectional variation of stock returns using two different methods of ordering stocks into portfolios. The period of analysis extended from 1983 to 1990 for the UK stock market and the results of the tests showed that only two factors were priced while ordering stocks according to size. On the other hand, more macroeconomic variables were found to be priced while ordering stocks according to beta. Cheng (1995) investigated the relationship between a set of factors derived from factor analysis and a set of macroeconomic variables. The study was applied on UK data for the period between 1965 and 1988 using monthly stock returns. The canonical correlation analysis results showed that stock returns were positively correlated with several macroeconomic variables while there was also a small negative correlation between the returns and some of the variables. Fifield *et al.* (2000) examined the influence of local and global factors on a number of emerging stock markets (ESMs) including the stock markets of Hong Kong, Mexico, India, Greece and Turkey, during the period between 1987 and 1996. After the application of factor analysis on the macroeconomic variables, the derived factors were used as independent variables in a series of multi-factor regressions so as to examine whether they can explain the behavior of the indices of the ESMs. The results of the regressions showed that a selective number of global and local variables exhibited a significant influence on stock returns. Diacogiannis *et al.* (2001) investigated the pricing of possible risk premia in the ASE by applying a different form of APT model, which used observable macroeconomic and financial variables for the construction of the factors used in the analysis. They used quarterly data for the period 1980−1992 and the results showed the existence of two, at least, common factors for the 1980−1986 and the 1986−1992 sub-period under examination. The main conclusion of the study was that the variables had an effect on the pricing of risk premia. Bilson *et al.* (2001) examined whether a set of macroeconomic variables had explanatory power over stock returns in emerging markets. The results gave evidence of the existence of relationships between the variables but the influence of the factors was relatively poor. Furthermore, Leledakis *et al.* (2003) examined the cross-sectional determinants of stock returns in the ASE for the period between 1990 and 2000. A maximum likelihood technique was employed, similar to that developed by Litzenberger and Ramaswamy (1979), which was used instead of the portfolio grouping procedure. The findings of the tests suggested that the only significant variable in the explanation of the cross-sectional variation of the market was the market equity that captures the size effect. Cauchie *et al.* (2004) compared the statistical and the macroeconomic APT model using monthly data from the Swiss stock market between 1986 and 2000. The results showed that the statistical APT model provided more robust results in the explanation of stock returns behavior, a similar result with our conclusions. Azeez and Yonezawa (2006) examined the pricing of specific macroeconomic factors in the Japanese stock market with the application of the APT model during the period between 1973 and 1998. The results indicated that the null hypothesis, that expected returns are determined by the APT model with specific risk factors, is accepted. There seem to be four different types of risk factors that have significant influence on expected returns in the sample period: the money supply, inflation, exchange rate, and industrial production. Karanikas *et al.* (2006) examined the significance of macroeconomic factors and firm-specific variables in the explanation of the cross-sectional variation of expected stock returns in the ASE between 1991 and 2004. A standard and a recursive application of the Fama and MacBeth (1973) testing procedure were followed in order to achieve their goal. The results of the tests indicated that the changes in the short-term interest rates and firm size can explain a significant proportion of the variation of individual returns. Finally, Guermat and Freeman (2010) introduced a new net beta test which shares a number of characteristics with conditional beta tests. They extended the method to the multi-factor case when there are mimicking portfolios of assets for the underlying factors, including the Fama–French (1993) three-factor model. The results showed that the net beta estimators have lower standard errors than those generated by the standard Fama–MacBeth (1973) test.

III. METHODOLOGY

A. The Statistical APT Model

Specifically, the methodology used for the APT is the following:

(1) In the beginning the excess returns are estimated by subtracting for each stock the risk-free rate of return ($R_{it} - R_{ft}$). The market premium (excess market proxy) is also estimated by subtracting from the general market index the risk free-rate of return ($R_{mt} - R_{ft}$).

(2) A regression follows between the excess return of each stock and the excess return of the stock market index. This specific regression was based on the following equation:

$$R_{it} - R_{ft} = a_{it} + b_i (R_{mt} - R_{ft}) + e_{it} \tag{1}$$

where R_{it} is the return of each stock i for each period of analysis, R_{ft} is the risk-free rate of return and R_{mt} is the return of the general market index. In this way the betas are estimated and, based on past studies (e.g. Black *et al.*, 1972), portfolios of equal size are constructed. The number of 30 stocks into the portfolios is justified as a sufficient number of stocks by previous studies on the CAPM and the APT models (Roll and Ross, 1980). The study examines 24 portfolios comprised of 30 securities each.

(3) After the construction of the portfolios based on beta sorting (the stocks that are included in the portfolios are the ones that have the largest value of estimated betas and the rest of the stocks, with the smallest value of betas, were excluded from the data sample) a principal components analysis (PCA) was employed. The output of this analysis that is of interest for the cross-sectional tests is the number of artificial factors which are used in a series of regressions to produce the betas for the second stage. The decision of the number of factors that will be retained for the analysis is based on the scree plots (Cattell, 1966), the Kaiser criterion (Kaiser, 1958), or the amount of total variance of the initial variables.

(4) Then we proceed to the cross-sectional stage by regressing the returns of each of the constructed portfolios for each period on the estimated betas from the time-series regressions. Likewise, this stage of regressions is based on the following equation:

$$\tilde{R}_{it} = \gamma_0 + \gamma_1 b_{i1} + \gamma_2 b_{i2} + .. \gamma_n b_{in} + e_{it} \tag{2}$$

where $\tilde{R}_{it}$ is the return of each portfolio p comprised by the average monthly excess returns of each security i for each period of analysis (the dependent variable) and the b_is are the estimated betas from the first stage of analysis (the independent variable).

(5) All steps were followed for all portfolios for the whole period and the sub-periods of the analysis.

B. The Macroeconomic APT Model

The statistical APT and the macroeconomic APT model are both linear models and their only difference comes from the difference in the nature of their systematic factors. In order to empirically test the validity of the macroeconomic APT model, or macrovariable model (MVM), we follow the two-step procedure described in the study of Groenewold and Fraser (1997):

(1) Each security is sorted to some specific portfolio according to the ranking of its beta as in the case of the statistical APT model (Blume, 1970; Friend and Blume, 1970 and others). Then, we regress each security on the number of macroeconomic variables that have been selected for the analysis based on equation (3):

$$R_{it} = b_{i0} + b_{i1}F_1 + b_{i2}F_2 + \ldots + b_{ik}F_n + e_{it} \quad (3)$$

where F_n are the factors (macroeconomic variables) selected for the tests, b_{ik} represent the sensitivities that are estimated from the regression of each security's return, R_{it}, on the set of factors, and e_{it} is the random variable assuming that the mean of the variable is zero and its variance is constant ($E(e_i) = 0, Var(e_i) = \sigma^2$). It is also assumed that $E(e_i, e_k) = 0, i \neq k$ and $cov(e_i, F_n) = 0$ for all securities and factors. This stage is called the time-series regression stage as it involves the use of time series data to estimate a set of sensitivities (factor betas) for each asset (see: Groenewold and Fraser, 1997; Chen and Jordan, 1993).

