Fama & French Three-Factor model vs. APT; Evidence From the Greek Stock Market

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Abstract
This work studies the performance of value and size strategies for securities traded on the Athens Stock Exchange (ASE). There are evidence that 'value' sorted portfolios, outperform 'glamour' sorted portfolios while small firms do not earn higher returns. However, the differences are not statistically significant. The estimation of expected returns have been done using the Fama and French three-factor model and the Arbitrage Pricing Theory (APT). The period under examination is from June 2002 to June 2006. The Fama and French model outperform significantly the APT model in the time series regressions, while the APT seems to be slightly better in the cross sectional context. Besides, there are cases, where both models do not capture entirely the expected returns.

Keywords: Fama & French Three-Factor model; APT; Value and Size sorted portfolios; Athens Stock Exchange

1. Introduction

The quantification of the tradeoff between risk and expected return is one of the important problems of modern financial economics. The risk-return relationship is very important to investors and portfolio managers, as their main task is to estimate the investment risk (Tang and Shum, 2003). The Capital Asset Pricing Model (CAPM) developed by Sharpe (1964) and Lintner (1965) suggests that the only relevant risk measure for investments is the beta coefficient and a positive trade-off between beta and expected return should exist. They built on Markowitz's (1952) work to develop economy-wide implications of the model (Campbell, Lo, MacKinlay, 1997).

The Arbitrage Pricing Theory of Ross (1976) proposed as an alternative model to overcome some weaknesses that have been found for the CAPM. It can be more general than the CAPM and with better explanatory power since it permits for multiple risk factors (Groenewold and Fraser, 1997). Unlike the CAPM the APT does not require the identification of the market portfolio. The intuitive idea behind the model is that asset prices are formulated by several factor prices, which have some fundamental and plausible relationship to the underlying company (Maringer, 2004).

More recently, Fama and French (1993, 1996, 1998) have shown that the return premia associated with size and book-to-market are compensation for risk, as described in the Arbitrage Pricing Theory or in the Intertemporal Capital Asset Pricing Model (ICAPM) of Merton (1973) (Daniel, Titman and Wei, 2001). They introduce in their model two additional non-market risk factors such as the SMB (the return on a portfolio of small stocks less the return on a portfolio of large stocks) and the HML (the return on a portfolio of high book-to-market value stocks less the return on a portfolio of low book-to-market value stocks).

Fama and French (1996) show that their model captures the returns to portfolios formed according to value strategies. These value strategies call for buying stocks that have low prices relative to earnings, dividends, book assets or other measures of value (Lakonishok, Shleifer, Vishny, 1994).The reason for which value strategies appear to be profitable remains controversial. One explanation is that value stocks may deliver higher returns because investors assume that stocks that have had low growth in the past will continue to have low earnings growth into the future, depressing their price. Another interpretation refers to that value stocks deliver higher returns because they are fundamentally riskier (Gregory, Harris, Michou, 2001).

The purpose of this work is to test the Arbitrage Pricing Model with that of the Fama and French Three Factor Model in the ability of each model to capture the returns of portfolios formed according to value strategies. The static approach of estimating the risk premium for the period 2002-2006 is employed, as it remains the most commonly used method in practice (Mayfield, 2004). The criterion for testing the models in the time series regression is the Theil's U^2 test while the methodology of Chen (1983) is employed in the cross sectional context. Besides problems of autocorrelation and heteroscedasticity are investigated as they can lead to misleading results (Brooks, 2002). The structure of the work proceeds as follows. Section 2 refers to methodology and the description of data, Section 3 shows the empirical results, Section 4 compares the models and Section 5 concludes the paper.

2. Methodology and Data

2.1. Arbitrage Pricing Theory

The Arbitrage Pricing Theory was developed from Ross (1976), as an alternative model of equilibrium. The model is based on the law of one price, assuming that there are several factors that influence the returns (Bodie et al., 2002). The form is:

$$R_i = a_i + \beta_{i1}\Pi_i + \beta_{i2}\Pi_i + \ldots + \beta_{iz}\Pi_z + e_i \qquad \textit{for } i=1,2,\ldots N \qquad (1)$$

In the above equation the return Ri of the i^{th} asset is linearly related to a set of factors Πj (j=1,2…z). The beta coefficients show the sensitivity of the asset to each factor and e_i is a random variable with $E(e_i)=0, E(e_i^2)=\sigma_i^2$ and $E(e_i e_k)=0, i \neq k$ (Hayashi, 2000). In a well-diversified economy with no arbitrage opportunity, the equilibrium expected return on the i^{th} asset with the presence of a risk free rate is given by (Groenewold and Fraser, 1997):

$$E(R_i) - r_f = b_1(\lambda_1 - r_f) + b_2(\lambda_2 - r_f) + \ldots b_z(\lambda_z - r_f) \qquad (2)$$

The term $(\lambda 1 - r_f)$ is the excess return that is required following the sensitivity of the ith asset to factor *Π1* while if there is only one factor and that is the market risk, then the APT equals to CAPM.

The null hypothesis that is tested is a Z-factor version of the APT that explains the cross section differences in asset returns and it is the equation (3) that will be tested in the next sections (Chen, 1983):

$$E(R_i) = \gamma_o + \gamma_1 b_{i1} + \gamma_2 b_{i2} + \ldots + \gamma_z b_{iz} \qquad (3)$$

In the above equation γ_o should not be statistically different from zero while other factors apart from the market risk should be priced. The hypothesis $\gamma_1 = \gamma_2 = \gamma_3 = \ldots = \gamma_z = 0$ is tested with the Wald test statistic (Chung, Jonson and Schill,2001). The t-test of the Fama-Macbeth (1973) is used for identifying the significance of the risk premia (Clare and Thomas, 1994).

The most common procedure for testing the APT is a two-step method. In the first step the factor loadings are estimated for each asset, using time series data while the second step involves a cross sectional regression of the mean returns on the factor loadings (Groenewold and Fraser, 1997).

