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AN EMPIRICAL TEST TO SINGLE AND MULTIFACTOR CAPM MODELS IN THE EURONEXT LISBON (THE PORTUGUESE STOCK EXCHANGE

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Keywords: CAPM, market risk, multifactorial model, single factor model; PSI Geral; Lisbon Euronext.

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AN EMPIRICAL TEST TO SINGLE AND MULTIFACTOR CAPM MODELS IN THE EURONEXT LISBON (THE PORTUGUESE STOCK EXCHANGE).

Abstract

The objective of this paper was to test if the single-factor CAPM model is valid in the Portuguese stock exchange, when compared with the CAPM multifactorial proposed by Fama and French-Carhart. It used the Fama and French (1993; 1996) methodology, for a period of 14 years for a sample of 18 stocks from different sectors, using the risk factors developed by French (2015). The results suggest that, for the period under analysis, the CAPM multifactorial applied in the Lisbon stock exchange is not statistically enough to reject the single-factor CAPM. The results suggest that the risk market factor seems to be influential and important in explaining the expected average return in the Lisbon stock exchange.

UNA PRUEBA EMPÍRICA PARA MODELOS CAPM SIMPLES Y MULTIFACTORIAL EN LA EURONEXT LISBON (LA BOLSA DE VALORES PORTUGUESA

Resumen

El objetivo de este trabajo fue probar si el modelo CAPM de factor único es válido en la bolsa de valores portuguesa, en comparación con el CAPM multifactorial propuesto por Fama y French-Carhart. Se utilizó la metodología de Fama y French (1993, 1996), para un período de 14 años, para una muestra de 18 activos de diferentes sectores, utilizando los factores de riesgo desarrollados por French (2015). Los resultados sugieren que, para el período en análisis, el CAPM multifactorial aplicado en la bolsa de valores de Lisboa no es suficiente para rechazar estadísticamente el CAPM de factor único. Aun sugieren que el riesgo de mercado parece ser un factor influyente e importante en la explicación del rendimiento promedio esperado en la bolsa de valores de Lisboa.

1. INTRODUCTION

Financial theory and common sense tells us that the investments that are riskier must produce higher yields to compensate for the risk, so an investment without risk is when the real yield is always equal to expected return (Damodaran, 2012). Since late 1960's a model for valuing financial assets has been used, known as the Capital Asset Pricing Model (CAPM), which assumes that there is only a single factor that can explain the expected return on an asset - market risk and argues that, in equilibrium (no arbitration), the market compensates investors in accordance with the market risk level given in its investment. This model was developed by Sharpe (1964) and Lintner (1965) in sequence of Markowitz's work (1958). It also considers that the total risk of an asset can be eliminated in diversification. However, it quickly became apparent the existence of problems with the sample matrix of expected variance-covariance of returns, which produces market portfolio with selling short position and the beta risk market's inability to explain the expected returns (Disatnik & Benninga , 2007). Sharpe (1964) recognized that the assumptions of the model are undoubtedly highly restrictive and unrealistic, however, the test suggests that the assumptions of the model is accepted in view of the lack of alternative models that lead to practical results similar to the model.

Five decades after its appearance, despite the "death sentence", CAPM is assumed as (i) the most widely used in corporate finance to estimate the cost of capital and portfolio valuation; according to Graham and Harvey (2001; 2010; 2013), indicate that 74% of American companies use the CAPM. According to Brounen, Jong and Koedijk (2004), 45% of European companies use the CAPM; (ii) (Fama & French, 2004) recognize that it is still the central element in post graduate courses in corporate finance, about 75% of finance professors recommends using the CAPM to estimate the cost of capital (Welch, 2008) .

Based on this framework, this paper aims to test whether the single-factor CAPM is valid in the Portuguese stock exchange, compared with the multifactor CAPM model proposed by Fama and French. For a sample of 18 stocks traded in Lisbon Euronext Stock Exchange from different sectors, it was applied the methodology of Fama and French (1993, 1996) for a period of 14 years and using risk factors developed by French (2015).

The paper is organized in three sections, besides this introduction and conclusions. The next section presents a brief theoretical framework on the CAPM model, the following is the description of the methodological process adopted, objectives and research hypotheses and fourth section presents and discusses the results. Ends with

considerations and summary of the main conclusions arrived at work, identifying the limitations of the study and suggestions for future research.