(2) After the factor betas for each security have been estimated, during the time-series stage, we cross-sectionally regress these estimated factor betas on the average returns of securities for each portfolio. This cross-sectional regression is based on equation (4) which is the same with equation (2) of the statistical APT model:

$$\tilde{R}_{it} = \gamma_0 + \gamma_1 b_{i1} + \gamma_2 b_{i2} + \ldots \gamma_n b_{ik} + e_{it} \quad (4)$$

where $\tilde{R}_{it}$ is the return of each portfolio p, which is comprised by the average monthly excess returns of each security i for each period of analysis (the dependent variable) and b_is are the estimated factor betas or sensitivities, from the time-series stage of analysis (the independent variable). The results of this regression are the values of the estimated risk premiums, γ, for each (macroeconomic) factor for each portfolio of analysis (Groenewold and Fraser, 1997).

(3) All steps were followed for all portfolios for the whole period and the sub-periods of the analysis.

C. Comparison between the Statistical APT Factors and the Macroeconomic APT Variables

1. Fisher's Joint Test

Fisher's (1948) method is a "meta-analysis", which means that we can analyze data after they have already been analyzed and have given specific results. Fisher's analysis is applied on these results. Specifically, it is a technique that combines the results from a variety of independent tests bearing upon the same overall hypothesis (H_0) as if in a single test. Fisher's method combines the value probabilities, p , or " p -values", into one test statistic (x^2), having a chi-square distribution using the following equation (5):

$$x^2_{2k} = -2\sum_{i=1}^{k}\log_e(p_i) \quad (5)$$

The p -value for the x^2 distribution itself can then be interpolated from a chi-square table using $2k$ "degrees of freedom", where k is the number of tests being combined. As in any similar test, H_0 is rejected for small p -values, usually < 0.05. Fisher's joint test is applied in the p -values from the time-series regressions of the factor scores (estimated for the statistical APT during the factor analysis for each portfolio under examination) on the set of the macroeconomic variables selected for the analysis (Chen and Jordan, 1993). The purpose of the tests is to verify if there is truly an overall significant relationship between the factor scores from the statistical APT model and each macrovariable from the macroeconomic APT model.

2. Canonical Correlation Analysis

Canonical Correlation is an extension of multiple regressions. In multiple regression analysis the variables are partitioned into a x -set containing q variables and a y -set containing $p = 1$ variable. The regression solution involves finding the linear combination $a'x$ which is most highly correlated with y . In canonical correlation analysis the y -set contains $p \geq 1$ variables and we look for vectors a and b for which the correlation between $a'x$ and $b'y$ is maximized (Mardia *et al*,. 1979). Let us suppose that x is a q -dimensional random vector having mean μ and y is a p -dimensional random vector having mean ν and that:

$$E\{(x-\mu)(x-\mu)'\} = \Sigma_{11} \quad (6)$$

$$E\{(y-\nu)(y-\nu)'\} = \Sigma_{22} \quad (7)$$

$$E\{(x-\mu)(y-\nu)'\} = \Sigma_{12} = \Sigma'_{21} \quad (8)$$

Now consider the two linear combinations $\eta = a'x$ and $\phi = b'y$. The correlation between η and ϕ is:

$$\rho(a,b) = \frac{a'\Sigma_{12}b}{(a'\Sigma_{11}ab'\Sigma_{22}b)^{1/2}} \quad (9)$$

The correlation $\rho(a,b)$ varies with different values of α and b , hence one might ask what values of α and b maximize this correlation. Equivalently, we can solve the problem:

$$\max_{a,b} a'\Sigma_{12}b \text{ subject to } a'\Sigma_{11}a = b'\Sigma_{22}b = 1 \quad (10)$$

The solutions to this problem are vectors a_i and b_i which are called the i -th canonical correlation vectors for x and y, respectively, while the random variables $\eta_i = a_i'x$ and $\phi_i = b_i'y$ are called the i -th canonical correlation variables or canonical variates and the $\rho(a,b)$ is the i -th canonical correlation coefficient between the canonical variates, while the correlations between the canonical variates and the original variables x and y are called canonical loadings and are used for the characterization of the new canonical variates.

D. Comparison of the Statistical APT and the Macroeconomic APT Model

The following criteria are used for the comparison between the models:

(a) The adjusted R square and the significance of the F statistic are used for each portfolio after the cross-sectional regressions for both models.

(b) The Davidson and MacKinnon (1981) equation is applied for the comparison of the models. This equation has the following form:

$$R_{p,t} - R_{MAPT,t} = a_t(R_{SAPT,t} - R_{MAPT,t}) + e_t \qquad (11)$$

In equation (11) R_{SAPT} and R_{MAPT} are the expected returns which were generated by the models respectively. If the null hypothesis H_0 is not rejected and the coefficient a is equal to zero, it means that the macroeconomic APT is the better model, which shows that there might be observed variables able to explain the behavior of stock returns. The same comparison criteria are applied for all the portfolios and the periods of examination.