2.2. Fama and French Three-Factor Model

The three-factor model suggested by Fama and French (1996) relates the expected return on a portfolio in excess of the risk-free rate $E(R_i) - R_f$ to three factors. The first is the excess return on a broad market portfolio (i.e. $R_m - R_f$), the second factor is the difference between the return on a portfolio of small stocks minus the return on a portfolio of large stocks (i.e. Small Minus Big, SMB) and finally the third factor is the difference between the return on a portfolio of high book-to-market stocks minus the return on a portfolio of low book-to-market stocks (i.e. High Minus Low, HML). Thus, the expected return on portfolio i is:

$$E(R_i) - r_f = b_i[E(R_m) - r_f] + s_i E(SMB) + h_i E(HML) \quad (4)$$

The terms $(R_m) - r_f, E(SMB), E(HML),$ are expected risk premiums and the factor loadings, $b_i, s_i, h_i,$ are the slopes that come from the OLS time series regression of the following form (Hussain and Toms, 2002):

$$Ri - r_f = a_i + b_i(R_m - r_f) + s_i SMB + h_i HML + e_i \quad (5)$$

Again e_i is a random variable with $E(e_i) = 0, E(e_i^2) = \sigma_i^2$ and $E(e_i e_k) = 0, i \neq k$ while the intercept a_i, if the model is correct, should not be statistically different from zero. It is important to refer at this point that Fama and French (1996) noted that the three-factor model has no foundation in finance theory, but it is merely a statistical model that summarises the empirical regularities that have been observed in US stock return (Gregory, Harris and Michou, 2001).

The hypotheses that are tested for the FFM are similar to that used for the APT and come from the following regression (Harvey and Siddique, 2000):

$$E(R_i) = \gamma_o + \gamma_m b_i + \gamma_{SMB} s_i + \gamma_{HML} h_i \quad (6)$$

Using the two-step method approach the intercept γ_o in the above equation should not be statistically different from zero while the factor risk premiums should be priced. The Wald statistic will determine if the risk premiums jointly equal to zero while the t-statistic will determine the same hypothesis for the intercept. The two models will be compared in the next sections both in cross sectional regressions and individually across the portfolios.

2.3. The Data

The data used for this study concern securities listed on the Athens Stock Exchange (ASE) covering a period of five years from June 2002 to June 2006. The five-year period is good enough for testing the models, as it is the best period to take reliable estimators for the systematic risks (Dimpson and Marsh, 1983). Monthly returns and accounting data were taken from Datastream. Following Fama and French (1992), for constructing value portfolios, financial firms were excluded from the sample because the high leverage that is normal for these firms does not have the same meaning as for nonfinancial firms. The rate of return for each security, r_i, is calculated as $r_i = (P_t - P_{t-1}) / P_{t-1}$ excluding dividends while it is adjusted for splits and changes in capital structure.

The choice of variables that used for testing the APT has been done arbitrarily. They are macroeconomic variables that influence the securities in the same degree and found to be significant in other studies such as Chen, Roll and Ross (1986) for the US, Clare and Thomas (1994) for the UK and Messis, Iatrides and Blanas (forthcoming) for the ASE. Thus, the included variables are, apart from the General Market Index (GI), the Inflation rate (INFL), the Industry Production Index (IPI), the Retail Sales (RS) and the Exchange Rate (EXCR) as it is formulated by the parity between the Euro and the US dollar. Following Clare and Thomas (1994) the variables INFL, IPI and RS have been inserted into the model with time lag one period, in order to capture the shocks of the agents in the announcements of the macroeconomic variables. This is not the case for the financial variable EXCR. The risk free interest rate is the three-month Treasury bill.

Five sets of different portfolios formed on BV/ME (i.e. Book Value[1] to Market Equity[2]), C/P (i.e.Cash Flow to Price[3]), E/P (i.e. Earnings per share[4]), 3-Y SG (i.e. Three Year Sales Growth[5]) and MV (i.e. Market Value). This is the one-way classification as there is also the two way classification proposed by Lakonishok, Shleifer and Vishny (1994) where portfolios are formed of the intersection between one of the BV/ME, C/P and E/P with that of the SG. However, the two-way classification is not a good measure for asset pricing (Cochrane, 2005). "Value" portfolios constructed from stocks that have low BV/ME, C/P, E/P or high past sales growth. "Growth" portfolios are the opposite of value portfolios. The latter are assumed to have low average returns.

These portfolios are formed each year at the and of June in order to be ensured the availability of the accounting data from the previous year. The fiscal year end for most of the companies, traded on the ASE, is the 31 December. For companies that have end of fiscal year other than 31 December were excluded from the sample so as not use information that is not actually available to the investors at the time of portfolio formation, avoiding with this way a possible look-ahead bias (Banz and Breen, 1986;Brouwer, Put, Veld, 1997). Besides excluded companies with negative prices of the above accounting values, while the formed portfolios are equal weight. Each decile portfolio contains 10% of the total number of stocks that selected for the reference year. If a stock disappears from the ASE during a year, its return is replaced with the return on a corresponding size decile portfolio until the end of the year. At the end of each year the portfolio is rebalanced as the relative ratios change each year (Lakonishok, Shleifer and Vishny, 1994).

For the construction of the FFM (i.e. SMB and HML) we define six value-weighted portfolios, S/L, S/M, S/H, B/L, B/M and B/H from the intersections of the size and BE/ME groups. The first 150 stocks of the sample with the biggest capitalization were used for the portfolios construction. These stocks account for almost 75% of the total capitalization of the General Index on average each year. The use of the largest 150 companies rather than the whole sample to define the breakpoint for the size split reduces the imbalance in the market capitalization of the small and large groups (Gregory, Harris, Michou,

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[1] BV is defined as the equity capital and reserves minus total intangibles.

[2] ME is the total capitalization of the firm.

[3] Cash Flow is defined as earnings less ordinary dividends, plus depreciation and deferred tax.

[4] Earnings are earnings minus extraordinary items.

[5] Past years sales growth is calculated using the geometric mean over the previous three-year sales instead of arithmetic mean as it uses different basis of calculation (Halkos, 2000). Thus the geometric mean is given by $r = (\sqrt[n-1]{\frac{X_n}{X_1}} - 1) * 100$.