2. THE CAPM MODEL: SINGLE FATOR MODEL AND THE MULTI FACTOR MODEL

Markowitz (1952) pioneered the analysis process of risk-return function and developed a methodology based on the maximum expected utility. He proposed a general solution to the portfolio selection. After, Tobin (1958) sought to show that, under certain conditions, the Markowitz's model (1952), involves a process of choice of investments that can be divided into two phases: (i) the choice of an ideal combination of risky assets on average - variance; (ii) independent application of funds between this ideal combination of risky assets and a single risk-free asset. From this analysis derived a powerful tool that can simplify the risk - profitability function and became "cornerstone" of modern finance - the Capital Asset Pricing Model (CAPM), proposed independently Sharpe (1964), Lintner (1965).

The CAPM assumes that there is only a single factor that can explain the expected return on an asset - market risk and argues that, in equilibrium (no arbitration), the market compensates investors in accordance with the market risk level assumed in your investment and, part of the total risk of an asset may be reduced by diversification according to the following equation:

$$E(R_i) = R_f + \beta_i (R_m - R_f), \text{ where } \beta_i = \frac{Cov(R_i, R_m)}{\sigma^2{}_m} \qquad (1)$$

Being, R_i - Expected rate of return on an asset i; R_m - expected rate of return on market portfolio M; R_f – rate of return on assets without risk (riskless assets) and β_i - systematic risk of asset i; $Cov\ (R_i, R_m)$ - covariance between return on asset i and return of the market portfolio.

The CAPM (equation 1) can be tested by simple linear regression equation, where the value of the beta coefficient is obtained from the excess return over the risk-free rate (Fama & French, 2004; Marcelo, Quirós & Quirós, 2010). The resulting stretch of this model is known as security market line (SML) - see equation 2.

$$R_{it} - R_{ft} = \alpha_i + \beta_i (R_{mt} - R_{ft}) + \varepsilon_{it}, \text{ with } \alpha = 0 \quad (2).$$

Being, R_{it} - R_{ft} - excess return of asset i at time *t;* β_i $(R_{mt}$ - $R_{ft})$ - market risk premium of asset *i.*

The difference between the CAPM model (equation 1) and the linear regression model (equation 2) is the value of the alpha coefficient; α> 0, indicates a higher yield than suggested by its market risk, means that income is above the SML, on the other hand, α <0 indicates a lower yield than suggested by its market risk, implies that the income is below the SML line. According to Marcelo et al., (2010), in both cases (α> 0, α <0), is divergent to the theoretical condition of market equilibrium which implies that market values should be located along the line setting the regression model, i.e. the SML.

However, the lack of efficient portfolio has attracted a great research interest in search of a method able to explain the behavior of the market portfolio. Fama and French (2004) rescued studies published since the 1970s up to 2002[2], updated and summarized the evidence of empirical failures to invalidate the way the model is applied and reinforce the call for the use of the CAPM three-factor model proposed in 1993. They emphasize the proposal of the three-factor model of expected return as the one-factor CAPM, also called single factor (based solely on market risk as measured by beta coefficient) is not adequate to explain the expected return, adding two more factors: size (market value or market capitalization) and book-to-market index (in the following of the paper we will simply denote it by B/M ratio), which may explain unobserved risk factors. This argument came from Fama and French's (1993, 1996) evidence, that in a time series test using 25 different portfolios based on size and B/M ratio, it was found that based on CAPM single factor, many alpha coefficients were significantly different from zero unlike the alpha coefficients of the model 25 portfolios based on three factors (which were not significantly different from zero). Accordingly, Fama and French (1993, 1996) proposed the three-factor CAPM model based on market risk, size and B/M, represented by the following equation:

$$E(R_{it}) - R_{ft} = \beta_i \left[E(R_{mt}) - R_{ft}\right] + \beta_{is} E(SMB_t) + \beta_{ih} E(HML_t) \quad (3)$$

Where, SMB_t (*Small minus Big*) - the average return on the three small portfolios minus the average return on the three big portfolios; HML_t *(High minus Low)* - the average return on the two value portfolios minus the average return on the two growth portfolios; and β - rate of change in multiple regression excess return of asset *i; (Rmt - Rft)* is the market risk premium*.* Fama and French (1993; 1996; 2004) report that from the equation (3) of trifactorial model, the intercept α_i of the time series regression is zero for all assets i according to the following equation (see equation 4):

$$R_{it} - R_{ft} = \alpha_i + \beta_{im}(R_{im} - R_{ft}) + \beta_{is}(SMB_t) + \beta_{ih} E(HML_t) + \varepsilon_{it}, \text{ with } \alpha = 0 \quad (4)$$

[2] For a contextual reading see Fama and French (1993; 1996).