IV. DATA COLLECTION

The data was obtained from the ASE databanks and it is comprised of daily closing prices of common stocks traded in the ASE during the period between 1989 and 2010. They are raw prices in the sense that they do not include any dividends but are adjusted to stock splits. We tried to split the entire period in specific sub-periods based on two criteria. The first criterion is based on the notion to test the robustness of the results by dividing the whole period into non-overlapping sub-periods of equal length (Leledakis *et al.*, 2003). We should note that due to data availability the last sub-period extends only from January 2007 to May 2010. The second criterion is related to specific changes in the functionality of the Greek economy. For example, the first sub-period (1989-1994) is characterized by specific reforms in the ASE. Although, before 1992, there was high volatility in the ASE market due to an international recession, the political problems in some Balkan countries and other domestic restrictions that reduced the investment interest in the ASE, several changes happened after the end of 1992. Specifically, after the signing of the Maastricht Treaty in the September of the same year, there were reforms in the ASE, such as capital market liberalization, an automated trading system, the dematerialization of stocks and fixed income securities and a relative political stability (Chortareas e*t al.*, 2000, Karanikas *et al.*, 2006) that made the ASE a place of interest. These reforms led to further changes which lead to the second sub-period of our research. After the domestic and international interest in the ASE, its general index started increasing rapidly after 1997, which implied significant increases in its returns. During the end of 1999 the index was at its highest level after consecutive years of market growth. The third sub-period is characterized by a significant monetary change which is the use of euro as the official currency in the transactions of Greece after 2001. Except of this change there were several other events in Greece such as the upgrade of the Greek market from an emerging to a developed one, according to the Morgan Stanley Capital International, the elections that led to the change of the government in 2004, as well as the Olympic Games that took place in Greece in 2004. As far as the final sub-period is concerned, it covers mainly the period that the economic turbulence started for the Greek economy as well as for several other countries. The data sample included both financial and non-financial stocks. The data set of 257 months was divided in four non-*overlapping* sub-periods (three sub-periods of 72 months each and a forth one of 41 months) for the needs of the analysis based on prior empirical studies (Chen, 1983; Roll and Ross, 1980). The study examines 24 portfolios comprised of 30 securities each. Specifically, one of them covers the whole period of analysis (from 1989 to 2010), two portfolios cover the 1989-1994 sub-period, five portfolios cover the 1995-2000 sub-period, while there are eight portfolios both for the third and the fourth sub-period. All stocks used in the study had a complete price history, which means that they had no missing values due to temporary delisting or suspension or just because of missing data (Chen, 1983). Subsequently, for the four sub-periods sample sizes of 72, 166, 259 and 263 were produced respectively, while for the whole period the sample size consisted of 43 stocks − the only stocks with no missing values during the period 1989−2010. Moreover, only one portfolio was constructed based on beta sorting for the period between 1989 and 2010 as explained in part A of section III. In the case of the first sub-period two portfolios (30 stocks each) were constructed, for the second sub-period five portfolios were constructed while for the third and fourth sub-periods eight portfolios were constructed. The return of the market was obtained from the ASE Composite (General) Share Price Index. Finally, the three-month Government Treasury Bill Rate, which is considered to be a short-term interest rate, was used as the risk-free interest rate and was obtained from the Central Bank of Greece. The daily returns of stocks were calculated using the logarithmic approximation:

$$R_{i,t} = \log\left(P_{i,t} / P_{i,t-1} \right) \tag{12}$$

where $P_{i,t}$ is the closing price of day t for asset i (Chortareas *et al.*, 2000). Then the daily returns were aggregated to compose the monthly return series used as the input of the analysis. As mentioned before, while in previous empirical studies like the one of Roll and Ross (1980) the stocks were sorted alphabetically into portfolios, in our study the portfolios were constructed on the ranking of betas, a procedure similar to the studies of Blume (1970) and Friend and Blume (1970). The purpose was to eliminate the diversifiable risk and to reduce the error-in-variables problem (Clare and Thomas, 1994; Campbell *et al.*, 1997). The variables explained above were used for the application of the statistical APT model. As far as the macroeconomic APT model is concerned, a number of macroeconomic variables were also collected based on previous theory in order to test the model and compare the results with prior studies (Chen *et al.*, 1986; Groenewold and Fraser, 1997). We should also mention at this point that, although we test predetermined factors in the macroeconomic model, there are methods which are used to determine the number and identity of relevant prespecified factors before estimating a pricing model (Mei, 1993). In Table 1 we present the basic data series and the respective derived series.

Table 1
The presentation and measurement of the macrovariables

Macroeconomic Variables		
A. Basic Data Series		
Symbol	Variable	Measurement
I_t	Inflation	Consumer Price Index
IP_t	Industrial Production	Total Index of Industrial Production
PS_t	Petroleum Series	Producer Price Index: Manufacture of Coke, Refined Petroleum Products and Nuclear Fuels
RMI_t	Stock Market Index Return	Return on an equally-weighted market portfolio of the ASE
$USDER_t$	US Dollar to Euro Exchange Rate	US Dollar to Euro Exchange Rate
$BPER_t$	British Pound to Euro Exchange Rate	British Pound to Euro Exchange Rate
TBR_t	Risk-Free Rate of Return	3-month Treasury Bill Rate
$LTGB_t$	Long-Term Government Bond	5-year Government Bond Rate
B. Derived Series		
Symbol	Variable	Measurement
$E(I_t)$	Expected Inflation	Estimated from an ARIMA (0,1,5) (0,0,1) model, based on the Box-Jenkins (1976) methodology
UI_t	Unexpected Inflation	$UI_t = I_t - E(I_t)$
CEI_t	Change in Expected Inflation	$CEI_t = E(I_{t+1}) - E(I_t)$
$GRIP_t$	Growth Rate in the Industrial Production	$GRIP_t = \log_e(P_t / P_{t-1})$
CPS_t	Change of the Petroleum Series	$CPS_t = \log_e(PS_t / PS_{t-1})$
TP_t	Term Premium	$TP_t = LTGB_t - TBR_t$

It is of interest to mention that summary statistics for all the portfolios showed that for most of the cases there is no visible deviation from normality for the excess returns of the ASE portfolios. The results are available upon request for all portfolios and sub-periods of investigation.

V. EMPIRICAL RESULTS

A. APT Principal Components Analysis Results

The number of factors and the estimated betas of the APT model, used later in the cross-sectional tests, are determined through principal components analysis. Varimax rotation is used so as to minimize the number of variables who may have high loadings on some factors. In this section we present as an example portfolio 1 of the 1st sub-period (1989−1994). The procedure is the same for all the other portfolios of the analysis. The Kaiser-Meyer-Olkin test value is high (0.887) and the Bartlett's test is statistically significant (0.000), which means that the factor analysis followed is the proper technique for this data. The KMO test values between 0.8 and 0.9 can be described as excellent. The Bartlett's test of sphericity tests the hypothesis that there is no shared variance in the component matrix under examination. In this test a significant chi-square statistic explains that factor analysis is appropriate as a method for the data. In the present portfolio, as well as at the rest of the portfolios for all periods, the KMO test value and the test of sphericity are high and significant respectively. Furthermore, the eigenvalues representing the proportion of total variance in all variables that is accounted for by that specific factor. In order to decide the number of factors that will be retained, we examine the scree plot and the possible maximum amount of variance explained. The results showed that there are six significant factors. As far as the scree plot is concerned, which presents the eigenvalues for each of the components under examination, the respective figure showed that after the sixth factor the eigenvalues are decreasing slowly and we decide to retain the six factors (Cattell, 1966). From the observations above we come to the conclusion to retain the first six significant factors that account for over 80 per cent of the total variance. In other words, the results from the tests show that there are six factors that have an effect on the behavior of ASE stock prices. We should mention here that the first factor alone explains more that 21 per cent of the total variance.