2001). Big stocks (B) are above the median market equity and small stocks (S) below. Besides low BE/ME stocks (L) are below the 30% of the selected firms, medium BE/ME stocks (M) are in the middle 40% and high BE/ME stocks (H) are in the top 30%. Thus the mimicking portfolios SMB and HML are defined as follows (Davis, Fama, French, 2000):

$$SMB = (S/L + S/M + S/H)/3 - (B/L + B/M + B/H)/3 \quad (7)$$

and

$$HML = (S/H + B/H)/2 - (S/L + B/L)/2 \,. \quad (8)$$

Summary statistics for the rates of return for portfolios, macroeconomic variables and the mimicking portfolios of FFM are provided in table 1 (see appendix). The means are monthly proportional rate of return and from panel A of the table it is clear that the three lowest portfolios have the highest standard deviation than the three highest portfolios, except for the portfolios formed on BV/ME. Besides the table depicts tests that have been done for testing normality and stationarity of returns. The Jarque-Bera tests the normality of returns. The 5% critical value for χ^2 is 5.99 and twenty out of fifty portfolios does not follow the normal distribution and the heteroscedasticity problem might be arose (Campbell, Lo, MacKinlay, 1997). For the stationarity of the time series data has been used the Augmented Dickey-Fuller (ADF) test. The null hypothesis for non-stationarity is rejected if ADF $|t| > |t_c|$. The critical value is 4.11 at the 1% level of significance and all time series data were found to be stationary at 1% level.

The highest correlation among the regressors is between the GI and the SMB variable (0.40) but it is not too much to cause multicollinearity problem. Besides the correlation between SMB and HML is only 0.026. Thus, SMB seems to provide a measure of the size premium that is relatively free of BE/ME effects and HML is a measure of the BE/ME premium free of size effects (Davis, Fama, French, 2000). Finally Panel C presents the differences in returns between the two highest and two lowest portfolios. The average returns are positive for all portfolios except for the 3-Y SG sorted portfolios. Besides small firms do not seem to earn higher returns than big firms. The t-statistic indicates that these differences in returns are not statistically significant at 10% level. However, it is an indication that value portfolios outperform glamour portfolios. This does not happen with 3-Y SG sorted portfolios while the firm size ordering does not provide evidence for the 'small firm effect' of Banz (1981), empirical evidence that also found Clare and Thomas (1994) for the UK stock market.

3. Empirical Results

3.1. Arbitrage Pricing Theory

3.1.1.Ordinary Least Squares Regression

The first step for the analysis and the empirically examination of the data involves the estimation of the parameters under investigation. Table 2 shows the results that come from an OLS regression of the returns of each portfolio on the market excess return, inflation rate, industrial production index, retail sales and exchange rate. The model has the following form:

$$R_i - r_f = a_i + b_{1i}(R_m - r_f) + b_{2i}INFL + b_{3i}IPI + b_{4i}RS + b_{5i}EXR + e_i \quad (10)$$

From the table 2 we can see that 12 out of 50 intercepts or the 24% of the sample are statistically significant at least 10% level according to t-statistic. If the APT model is correct then the intercepts of time series regressions should be close to zero (Fama and French, 1993). The only case where intercepts are close to zero is for the 3-Y SG portfolios. On the basis of the R^2 criterion, the average is 76.1% and the highest capture of the variation of stock returns from the factors is done for the C/P portfolios. Besides all the betas for the market excess return are statistically significant.

3.1.2 Cross- sectional regression

Having estimated the beta coefficients we proceed the analysis identifying the risk premiums that come from the macroeconomic variables in the APT context. The cross-sectional regression, a procedure adopted by Fama and MacBeth (1973), helps in this direction. Table 3 presents the results. The first column of Panel A depicts the intercepts. If the model is correct then the intercepts should not be statistically different from zero. However, portfolios formed on E/P and MV seems to have statistically significant intercepts as it is measured from t-statistic (i.e. t-statistic in parentheses). The columns 9 and 10 test the hypothesis that $\gamma_1 = \gamma_2 = \gamma_3 = \gamma_4 = \gamma_5 = 0$ with the Wald test. The F-statistic is 5.05 for F5 (i.e. 5,5 df) and 4.53 for F4 (i.e.4, 6 df). The null hypothesis that all factors jointly equal to zero (i.e. F5) is rejected at 5% level for portfolios formed on C/P and 3-Y SG. The same results hold even when the test is done for all the factors without the market risk.

Besides table 3, Panel A, depicts the Squared Sharpe ratio for each factor. This ratio measures the expected return per unit risk and it is useful to provide a basis for economic interpretation of the tests (Campbell, Lo and MacKinlay, 1997). The aggregate squared Sharpe ratio (AGRSSR) can be assumed to be the tangency portfolio, formed from the factor portfolios (Brennan, Chordia and Subrahmanyam, 1998). The highest value for the AGRSSR is for the 3-Y SG portfolios and the lowest for C/P portfolios, only 7.48% per month per unit risk. Furthmore, the average SSR is 3.9% for the excess market risk, 0.8% for the excess inflation, 2% for the excess IPI, 7% for the RS and 3.4 % for EXR. The market risk premium is positive for the three out of five categories of portfolios while all the portfolios have the right sign for the inflation risk premium. The priced factors change as we change category of portfolio. Only the C/P and M/V portfolios reveal the same risk factors. Thus, it is obvious that the search for macro-factors is sensitive with respect to the ordering method chosen (Clare and Thomas, 1994).

3.1.3 Statistically significant estimators for the APT

The estimators depicted in table 3 are not all statistically significant at the different level of 10%, 5% and 1%. Besides these coefficients may have problem of autocorrelation, heteroscedasticity or departure from normality of residuals, facts that may cause problems to the coefficient estimates and their associated standard errors in the OLS context. The tests that have been done for checking the OLS assumptions are the Durbin-Watson and Breusch-Godfrey tests for autocorrelation, White and ARCH test for heteroscedasticity and the Jarque-Bera test for the departure from normality of residuals. According to D-W test, there is no residual autocorrelation if DW is between 1.62 and 2.38 for T=60. The Breusch-Godfrey criterion is based on the Langrange Multiplier test (LM). The null hypothesis of not existence of autocorrelation is rejected when (N-ρ) $R^2 > X^2_{\alpha,\rho}$ which is 5.99 (α=0.05, ρ=2). There are 8 cases of existence of autocorrelation according to D-W criterion and 2 cases according to B-G criterion. The problems of autocorrelation have been corrected with the Cochrane-Orcutt procedure (Brooks, 2002).