B. Statistical APT Cross-sectional Test Results

Table 2 presents the cross-sectional results of the statistical APT model. The first row of each cell for each factor depicts its beta coefficient, while in the second row of the same cell the respective p -value is presented. During the whole period (1989−2010), it is obvious that the APT has an adjusted R^2 equal to 39.9 per cent for its only portfolio. This means that the model offers some explanation to the relationship between average excess returns and a number of unobserved variables. Moreover, the F statistic (sig. = 0.008) shows that the independent (unobserved) variables are valid in the explanation of the variation of the dependent variable (the portfolio). As far as the 1st sub-period is concerned, the results are in favor of the application of the APT model, as the portfolios have a significant adjusted R^2, the F statistic shows that the factors can explain the variation in the average excess returns and several coefficients are statistically significant. Overall, during this period, the APT performs well. For the 2nd sub-period the test results are also strong. They report sufficient values of the adjusted R^2, except of portfolio 3. This means that the model provides an adequate explanation between the behavior of average excess returns and the effect of the statistical factors. The F statistic is also significant in most of the cases.

Table 2
The cross-sectional test results of the statistical APT model

Period	Portfolios	γ_0	γ_1	γ_2	γ_3	γ_4	γ_5	γ_6	γ_7	γ_8	γ_9	Adjusted R^2	DW	F Sig.
1989–1994	P1	-0.006	0.054	0.018	0.056	0.037	0.041	-0.008				0.433	1.442	0.003
		0.342	0.480	0.770	0.352	0.257	0.030	0.683						
	P2	-0.012	0.036	-0.016	0.024	0.015	0.013	0.001	0.047	0.000	0.049	0.515	1.538	0.003
		0.032	0.546	0.587	0.426	0.567	0.644	0.966	0.023	0.989	0.007			
1995–2000	P1	0.010	-0.086	-0.017	-0.032	-0.019	-0.005					0.274	2.713	0.024
		0.413	0.585	0.896	0.771	0.823	0.950							
	P2	0.006	0.023	-0.018	0.050	0.026	0.011					0.481	1.749	0.001
		0.374	0.742	0.792	0.468	0.669	0.761							
	P3	0.012	-0.043	-0.063	-0.036	-0.035	-0.028	-0.003				-0.073	1.494	0.673
		0.452	0.827	0.725	0.769	0.756	0.785	0.960						
	P4	-0.167	2.355	2.167	2.143	1.436	0.773					0.132	1.986	0.135
		0.139	0.053	0.056	0.055	0.098	0.009							
	P5	0.010	-0.039	-0.036	-0.008	-0.013	0.023	0.001	-0.014			0.287	2.192	0.037
		0.036	0.405	0.408	0.847	0.737	0.237	0.943	0.389					
2001–2006	P1	-0.001	-0.231	-0.215	-0.177							0.313	1.651	0.005
		0.859	0.040	0.025	0.014									
	P2	0.001	-0.234	-0.298	-0.211	-0.071	-0.099					0.576	2.296	0.000
		0.926	0.003	0.000	0.002	0.019	0.001							
	P3	0.001	-0.161	-0.154	-0.168	-0.164	-0.101	-0.058				0.244	2.061	0.048
		0.870	0.020	0.021	0.012	0.011	0.043	0.060						
	P4	-0.001	-0.118	-0.093	-0.084	-0.085	-0.091	-0.095				0.698	2.337	0.000
		0.882	0.064	0.102	0.092	0.091	0.026	0.002						
	P5	-0.007	-0.055	-0.078	-0.066	-0.054	-0.051	-0.052				0.390	2.589	0.006
		0.205	0.349	0.169	0.074	0.071	0.106	0.040						
	P6	-0.013	0.189	0.090	0.072	0.077	1.060	0.000	-0.024			0.803	2.067	0.000
		0.829	0.781	0.870	0.876	0.774	0.000	0.999	0.907					
	P7	-0.001	-0.100	-0.101	-0.082	-0.050	-0.060	-0.050	-0.069	-0.010		0.678	1.205	0.000
		0.579	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.260				
	P8	0.006	-0.135	-0.109	-0.051	-0.066	-0.025	-0.043	-0.052	-0.055	-0.049	0.579	1.149	0.001
		0.081	0.000	0.000	0.003	0.000	0.025	0.002	0.000	0.000	0.001			

Table 2 (continued)

2007–2010	P1	0.006	-0.236	-0.038	-0.258	0.011						0.017	2.285	0.368
		0.820	0.076	0.635	0.091	0.896								
	P2	-0.023	-0.120	-0.047	-0.033	-0.055	0.036	-0.061	0.229			0.199	1.622	0.097
		0.587	0.613	0.809	0.761	0.724	0.757	0.526	0.027					
	P3	-0.014	-0.209	-0.015	-0.068	0.026	-0.144	0.130				0.294	1.382	0.025
		0.729	0.329	0.931	0.782	0.859	0.123	0.022						
	P4	0.030	-0.175	-0.278	-0.422	-0.301	-0.150	-0.091				0.210	2.035	0.071
		0.369	0.346	0.114	0.073	0.006	0.097	0.234						
	P5	-0.015	-0.175	-0.075	-0.060	0.101	-0.167	-0.017	-0.002			-0.027	2.153	0.531
		0.630	0.389	0.707	0.708	0.271	0.183	0.857	0.987					
	P6	-0.025	-0.021	0.027	-0.010	-0.093	-0.033	0.017	0.144			-0.053	1.749	0.602
		0.320	0.877	0.898	0.947	0.525	0.674	0.874	0.047					
	P7	-0.009	-0.171	-0.061	-0.120	-0.038	0.053	-0.129	-0.163	0.017		0.220	2.172	0.094
		0.650	0.273	0.743	0.445	0.754	0.350	0.345	0.008	0.851				
	P8	-0.022	0.103	0.123	-0.110	0.122	-0.095	-0.078	0.026	0.055	-0.056	0.014	1.856	0.447
		0.097	0.618	0.431	0.262	0.319	0.345	0.430	0.703	0.577	0.603			
1989–2010	P1	0.000	0.021	-0.003	-0.044	-0.083	-0.056	0.015	0.020			0.399	1.745	0.008
		0.965	0.660	0.932	0.174	0.003	0.177	0.561	0.441					

Moreover, for the third sub-period (2001−2006), the adequacy of the model is still evident as it can be seen from the values of the adjusted R^2 and the F statistic. The last sub-period (2007-2010) seems to present results not in favor of the APT model. The adjusted R^2 has negative values in some cases, while the F statistic is significant only in the case of portfolio 3. This is a sign that the latest events in the Greek economy due to the economic crisis have affected the ASE stocks. As the model is based on information that is the result of statistical analysis using as data only stock returns, in order to construct the artificial factors, it is possible these last economic events to have an effect on the behavior of stocks as well as on the performance of the APT model.