As far as concern the heteroscedasticity the White test is based on the R^2, which is obtained from the regression between the squared residuals and the rest independent variables. The null hypothesis is rejected if $NR^2 > X^2_{\alpha,\rho}$, which is 7.815 for α=5% and ρ=3 (Christou, 2002). The ARCH test exists not only in pooled data, but also in the case of time series analysis. In cases where the residuals behave as an ARCH procedure, the residuals tend to exhibit autocorrelation. In reality, the variance of the residuals is a function of their lagged prices. The null hypothesis is rejected when $NR^2 > X^2_{\alpha,\rho}$, which is 5.99 for α=5% and ρ=2. According to the White test, there are 11 portfolios that display hereroscedasticity and 7 according to ARCH test. The WLS method has been dealt with the problem of heteroscedasticity. Finally, the normality test of residuals has been performed using the Jarque-Bera test. The null hypothesis is rejected if $JB > \chi^2$, which is 5.99 for the 5% level of significance. The assumption of normality is violated in 20 out of 50 portfolios. However, because the sample is sufficiently large the test statistics will asymptotically follow the appropriate distributions even in the absence of error normality (Brooks, 2002). The standard errors after the correction are even lower and the difference is statistically significance at 5% level.

The results that come from the OLS regression for only statistically significant estimators and after correcting for autocorrelation and heteroscedasticity indicate that now 22 out of 50 intercepts are statistically significant, an increase of 83% in comparison to table 2 while the average R^2 adj. at this time is 80.9% which means that risk factors explain better the variation of returns. The higher adj. R^2 is for the E/P sorted portfolios and the lower for C/P. Retail Sales found to be significant in most of the cases, 22 out of 50 portfolios, while EXR in only 8. Besides the INFL that is not priced in the cross sectional regression influences 12 cases, IPI 9 and market risk in all cases.

3.2 The Fama and French three-factor model

3.2.1 Ordinary Least Squares Regression

Following the same procedure with that of the APT the first step is to estimate the risk factors for the FFM of the equation 5. The results are depicted to table 4. If the 3FM describes the expected returns, the regression intercepts should not be statistically different from zero. There are only 5 out of 50 intercepts that are significant and three of them belong to E/P portfolios. The average R^2 is 82% and the model does capture most of the variation in the average returns. If this criterion of the FFM is compared with the APT model the difference is about 7% higher and it is statistically significant at 5% level. Besides consistent with other studies (Fama and French, 1993; Faff, 2003) the mean market beta is near to unity (0.91) and it is significant for all portfolios. A high proportion of SMB betas are statistically significant (i.e. 90% of the sample) while for the HML the fraction is lower (i.e. 60% of the sample). Furthemore, HML slopes are related to Book-to-market ratio. They increase from negative values for the lowest book to market portfolio to positive values for the highest portfolio. Similarly the SMB slopes are related to size. They decrease from small to big capitalization. The results are consistent with that of Ajili (2003).

3.2.2 Cross- sectional regression

The results of the cross-sectional regression are presented to table 5. There are 2 out of five intercepts that are statistically different from zero while the market index is priced only one time. The F-statistic rejects the null hypothesis that all factors are equal to zero (i.e. $\gamma_1 = \gamma_2 = \gamma_3 = 0$) for the case of E/P and MV. In the former case the only factor that is priced is the market risk thus it equals to CAPM and not to FFM. However, from the Panel B of the table where all the significant factors are depicted, there are three out of five cases where other factors than the market risk are priced. The average AGRSSR for the FFM is almost 12% per unit risk while that of APT almost 17%. Thus the reward for risk implied by the APT factors is 5% above the risk implied by the FF factors. The main contributor to the aggregate SSR of the FF portfolios is the SMB portfolio, which has an average of 8.2%, almost three times that of market risk.

3.2.3 Statistically significant estimators for the FFM

At this part of the work is completed the analysis for the FFM referring the results of the statistically significant estimators and after correcting the problems of autocorrelation and heteroscedasticity. In the case of FFM there are 8 and 4 portfolios out of 50 that found to have autocorrelation with the D-W test and B-G respectively. Besides there are 20 portfolios with heteroscedasticity according to White test and 10 portfolios according to ARCH test. The problems have been corrected with the same way as above. The point that is significant here is the increase in the number of intercepts that are statistically different from zero. Before the elimination of insignificant factors and the correction of the problems there were only 5 and now they are 14. Besides the average R2 adjusted is 87,2% a difference of only 7% with that of APT. The SMB factor, except for the market, is statistically significant in most of the cases.

Following Connor and Korajczyk (1988), figure 1 presents the average absolute mispricing across all categories of sorted portfolios. The errors are the intercepts of the equations (8) and (10) with only statistical factors. It is clear that the average absolute error is much smaller for the FF model.

4.Evaluation: Fama and French Three-Factor Model versus APT

4.1 Performance measurement in the cross-sectional regression

Following Chen (1983), we try to compare the models using the residuals that come from the cross sectional regression. According to this procedure if one of the models is not misspecified, the expected return of asset i would be captured by its beta coefficients and the residuals would behave like white noise with zero mean. If the model is misspecified and the residuals do not capture all the information then if there is another model that can price the remaining part of the expected return, the residuals will be priced by that model. Table 6 presents the results.

Table 6 must be compared with table 3. If a factor is priced in table 6 but not in 3 is probably spurious while this is not the case if a factor is priced in 3 and again in 5 with the same sign and relative same measures of value. From the table C/P variables are spuriously induced as in table 3 no variable has been found to be statistically different from zero. The remaining results are almost the same and the FFM rather seems to not do so well in the cross sectional regression. As far as concern the APT the results are presented to table 7. The APT did well only in the case of E/P. In the table 5, where the market risk premium and the intercept are priced, the APT factors capture all the information making them insignificant. Thus even in one case the APT rather applies better in the cross sectional regression.