C. Empirical Findings of the Macroeconomic APT Model

1. Time-series Regression Analysis between the Factor Scores and the Macrovariables

In this section we investigate for possible relationships between the macrovariables that are used in the analysis and the factor scores that were generated during factor analysis (Chen and Jordan, 1993). Fisher's (1948) joint test is applied based on the hypothesis that the coefficient on that variable is jointly equal to zero. Although there is a significant relationship between several variables and the respective factor scores for many of the portfolios, the results from the joint tests show that, overall, only the stock market index has a strong relationship with the factor scores generated from the factor analysis of stock returns. This is visible in most of the cases and it is in accordance with the findings of Chen *et al.* (1986) and Chen and Jordan (1993). Additionally, the two inflation variables, while they generally present insignificance in almost all the portfolios, at least one of them seems to play a significant role for the portfolio of the whole period, the first portfolio of the second sub-period and the second portfolio of the third sub-period. This result of the weak performance of the inflation variables is in agreement with the findings of Chen *et al.* (1986). The addition of new variables during the last sub-period did not change the empirical findings as the effect of both exchange rates and the term premium was minor on portfolio returns. Contrary to prior studies that verified the significance of term premium (McGowan and Dobson, 1993) the results are insignificant, which could be due to the fact that the new economic situation in Greece in not affected by specific economic factors and new ones should be determined, even on an international level. While in the work of Chen and Jordan (1993) the unexpected growth rate in the industrial production presents a small significance, in our case this variable is insignificant at all levels of significance, except of the case of portfolio 3 during the last sub-period (2007-2010). On the contrary, other variables, such as the stock market index, are based more directly on market prices (Chen and Jordan, 1993) and this may be a reason of significance based on the results from the joint test. As far as the unexpected change in the petroleum series is concerned, which is used here as a similar index to the one used by Chen *et al.* (1986) and Chen and Jordan (1993), only for the first and the second portfolio of the third sub-period (2001−2006) the variable seem to be significant at the 10 and 5 per cent level (0.098 and 0.030 respectively). This result may be due to the fact that we use a similar and not the same index (i.e. crude petroleum index) used in previous studies (Chen *et al.*, 1986; Chen and Jordan, 1993; Clare and Thomas, 1994). The table with the joint test results is available upon request for all the portfolios.

2. Canonical Correlation Analysis between the Set of Factor Scores and the Set of Macroeconomic Variables

The purpose of canonical correlation analysis is to find the linear combinations that maximize the correlations between the members of each canonical variate pair. This pair consists of different combinations between two sets of variables, one set of dependent variables and the other set of independent ones. As an example, for the first portfolio of the second sub-period (1995−2000) the squared canonical correlation is equal to 0.945 which means that approximately 94.5 per cent of the total variance of the first linear combination of the factor scores is explained by the total variance of the respective linear combination of the macrovariables. The canonical loadings for almost all the portfolios show that the first linear combination is due to the return on the stock market index, a finding which is exactly the same as in the work of Chen and Jordan (1993). This is another confirmation that the stock market index still has the power to absorb the necessary amount of information so as to explain the behavior of securities. This is a sign that the results contradict up to a point the findings of Chen *et al*. (1986), although this conclusion was a result of multiple regressions and not of canonical correlation analysis. Except of the significance of the stock market index, the second linear combination seems to be due to the change in the expected inflation and the unexpected inflation (although this happens only in one case during the third sub-period). While these results contradict the findings of Chen and Jordan (1993), there are similarities with our results from Fisher's joint test as in the case of the second portfolio of the third sub-period (2001−2006). In this case the inflation measure seems to be statistically significant from the results of the joint test and the results of the canonical correlation analysis. The results are in accordance to the fact that the inflation measures such as the change in the expected inflation have relatively more power to affect the behavior of stock returns, especially when these variables are more volatile during specific periods. The findings of the relatively small but interesting role of the inflation variables in the ASE, confirms the conclusions of Chen *et al.* (1986) about the small but interesting performance of these variables in stock markets. However, our results contradict those of Chen and Jordan (1993) where at least the unexpected growth rate in the industrial production seems to be significant for any of the portfolios, while, the unexpected change in the petroleum series seems to be significant only in one case during the fourth sub-period. The results of the joint test and the canonical correlation analysis verify that these two variables are relatively insignificant in the explanation of the variance of any set of factor scores. The minor significance of the petroleum index can partially be explained by the fact that several similar indices, that include petroleum, have become much more volatile through the years due to several reasons, such as the increase in the price of crude petroleum which affects the cost of petroleum products and have an effect on a country's economy. The table that presents the significant linear combinations between the two sets, with the respective squared canonical correlations that show the percentage of variance shared between the two sets of variables, the p-value, which shows the significance of the correlation between them, and the macrovariables with their respective significant loadings for each set of macrovariables is available upon request from the authors.