4.2 Comparison in a time series context

4.2.1 Theil's U^2 test

The Theil's U- statistic is used firstly, for the comparison of the models in the time series regression. The model has been also used in other studies such that of Chen and Jordan (1993), Sun and Zhang (2001) and Chen (2003). The test is given as follows:

$$U_i^2 = \frac{\sum_{t=1}^{61}(\mathrm{R_{i,t}} - \mathrm{R_{i,t}^{model}})^2}{\sum_{t=1}^{61}(R_{i,t} - \bar{R}_i)^2} \quad (11)$$

where R_{it} is the historical return for asset *i* in month *t*, $R_{i,t}^{model}$ is the forecast return for asset *i* in month *t* according to APT and FFM and $\bar{R}_i$ is the monthly average historical return for asset *i* over the examined period. The smaller the ratio, the better the model forecast is relative to the naïve model. A ratio with a value greater than one would indicate the inappropriateness of the model. Table 8 depicts the results while table 9 presents the paired t-test making clear that that FFM outperforms the APT, as the differences between the two are statistically significant at 1% level. The FFM has an average mean 0.183 while the APT model 0.259. Besides there are some cases where the only statistically significant factor is the market risk, most of which belong to APT.

5. Conclusions

This study explores the ability of two multifactor models, the Arbitrage Pricing Theory and the Fama and French three-factor model, to explain the performance of portfolios sorted by five different criteria. The four out of five criteria refer to 'value' strategies and have been identified from a lot of researchers that 'value' portfolios (i.e. portfolios with high BV/ME, C/P, E/P or low past year Sales Growth) earn higher returns than 'glamour' portfolios. The fifth criterion classifies portfolios according to MV of securities as it has been argued that small firms tend to earn higher return than big firms. Our evidence suggest that really 'value' sorted portfolios earn higher return in the period under examination for the ASE apart from the case of the 3-Y SG. However, these differences are not statistically different from zero. Besides big firms earn higher returns than small firms, having also a lower risk as it is measured by the market beta, a fact that contradicts to finance theory.

The APT model uses macroeconomic variables such as the inflation rate, the industry production index, the retail sales and the exchange rates, factors that influence the general macroeconomic environment and as a consequence the performance of the firms. The FFM uses firm characteristics to form factors portfolios such as firm's size and book value to equity. The comparison of the models has been done both in a cross sectional level and time series regression. In the first case, the APT is slightly better as it offers higher average return per unit risk, has less intercepts statistically different from zero and captures all the information in one case according to Chen (1983) methodology where the FFM factors are not priced. However, the superiority of the FFM is apparent in the time series analysis procedure. It has higher R^2, lower misspricing errors, less intercepts that are statistically different from zero and lower prices according to Theil's U-statistic.

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Appendix

Table 1: Summary Statistics for the dependent and the independent variables.The covered period is from June 2002 until June 2006 (60 months)

Panel A: Sample Statistics of the Dependent Variables

	Deciles									
	1	2	3	4	5	6	7	8	9	10
BE/ME	**Low**									**High**
Mean	1.10%	0.9%	0.5%	1.00%	0.4%	1.2%	0.8%	0.9%	1.4%	1.4%
Std. Dev.	8.4%	7.8%	8.9%	11.0%	8.2%	8.3%	11.7%	10.2%	11.8%	13.9%
J-B	5.955	5.406	2.062	3.085	10.138	7.288	6.878	2.929	5.538	10.78
ADF	-8.201	-7.579	-8.123	-7.379	-7.589	-8.785	-7.108	-7.387	-7.213	-7.79
C/P	**Low**									**High**
Mean	1.0%	0.2%	-0.4%	0.4%	1.00%	1.5%	0.4%	0.2%	1.8%	1.1%
Std. Dev.	11.7%	13.0%	11.2%	10.8%	10.3%	10.2%	11.5%	8.3%	9.3%	6.8%
J-B	1.843	3.428	5.864	1.585	8.832	6.662	3.421	0.313	0.695	9.304
ADF	-7.896	-6.905	-8.017	-7.666	-7.935	-7.667	-7.953	-7.577	-7.501	-7.63
E/P	**Low**									**High**
Mean	1.2%	0.3%	-0.1%	0.2%	0.2%	0.7%	1.00%	1.9%	0.4%	1.3%
Std. Dev.	11.2%	12.4%	12.7%	11.7%	10.7%	10%	10.2%	9.2%	9.5%	7.2%
J-B	10.088	14.241	2.469	11.637	8.895	4.277	5.586	2.019	11.735	3.464
ADF	-7.086	-8.073	-8.048	-8.299	-7.212	-8.038	-7.467	-7.468	-8.587	-7.37
3-Y SG	**High**									**Low**
Mean	0.6%	1.1%	0.9%	1.00%	0.6%	1.6%	1.6%	1.3%	0.3%	0.5%
Std. Dev.	10.6%	10.7%	9.6%	9.2%	9%	7.9%	10.3%	8.7%	10.1%	12%
J-B	4.501	3.725	1.532	6.429	11.60	14.09	5.544	14.19	15.84	1.990
ADF	-7.217	-8.236	-7.675	-7.547	-7.562	-7.293	-7.981	-7.532	-7.090	-7.81
MV	**Low**									**High**
Mean	0.9%	-0.1%	0.5%	0.5%	0.6%	0.7%	-0.6%	1.3%	0.7%	1.3%
Std. Dev.	13.7%	12.5%	10.4%	10.9%	10.2%	10.3%	10.4%	9.2%	8.7%	7.6%
J-B	14.64	5.516	8.429	3.691	2.866	3.580	2.928	5.003	5.792	6.297
ADF	-7.903	-7.431	-7.305	-8.340	-7.613	-7.727	-7.413	-7.816	-6.940	-7.76