D. Macroeconomic APT Cross-sectional Test Results

Table 3 presents the cross-sectional results after the application of the macroeconomic APT model (Chen *et al.*, 1986; Chen and Jordan, 1993; Groenewold and Fraser, 1997). The first row of each cell for each factor depicts the beta coefficient of each factor, while in the second row of the same cell the respective p -value is presented. As far as the only portfolio for the whole period (1989−2010) is concerned, the macroeconomic APT model does not seem to have the power to explain stock returns. The adjusted R^2 is 0.168 and the F statistic is equal to 0.071. The results of the macroeconomic APT model for the whole period are different to those of the statistical APT model, as the latter's adjusted R^2 is equal to 0.399 and the F statistic is equal to 0.008. In the 1st sub-period (1989−1994) the results of the models are even more similar as they both seem to have the potential to affect stocks (adjusted R^2 equal to 0.417 and 0.400 for the first and the second portfolio respectively). In all these cases the F statistic is also significant at the 1 per cent level (0.001 and 0.002). This might be a sign of concurrence between the artificial factors and the observed macrovariables. This period of investigation is characterized by several reforms in the ASE in order to overcome the difficulties in its functionality, so it is very interesting to see that such concurrence may be feasible. During the 2nd period (1995−2000) on a domestic and an international level the results are different between the models. If we see the F statistics for each portfolio in both tables, we can see that at the cells that the one model has the ability to explain stock returns, in the respective cell of the other table the other model performs poorly (for example, while portfolio 4 in Table 2 of the statistical APT model shows an adjusted R^2 equal to 0.132 and F statistic equal to 0.135, Table 3 shows that for the same portfolio the adjusted R^2 is equal to 0.277 and the F statistic is 0.023). These results might be, as already mentioned, the aftermath of macroeconomic crises around the world, for instance in Brazil and Russia, and other economic problems that have occurred domestically and internationally. These phenomena motivate the use of more variables, mostly international, in these tests. In the 3rd sub-period (2001−2006), the macroeconomic APT model seems to explain stock returns less in comparison to the statistical APT model, a result which is evident by the F statistics (which in more than half the cases are insignificant at the 5 per cent level) and the adjusted R^2s which are relatively small. This is a sign that, as the ASE has become a developed market in the new millennium new factors may affect stocks' behavior. This is why the artificial factors of the statistical APT model seem to be more significant in comparison to the macroeconomic model. It includes a number of significant (unobserved) factors and the only problem is to be identified and used in the tests. The results of the last sub-period (2997-2010) are even worse for the model as in only one case (portfolio 2) the model seems to be adequate in the explanation of stocks' behavior. These findings verify once more that the addition of new variables during the last sub-period did not change the empirical findings as the effect of both exchange rates and the term premium was nonexistent on portfolio returns. Regarding the insignificance of the exchange rates and the term premium, the results are in agreement to prior studies (Groenewold and Fraser, 1997 and Antoniou *et al.*, 1998 respectively). Moreover, one can say that due to the new economic situation in Greece financial institutions should determine new – domestic or even international – factors in the explanation of the variation of stocks.

Finally, we should mention that, as the Olympic Games took place in Greece in 2004, significance is observed in the industrial production factor according to the results of portfolio 8. This inference is in agreement with the results of Veraros *et al.* (2004) that, during the preparation of the event, positive effects were observed at specific stocks related to infrastructure development. Specifically, portfolio 8 contains stocks of firms that belong to the industrial production sector whose work had increased before the period of the Games due to the need for new constructions, that is new buildings and stadiums, reconstruction of older ones and so on.

E. A Comparison Criterion between the Macroeconomic APT and the Statistical APT Model

1. Davidson and MacKinnon Analysis

Based on the Davidson and MacKinnon (1981) equation we compare the two forms of the APT model. According to theory behind equation (11), if the null hypothesis H_0 is accepted and the coefficient a is equal to zero it means that the macroeconomic APT is the better model. Table 4 shows that for most of the portfolios the statistical APT is the better model. This is clear from the p-values, presented in the second row of the cell of the coefficient, which show that the coefficient is significant in most cases. The results justify that there might be other factors − unobserved at the moment − or combinations of new factors with the existent ones that could play a major role in asset pricing. Alternatively, there are some cases as in the case of portfolio 1, 3 and 4 during the second sub-period as well as in portfolios 7 and 8 of the third sub-period of analysis, where the macroeconomic factors seem to be able to explain the cross-section of stock returns. These might be due to the fact that the high volatility of some of the variables, like in the case of the inflation variables, plays a crucial role in asset pricing, a conclusion similar to that of Chen *et al.* (1986).

VI. CONCLUSIONS

The study explored the ability of specific forms of APT models to explain the behavior of stock returns during the period between January 1989 and May 2010. The results verified the influence of artificial as well as economic factors on stocks' portfolios for specific sub-periods. The period extends from January 1989 to May 2010 and it includes periods of economic and social changes in Greece that is reforms in the ASE, several elections and the Olympic Games of 2004 held in the city of Athens. Furthermore, the period of analysis is also characterized by the economic crisis that led to a new turbulent period for the Greek economy during the last few years. Now the Greek economy, fearing bankruptcy, had to turn to the European Union and the International Monetary Fund (IMF) so as to encounter the higher cost of borrowing. The empirical conclusions are beneficial so that it could be clearer whether there are any potential opportunities for profit from the inefficiency of the stock market mechanism. Since the 90's the changes in the ASE led to an increase in its liquidity and efficiency. These changes contributed to the ability of the ASE to respond faster to any kind of information that had to do with investments and possible gains for the investors.

Table 3

The cross-sectional test results of the macroeconomic APT model

Period	**Portfolios**	γ_0	CEI_t γ_1	UI_t γ_2	$UGRIP_t$ γ_3	$USDER_t$ γ_4	$BPER_t$ γ_5	TP_t γ_6	$UCPS_t$ γ_7	RMI_t γ_8	**Adjusted** R^2	**F Sig.**
1989–1994	P1	-0.008	0.001	0.001					0.026	0.008	0.417	0.001
		0.386	0.032	0.356	-	-	-	-	0.004	0.366		
	P2	-0.024	-0.001	0.002					0.014	0.030	0.400	0.002
		0.005	0.158	0.056	-	-	-	-	0.148	0.050		
1995–2000	P1	0.011	0.000	0.000	0.002				-0.004	-0.003	-0.176	0.984
		0.651	0.690	0.937	0.703	-	-	-	0.623	0.865		
	P2	0.003	0.000	0.000	0.005				0.001	0.012	0.017	0.385
		0.945	0.751	0.347	0.215	-	-	-	0.761	0.754		
	P3	0.068	0.000	-0.001	0.007				0.007	-0.066	0.243	0.036
		0.149	0.673	0.193	0.046	-	-	-	0.363	0.203		
	P4	0.599	0.022	-0.021	-0.022				-0.173	-0.753	0.277	0.023
		0.452	0.051	0.005	0.661	-	-	-	0.004	0.465		
	P5	0.016	0.001	0.000	-0.005				0.007	-0.011	0.065	0.259
		0.414	0.271	0.946	0.237	-	-	-	0.085	0.736		
2001–2006	P1	-0.016	-0.001	0.001	-0.005				0.014	0.005	0.117	0.158
		0.511	0.269	0.068	0.167	-	-	-	0.036	0.750		
	P2	0.134	0.000	0.001	0.003				0.031	-0.111	0.530	0.000
		0.039	0.492	0.086	0.429	-	-	-	0.000	0.033		
	P3	0.068	0.000	0.000	0.001				0.005	-0.071	-0.055	0.629
		0.458	0.631	0.790	0.821	-	-	-	0.489	0.385		
	P4	-0.028	0.001	0.000	0.000				0.018	0.025	0.295	0.018
		0.685	0.115	0.842	0.949	-	-	-	0.022	0.715		
	P5	0.064	0.000	0.000	-0.005				0.005	-0.077	0.186	0.074
		0.274	0.563	0.583	0.283	-	-	-	0.397	0.217		
	P6	-0.597	-0.004	-0.007	-0.066				-0.319	0.670	0.141	0.122
		0.381	0.697	0.450	0.470	-	-	-	0.014	0.412		