Panel B: Sample Statistics of the Independent Variables

	Mean	**Std.Dev.**	**Min.**	**Max.**	**Skew.**	**Kurt.**	**J-B**	**ADF**
Market Index								
ASE INDEX (GI)	1.56%	8%	-0.194	0.247	0.274	3.874	2.666	-7.86
SMB	-1.2%	4.6%	-0.123	0.128	0.374	3.862	3.260	-6.56
HML	0.9%	5.4%	-0.119	0.229	1.226	6.347	42.98	-9.15
MACROECONOMIC VARIABLES								
INFLATION (INFL)	0.2%	1%	-0.019	0.025	0.285	2.979	0.814	-13.2
INDUSTRY PRODUCTION (IPI)	0.4%	8.9%	-0.210	0.224	0.086	3.458	0.600	-8.66
RETAIL SALES (RS)	1.4%	12.5%	-0.259	0.325	0.263	3.570	1.508	-7.12
EXCHANGE RATE (EXR)	0.7%	2.5%	-0.045	0.061	0.257	2.508	1.265	-6.62

Correlations

	GI	INFL	IPI	RS	EXR	SMB
INFL	0.116					
IPI	0.130	0.205				
RS	0.131	0.250	0.189			
EXR	-0.195	0.009	-0.148	-0.012		
SMB	0.400	-0.040	0.126	0.162	-0.163	
HML	0.207	0.225	-0.020	0.189	-0.035	0.026

Panel C: Differences in returns between the two highest and the two lowest Portfolios

Year	(B/M: 9,10-1,2)	(C/P: 9,10-1,2)	(E/P: 9,10-1,2)	(3-Y SG: 9,10-1,2)	(MV: 9,10-1,2)	Total Shares
2002	3%	2%	-0.5%	-1.1%	-1.8%	202
2003	-2.7%	1.9%	-0.2%	-1.5%	0.5%	226
2004	-1.1%	2.6%	3.1%	-6.2%*	5.1%	232
2005	0.2%	3.3%*	3.6%*	1.2%	6.8%*	232
2006	4.8%	-1.3%	-4.9%	3.3%	-4.3%	223
AR	0.8%	1.7%	0.2%	-0.8%	1.2%	
T-stat	0.44	1.02	0.15	-0.59	0.67	

Notes: The critical value for the Jarque-Berra test is 5.99 for 5% statistical level. The critical value for the ADF test for stationarity is 4.11 at the 1% level of significance.
(*) Indicates statistically significant level 10%.

Table 2:Use of OLS to estimate the risk factors of the APT from Eq. (10)

	Deciles									
	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
BE/ME	***Low***									***High***
a	-0.003	-0.002	-0.009	-0.001	-0.010	-0.004	-0.007	-0.009	0.002	-0.003
t(a)	-0.627	-0.416	-2.075	-0.108	-1.706	-0.788	-0.907	-1.492	0.241	-0.300
R^2	0.837	0.670	0.881	0.676	0.729	0.819	0.787	0.835	0.639	0.745

Continued **Table 2**

C/P	***Low***									***High***
a	-0.007	-0.020	-0.025	-0.012	-0.006	0.001	-0.014	-0.010	0.004	0.000
t(a)	-0.953	-1.937	-3.174	-1.597	-0.994	0.222	-1.788	-1.941	0.562	0.087
R^2	0.787	0.704	0.769	0.747	0.835	0.835	0.783	0.790	0.727	0.836
E/P	***Low***									***High***
a	-0.005	-0.016	-0.022	-0.015	-0.015	-0.008	-0.005	0.006	-0.011	0.002
t(a)	-0.721	-1.694	-2.352	-1.716	-1.826	-1.299	-0.886	0.886	-2.128	0.576
R^2	0.765	0.720	0.743	0.739	0.696	0.788	0.810	0.694	0.843	0.815
3-Y SG	***High***									***Low***
a	-0.010	-0.002	-0.001	-0.005	-0.010	0.002	-0.001	-0.001	-0.009	-0.011
t(a)	-1.462	-0.337	-0.168	-0.988	-1.648	0.466	-0.183	-0.312	-0.876	-1.255
R^2	0.778	0.786	0.769	0.833	0.767	0.765	0.767	0.764	0.506	0.740
MV	***Low***									***High***
a	-0.014	-0.018	-0.014	-0.008	-0.008	-0.007	-0.024	0.001	-0.006	-0.001
t(a)	-1.16	-1.853	-1.625	-1.013	-1.207	-1.113	-3.323	0.167	-1.263	-0.453
R^2	0.638	0.714	0.672	0.730	0.771	0.788	0.769	0.708	0.826	0.924

Notes:t-statistics in parentheses. Prices above 1.70 indicate statistically significant level 10% and above 2, 5%.

Table 3:Cross-sectional Regression of Returns

Panel A. On the APT factors

$$r_i - r_f = \gamma_o + \gamma_{i1} \ddot{b}_i + \gamma_{i2} \ddot{INFL}_i + \gamma_{i3} \ddot{IPI}_i + \gamma_{i4} \ddot{RS}_i + \gamma_{i5} \ddot{EXR}_i + e_i$$

Variable	$\hat{\gamma}_0$	$\hat{\gamma}_1$	$\hat{\gamma}_2$	$\hat{\gamma}_3$	$\hat{\gamma}_4$	$\hat{\gamma}_5$	R^2	F5	F4
BV	-0.0033	0.0146	-0.0123	-0.0183	-0.0565	0.0050	0.426	4.247	3.744
	(-0.433)	(1.995)*	(-0.827)	(-0.628)	(-2.7)**	(1.104)		(0.09)	(0.116)
SSR		0.0658	0.0114	0.0066	0.1262	0.0199	AGRSSR 0.2299		
C/P	0.0023	0.0072	-0.0129	-0.0987	-0.0351	-0.0174	0.724	13.66	16.8
	(0.143)	(0.331)	(-0.556)	(-1.496)	(-1.205)	(-0.631)		(0.01)	(0.00)
SSR		0.0018	0.0051	0.0372	0.0241	0.0066	AGRSSR 0.0748		
E/P	0.0303	-0.0189	-0.0187	-0.0211	-0.0730	-0.0163	0.592	3.818	1.29
	(2.946)**	(-2.055)*	(-0.539)	(-0.509)	(-1.389)	(-0.481)		(0.10)	(0.40)
SSR		0.0705	0.0048	0.0043	0.0321	0.0622	AGRSSR 0.1739		
3-Y SG	-0.002	0.0065	-0.0049	-0.0029	0.0937	0.0321	0.807	20.01	25.1
	(-0.176)	(0.519)	(-0.617)	(-0.160)	(3.125)**	(2.080)**		(0.00)	(0.0)
SSR		0.0045	0.0063	0.0004	0.1634	0.0721	AGRSSR 0.2467		
MV	0.0602	-0.055	-0.0106	0.0945	-0.0224	-0.0328	0.639	4.111	2.56
	(2.078)*	(-1.767)*	(-0.913)	(1.740)*	(-0.434)	(-0.729)		(0.09)	(0.19)
SSR		0.0514	0.0139	0.0505	0.0031	0.0088	AGRSSR 0.1277		