Table 3 (continued)

2001–2006	P7	0.050	0.000	-0.001	0.003				0.003	-0.088	-0.050	0.613
		0.223	0.770	0.233	0.630	-	-	-	0.667	0.135		
	P8	0.004	0.000	0.001	-0.006				0.025	-0.009	0.358	0.007
		0.710	0.607	0.386	0.085	-	-	-	0.001	0.696		
2007–2010	P1	0.040	-0.002	0.000	-0.003	-0.002	0.003	0.000	0.018	-0.058	0.196	0.117
		0.206	0.272	0.727	0.594	0.717	0.346	0.126	0.103	0.011		
	P2	-0.025	0.002	0.002	0.012	0.006	0.005	0.000	0.011	-0.008	0.362	0.019
		0.648	0.053	0.040	0.004	0.347	0.063	0.426	0.519	0.870		
	P3	-0.051	0.000	0.001	0.000	-0.002	-0.003	0.000	-0.007	0.020	0.112	0.231
		0.114	0.785	0.357	0.893	0.731	0.275	0.641	0.581	0.532		
	P4	-0.054	0.000	0.000	0.006	-0.017	0.007	0.000	0.029	0.025	0.226	0.088
		0.672	0.267	0.725	0.184	0.274	0.037	0.285	0.439	0.852		
	P5	-0.027	0.000	0.002	0.005	0.002	0.002	0.000	0.000	-0.005	-0.094	0.698
		0.692	0.827	0.126	0.391	0.839	0.556	0.443	0.996	0.949		
	P6	0.028	0.001	0.001	0.001	0.006	0.001	0.000	-0.018	-0.072	0.054	0.341
		0.684	0.248	0.239	0.868	0.564	0.760	0.642	0.484	0.462		
	P7	-0.015	0.001	0.002	0.008	-0.002	0.002	0.000	-0.010	-0.014	0.107	0.240
		0.614	0.424	0.079	0.058	0.812	0.519	0.627	0.492	0.786		
	P8	-0.027	0.000	0.001	0.000	-0.008	-0.008	0.000	0.019	0.024	-0.064	0.624
		0.205	0.890	0.117	0.954	0.318	0.121	0.995	0.320	0.653		
1989–2010	P1	-0.006	0.002	0.000					0.017	0.004	0.168	0.071
		0.328	0.143	0.728	-	-	-	-	0.035	0.539		

Table 4
The Davidson and MacKinnon results

Period	Portfolios	a	R^2	Adjusted R^2
1989–1994	Portfolio 1	0.635 0.028	0.155	0.126
	Portfolio 2	0.765 0.000	0.389	0.368
1995–2000	Portfolio 1	0.262 0.186	0.059	0.027
	Portfolio 2	0.866 0.000	0.484	0.466
	Portfolio 3	0.071 0.807	0.002	-0.032
	Portfolio 4	0.344 0.132	0.077	0.045
	Portfolio 5	0.783 0.001	0.327	0.303
2001–2006	Portfolio 1	0.855 0.025	0.162	0.134
	Portfolio 2	0.594 0.016	0.184	0.156
	Portfolio 3	0.994 0.001	0.313	0.290
	Portfolio 4	0.940 0.000	0.591	0.577
	Portfolio 5	0.762 0.001	0.313	0.289
	Portfolio 6	1.018 0.000	0.790	0.782
	Portfolio 7	-0.100 0.634	0.008	-0.026
	Portfolio 8	-0.117 0.308	0.036	0.003
2007–2010	Portfolio 1	0.104 0.674	0.006	-0.028
	Portfolio 2	0.322 0.098	0.092	0.060
	Portfolio 3	0.664 0.020	0.173	0.145
	Portfolio 4	0.421 0.044	0.133	0.103
	Portfolio 5	0.519 0.059	0.117	0.087
	Portfolio 6	0.215 0.532	0.014	-0.020
	Portfolio 7	0.594 0.005	0.237	0.211
	Portfolio 8	0.737 0.015	0.186	0.158
1989–2010	Portfolio 1	0.752 0.000	0.409	0.389

Additionally, the fact that the number of listed stocks has rapidly increased during the last years, as the ASE transitioned in order to become a developed market (Chortareas *et al.*, 2000), means that nowadays it can play a more significant role in the Greek economy and may affect other stock markets, especially those who are also in a transition stage. The empirical results from the application of the statistical APT model presented an adequate performance for all the sub-periods and the whole period under examination. It shows that there are factors in the market, besides the stock market index of the traditional CAPM that could explain the behavior of the returns of assets. The following step, regarding the application of the macroeconomic APT model, was just to identify these factors, something that has been the main goal of many studies in the past (Chen *et al*., 1986; Chen and Jordan, 1993; Clare and Thomas, 1994; Cheng, 1995). It is also important to mention that the stock exchange in Greece is complex and the behavior of the returns of assets could depend on additional factors that is macroeconomic (Chen *et al.*, 1986) and financial (Fama and French, 1993) or even psychological, as explained by Niarchos and Alexakis (2000), which show that the optimal market portfolio (based on the theory of the CAPM) cannot explain stocks by itself. Moreover, the development of behavioral models might lead investors and analysts to even more accurate inferences.

There is another proposition for future research in asset pricing and this is related to investor sentiment. Specifically, Baker and Wurgler (2006) found that when sentiment is estimated to be high, the returns tend to be relatively low for small, young or high volatility stocks, as most of the Greek stocks are, while, when sentiment is low, the returns of the same stocks tend to be relatively high. Although it is not expected these results to be the same for the ASE, as most of these inferences are based on studies applied in more developed markets, that is the US market, it would be interesting to see what the results would be for the Greek market. The results of the statistical APT model fail to explain the behavior of returns over some portfolios, something which could be due to several reasons. One reason is that the risk and the return of assets may not be stationary during each period, while one of the assumptions of the APT model is that risk and return are assumed to be stationary. Another reason may be the lack of the application of non-linear models in the examination of stock returns, as the linear relationship assumption seems to be too strong to hold. As far as the macroeconomic APT model is concerned, a number of observed variables were selected for the application of the model on a number of portfolios for different time periods. During these sub-periods of examination there was an increase in the liquidity of securities and the information was easier to be absorbed which had to do with new investments and possible gains for the investors. Of course, this is not evidence of market efficiency in Greece, as it can be seen from the adequate empirical results of the APT models. But the fact that information is reflected to stock prices is empirically verified by the results of the tests as the return on the stock market index seems to play a relatively more significant role in portfolio returns explanation compared to the macroeconomic variables used in the application of the macroeconomic APT model. Moreover, during the application of the macroeconomic APT model it can be seen that the power of the model increases significantly when along with the market beta, a number of variables are included in the equation. These results imply that the market beta alone cannot provide an efficient mechanism of examining stock returns, but when it is combined with other variables, it enhances the quality of the model in terms of increased explanatory ability.