Notes: F-statistic is 5.05 at 5% level with (5,5) degrees of freedom and 4.53 for (4,6) degrees of freedom at the same level. (*), (**), (***) Indicate statistically significant factors at 10%, 5% and 1% level.

Table 4:Use of OLS to estimate the risk factors of the Fama and French model from Eq. (8)

	Deciles									
	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
BE/ME	***Low***									***High***
a	-0.001	0.004	-0.005	0.000	-0.002	0.003	-0.004	-0.002	0.003	0.004
t(a)	-0.270	0.724	-1.201	0.073	-0.499	0.743	-0.659	-0.554	0.399	0.739
R^2	0.843	0.720	0.885	0.716	0.780	0.806	0.852	0.922	0.803	0.901
C/P	***Low***									***High***
a	0.000	-0.010	-0.013	-0.003	0.000	0.006	-0.006	-0.004	0.007	0.000
t(a)	0.024	-1.138	-2.090	-0.466	0.127	1.563	-1.135	-0.912	1.110	0.201
R^2	0.837	0.755	0.849	0.843	0.839	0.918	0.878	0.832	0.753	0.821
E/P	***Low***									***High***
a	0.000	-0.007	-0.013	-0.004	-0.001	-0.000	-0.000	0.013	-0.009	0.002
t(a)	0.131	-0.922	-1.709	-0.693	-0.238	-0.191	-0.070	1.952	-1.737	0.573
R^2	0.843	0.770	0.807	0.834	0.796	0.879	0.891	0.735	0.834	0.815
3-Y SG	***High***									***Low***
a	-0.003	-0.003	0.000	-0.001	-0.002	0.007	0.005	0.000	-0.007	-0.006
t(a)	-0.515	-0.043	0.097	-0.347	-0.498	1.332	0.807	0.114	-0.731	-0.857
R^2	0.817	0.772	0.794	0.855	0.810	0.787	0.794	0.783	0.511	0.811
MV	***Low***									***High***
a	0.001	-0.005	0.002	0.001	0.002	0.002	-0.010	0.005	-0.005	-0.001
t(a)	0.131	-0.747	0.302	0.228	0.539	0.484	-2.046	0.975	-1.058	-0.415
R^2	0.760	0.844	0.806	0.836	0.928	0.902	0.893	0.797	0.843	0.916

Notes: t-statistics in parentheses. Prices of t-statistics above 1.70 indicate statistically significant level 10% and above 2 5%.

Table 5:Cross-sectional Regression of Returns

Panel A:On the FF3FM

$$r_i - r_f = \gamma_0 + \gamma_{i1}\hat{b}_i + \gamma_{i2}\hat{s}_i + \gamma_{i3}\hat{h} + z_i$$

Variable	$\hat{\gamma}_0$	$\hat{\gamma}_1$	$\hat{\gamma}_2$	$\hat{\gamma}_3$	R^2	F3	F2
BV	0.0044	0.0040	0.0013	0.0026	0.204	0.718	0.432
	(0.556)	(0.444)	(0.253)	(0.429)		(0.57)	(0.66)
SSR		0.0032	0.0010	0.0031	AGRSSR	0.0073	
C/P	0.0065	0.0126	-0.0212	0.0045	0.248	3.081	4.291
	(0.528)	(0.771)	(-1.915)*	(0.372)		(0.10)	(0.06)
SSR		0.0098	0.0621	0.0023	AGRSSR	0.0742	
E/P	0.0420	-0.0337	-0.0061	0.0033	0.501	7.227	0.223
	(3.913)***	(-2.664)**	(-0.665)	(0.382)		(0.02)	(0.80)
SSR		0.1181	0.0074	0.0024	AGRSSR	0.1279	
3-Y SG	0.0120	0.0028	-0.0079	-0.0077	0.149	2.646	3.377
	(1.056)	(0.257)	(-1.234)	(-1.188)		(0.14)	(0.10)
SSR		0.0011	0.0254	0.0235	AGRSSR	0.0500	
MV	0.0172	-0.0075	-0.0154	0.0266	0.707	15.72	16.51
	(2.347)**	(-0.778)	(-4.351)***	(2.239)**		(0.00)	(0.00)
SSR		0.0100	0.3172	0.0166	AGRSSR	0.3438	

Notes: F-statistic is 4.35 at 5% level with (3,7) degrees of freedom and 4.46 for (2,8) degrees of freedom at the same level.
(*), (**), (***) Indicate statistically significant factors at 10%, 5% and 1% level.

Figure 1

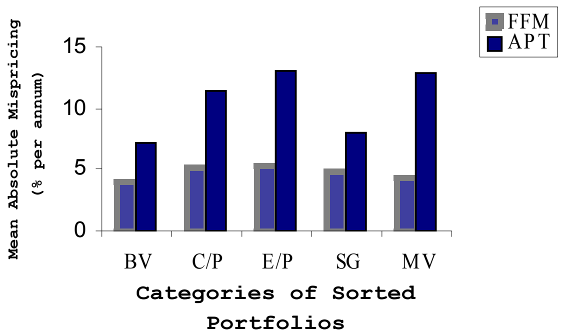

Table 6:Cross- sectional regression

A. Of the FFM on the APT Loadings

$$z_i = \gamma_0 + \gamma_{i1}\hat{b}_i + \gamma_{i2}\widehat{INFL}_i + \gamma_{i3}\widehat{IPI}_i + \gamma_{i4}\widehat{RS}_i + \gamma_{i5}\widehat{EXR}_i + \varphi_i$$

Variable	$\hat{\gamma}_0$	$\hat{\gamma}_1$	$\hat{\gamma}_2$	$\hat{\gamma}_3$	$\hat{\gamma}_4$	$\hat{\gamma}_5$	R^2	F5	F4
BV	-0.0054	0.0071	-0.0124	-0.0178	-0.0509	0.0035	0.244	2.954	3.508
	(-0.664)	(0.925)	(-0.786)	(-0.567)	(-2.325)**	(0.786)		(0.15)	(0.11)
C/P	-0.0193	0.0203	-0.0158	-0.1014	-0.0414	-0.0176	0.915	137.1	156.0
	(-3.95)***	(2.91)**	(-1.92)*	(-3.84)***	(-4.00)***	(-2.24)**		(0.0)	(0.00)
E/P	-0.0123	0.0134	-0.0291	-0.0294	-0.0897	-0.0042	0.301	2.238	2.791
	(-1.17)	(1.50)	(-0.83)	(-0.76)	(-2.15)**	(-0.13)		(0.22)	(0.17)
3-Y SG	-0.0206	0.0154	-0.0017	-0.0038	-0.1009	0.0352	0.819	183.0	67.2
	(-2.14)**	(1.63)	(-0.21)	(-0.31)	(-6.81)***	(4.30)***		(0.00)	(0.00)
M/V	0.0055	-0.0079	-0.0124	0.0229	0.0068	-0.0049	0.503	5.326	2.791
	(0.364)	(-0.468)	(-1.56)	(0.680)	(0.199)	(-1.79)*		(0.06)	(0.17)

Notes: F-statistic is 5.05 at 5% level with (5,5) degrees of freedom and 4.53 for (4,6) degrees of freedom at the same level.
(*), (**), (***) Indicate statistically significant factors at 10%, 5% and 1% level.

Table 7:Cross- sectional regression

A. Of the APT on the FFM

$$e_i = \gamma_0 + \gamma_{i1}\hat{b}_i + \gamma_{i2}\hat{s}_i + \gamma_{i3}\hat{h} + \psi_i$$

Variable	$\hat{\gamma}_0$	$\hat{\gamma}_1$	$\hat{\gamma}_2$	$\hat{\gamma}_3$	R^2	F3	F2
BV	-0.0016	0.0012	0.0024	-0.0025	0.018	0.037	0.053
	(-0.198)	(0.133)	(0.271)	(-0.325)		(0.98)	(0.94)
C/P	-0.0141	0.0261	-0.0249	0.0166	0.753	24.4	30.4
	(-3.67)***	(5.42)***	(-7.77)***	(3.59)***		(0.0)	(0.0)
E/P	0.0079	-0.011	0.0018	0.0089	0.128	1.571	1.219
	(0.825)	(-1.10)	(0.225)	(1.078)		(0.29)	(0.35)
3-Y SG	-0.0020	0.0048	-0.0025	-0.0061	0.248	11.44	5.34
	(-0.34)	(0.69)	(-0.44)	(-1.22)		(0.06)	(0.05)

Continued **Table 7**

MV	0.0034	-0.0057	-0.0026	0.0138	0.327	4.850	6.271
	(1.46)	(-2.17)**	(-0.61)	(1.16)		(0.04)	(0.03)

Notes: F-statistic is 4.35 at 5% level with (3,7) degrees of freedom and 4.46 for (2,8) degrees of freedom at the same level.
(*), (**), (***) Indicate statistically significant factors at 10%, 5% and 1% level.

Table 8: Theils' U-statistic

	Deciles									
	1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
BE/ME	***Low***									***High***
3FM	0.157	0.284	0.118	0.289	0.221	0.201	0.151	0.078	0.198	0.099
APT	0.168	**0.336**	0.146	0.337	**0.298**	0.187	0.223	0.177	0.362	0.258
C/P	***Low***									***High***
3FM	0.163	0.253	0.158	0.157	0.154	0.087	0.125	0.173	0.268	**0.180**
APT	0.219	0.334	0.273	0.278	0.230	**0.175**	0.243	0.233	**0.289**	**0.180**
E/P	***Low***									***High***
3FM	0.158	0.232	0.199	0.163	0.205	0.120	0.110	0.284	0.177	**0.199**
APT	**0.251**	**0.308**	0.298	**0.292**	**0.342**	0.232	**0.202**	0.314	0.176	**0.199**
3-Y SG	***High***									***Low***
3FM	0.183	0.227	0.207	0.145	0.188	0.223	0.198	0.219	**0.519**	0.187
APT	0.251	0.214	0.262	0.174	0.247	**0.244**	0.241	0.245	**0.519**	**0.286**
MV	***Low***									***High***
3FM	0.237	0.157	0.202	0.168	0.068	0.095	0.117	0.214	0.163	**0.085**
APT	0.377	0.338	0.365	0.280	**0.243**	0.222	**0.305**	**0.321**	**0.184**	0.081

----- : Indicates a better performance of the APT
Bold letters indicate cases where only the market factor is priced (i.e. CAPM).

Table 9: Paired T test for the better model: FF3FM vs APT

Case	Mean FF3FM	Mean APT	Difference	%Difference	T-Value	P-Value
BE/ME	0.1796	0.2492	-0.0696	-27.92%	-3.76*	0.004
C/P	0.1718	0.2454	-0.0736	-29.99%	-5.72*	0.000
E/P	0.1847	0.2614	-0.0767	-29.34%	-4.83*	0.001
3-Y SG	0.2296	0.2683	-0.0387	-14.42%	-3.68*	0.005
MV	0.1506	0.2716	-0.1210	-44.55%	-5.81*	0.000

Statistically significant level 1%