Similar conclusions are evident in the work of Chen and Jordan (1993) and partially evident in the work of Chen *et al.* (1986). Specifically, the time-series regression tests of the factor scores on the macrovariables for each portfolio, the canonical correlation analysis between the two sets of variables and the cross-sectional regression results show that the return on the stock market index can be a more important factor in comparison to other variables in the ASE. Additionally, in the case of the time-series regression tests of the factor scores on the macrovariables and from the canonical correlation results it is evident that the two inflation variables, the change in the expected inflation and the unexpected inflation, seem to have the ability to explain the behavior of stock returns. An increase in the inflation rate causes government policy makers to react by changing their monetary policy. These reactions that can affect investments are the basis of the notion that inflation is generally harmful for business (Niarchos and Alexakis, 2000). Moreover, while for the time-series tests and the canonical correlation analysis the results on the unexpected change in the growth rate of the industrial production and the unexpected change in the petroleum series are generally poor, the cross-sectional regression tests show that these variables may have some explanatory power on stocks' behavior. These findings are in accordance with the findings of Chen and Jordan (1993) and Chen *et al.* (1986). When the two APT models are compared based on the Davidson and MacKinnon (1981) analysis, it is clear that in most cases the statistical APT model performs better. These findings can also be verified by the fact that the variables that are used for the application of the macroeconomic model are observed variables and not artificial (Clare and Thomas, 1994; Cheng, 1995; Groenewold and Fraser, 1997). This means that the artificial factors were generated mathematically as a linear combination of the variables (stock returns) used in the analysis (Roll and Ross, 1980; Chen, 1983), while in the case of the macroeconomic model there is not a really specific theory that explains which of the factors are truly the best for the application of the model (Chan *et al.*, 1985; McGowan and Dobson, 1993; Clare and Thomas, 1994; Cheng, 1995) and in many cases scholars select a number of such variables based on past studies, previous experience, curiosity and logic. During the cross-sectional multiple regression tests the results seem to be in agreement with the work and suggestions of Chen *et al.* (1986). The stock market index loses some of its power, although it does not become totally insignificant and the unexpected change in the industrial production, for some portfolios, but most of all, the unexpected change in the petroleum series seems to be the best factor for the pricing of stock returns, especially for the second and the third sub-period (1995−2000 and 2001−2006, respectively). Finally, the two exchange rates and the term premium did not seem to affect stock portfolios as it can be seen from the empirical results and they did not add any explanatory power to the macroeconomic APT model. Although there has been an increase in economic globalization and all businesses seem to be, directly or indirectly, affected by international activities, the latest economic situation in Greece shows that the exchange rate changes do not affect the competitive position of companies. As a result, investors in the ASE should not evaluate the exchange rate changes as important risk factors during this period. Moreover, the poor influence of the term premium may also be due to measurement differences (e.g., Gunsel and Cukur, 2007; Koutmos and Theodossiou, 1993, etc.).

We should recall that the traditional CAPM is still widely used by many practitioners, although several theoretical problems have been documented through the decades (Roll, 1977). However, it is still one of the most common approaches employed for valuation purposes. The model is taught in most undergraduate corporate finance classes and, even though its weaknesses have been documented, practitioners are typically left with no alternative to replace it with, so it is generally accepted. But this could not be an obstacle for the use of the APT models and the empirical results of several studies can verify it. Moreover, while it has been documented in several studies that there are relationships between the macroeconomic variables and the stock markets, there is evidence showing that this is not universally accepted. There are stock markets that are affected by both local and global factors (Cauchie et al., 2004) while other studies only by global ones, leading to the suggestion that researchers should gather a sufficient number of variables so as to be even more precise when they come to such economic conclusions. Overall, although the results show that there might be some power in the stock market, the stock returns in the ASE seem to be related to several additional factors like the ones used in this study. Possible differences between the results of the tests are due to the methodologies that are used, the factors that are compared each time and the criteria that are used to explain the results, such as the level of significance. On an international level, the differences on the results between several studies is caused because of different time periods of analysis, the different measurement between the same variables used in these studies, the use of different variables for the same goal and, of course, the methodologies and techniques that each scholar use to explain asset prices (Chen *et al*., 1986; Clare and Thomas, 1994; Niarchos and Alexakis, 2000). The weak performance of the macroeconomic APT − in comparison to the statistical APT model based on the Davidson and MacKinnon (1981) results − seems to argue that stock prices are affected by other factors, which may be exogenous to the ASE. For instance, during the period 1997−1998 the crises in Asia, Brazil and Russia and the problem of recession in the US might have an effect on stock prices. We should also mention that, as the Olympic Games took place in Greece in 2004, a weak significance was observed in the industrial production factor from the results of portfolio 8 according to Table 3. This might be due to the fact that this portfolio includes stocks of firms that belong to the industrial production sector and their work had increased prior to the Games because of the need for new constructions that is new stadiums due to the enhanced need of athletic activities. Another factor might be the devaluation of the Greek drachma in comparison to the euro in 1998 which was one of the necessary criteria for Greece in order to be an equivalent member of the European Economic and Monetary Union, in 1999, and affected the inflation rate so as to make the Greek products more competitive. Finally, as far as the (weak-form) efficiency of the market is concerned, it seems that it is in doubt for the ASE as there are observed and unobserved factors, except of the general stock market index, that could influence stock returns. The situation has become even more difficult for the ASE to function properly due to the economic crisis in Greece. As the euro has weakened, the Greek economy needs to allocate more money every year for debt servicing. As it is believed that the IMF option may be the best one for the Greek economy, financial institutions as well as individual investors will have to develop and use asset pricing models that can be broadly applied in the explanation of stock returns behavior. By taking into consideration the economic problems domestically and globally, the variables/factors should be carefully determined a priori based on a theoretical context in order to lead to more solid inferences during portfolio formation and evaluation.

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