Jegadeesh and Titman (1993) observed a pattern behavior related to assets with high/low yields produced in the past returns that tend to present higher/lower than average for a certain period of time. They found that this behavior may be due to the arrival of new information to the market capable of estimating or temporarily underestimate asset prices. Charhart (1997) confirmed the evidence of Jegadeesh and Titman (1993) and proposes to add to the three-factor model a momentum factor resulting from the difference between high and low yields of the assets of the last 3-12 months (*reported by Win Lose Minus - WML*) which shows capture much of the variation in profitability of mutual funds, whose single factor CAPM model and trifactorial model are not able to explain, represented by the following equation (see equation 5):

$$E(R_{it}) - R_{ft} = \beta_{im}\left[E(R_{mt}) - R_{ft}\right] + \beta_{is}E(SMB_t) + \beta_{ih}E(HML_t) + \beta_{iw}E(WML_t) \qquad (5)$$

Where, SMB_t (*Small minus Big*) - the average return on the three small portfolios minus the average return on the three big portfolios; HML_t *(High minus Low)* - the average return on the two value portfolios minus the average return on the two growth portfolios; and β - rate of change in multiple regression excess return of asset *i; (Rmt - Rft)* is the market risk premium; *WML (Win minus Lose)* – the average return on the two high prior return portfolios minus the average return on the two low prior return portfolios over the last 3 to 12 months.

As in the equations (2) and (4) the intercept α_i of the time series regression is zero for all assets i for a four factors CAPM model, resulting in the following equation:

$$R_{it} - R_{ft} = \alpha_i + \beta_{im}\left(R_{im} - R_{ft}\right) + \beta_{is}\left(SMB_t\right) + \beta_{ih}E\left(HML_t\right) + \beta_{iw}E\left(WML_t\right) + \varepsilon_{it}\ , \text{ with } \alpha = 0 \qquad (6)$$

Fama and French (1996, 2004) recognized that the three-factor CAPM model cannot explain the abnormal behavior designated by momentum, also called momentum effect, and that they consider useful in applications whose goal is to abstract themselves from known patterns of means returns that reveal associated effects to certain information. However, these authors classify irrelevant this effect to estimate the cost of capital.

3. METHODOLOGY OF RESEARCH AND DATABASE

The objective of this paper is to verify that the CAPM is valid in the Portuguese stock market. To this end, it is proposed to test the CAPM model that best describes the expected returns for a sample of eighteen stocks of different sectors from the PSI Geral index (market index of Lisbon Euronext stock exchange, the Portuguese stock market) for a period of 14 years on a monthly basis by applying the methodology proposed by Fama and French (1993; 1996; 2004), which consists in a time series test, through the estimation of simple and multiple linear regression models to validate the CAPM model for one, three and four risk factors using risk factors developed by French (2015).

The CAPM states that the expected value of returns in excess of an asset is fully explained by its expected risk premium, thus, the alpha coefficient in a time series regression model is zero (Fama & French, 1993). This approach is also valid for the CAPM models of three and four factors when added other risk factors. In accordance to this was proposed the following research hypotheses for the time series test:

H1: The market risk explains the expected returns, whereby alpha is nonzero.

H2: Risk factors such as SMB, HML and WML provide expected average returns not explained by single factor CAPM.

For this purpose will be calculated the descriptive statistics (mean and standard deviation), the Pearson correlation matrix between risk factors (risk premium, SMB, HML and WML) and applied the hypothesis tests. In order to calculate the return, a logarithmic formula was used which is also known as continuous return. This formula is, according to Marcelo et al. (2010), the most widely used in empirical studies due to their statistical properties.

Historical data for the eurozone risk factors (RM - RF, SMB, HML and WML) as well as for the eighteen securities traded on the Lisbon Euronext stock exchange were obtained from the French's database (2015) through the web pages http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/ and http://finance.yahoo.com/, respectively.

At the stage of CAPM models validation, a time-series test will be undertaken, through the estimation of simple and multiple linear regression models, using the method of ordinary least squares. So it will be tested the alpha coefficient behavior CAPM with respect to models for one, three and four risk factors using the equations (2), (4) and (6) based on the methodology presented by Fama and French (1993). For these hypothesis tests the following conditions were imposed: (i) two-tailed test, with confidence level of 95%, a 5% significance level, and critical t equal to 2; (ii) for the value of the alpha coefficient be considered equal to zero, the absolute value of the t test should be less than 2, hence the CAPM is consistent, that is, if the intercept value is non-zero and statistically

significant (5%), the CAPM failure to forecast the risk premium. In order to of risk factors coefficients be significant, the respective t values should be greater than 2. It was tested the presence of residual autocorrelation, heteroscedasticity and multicollinearity of explanatory variables. The applied tests were Breusch- Godfrey, Breusch-Pagan and VIF statistics (Variance Inflation Factor), respectively. It will be used the Chow test to check the behavior (change or structural stability) of the intercept and the slope parameters of the regression model in the period February 2000 to April 2014[3]. The identified heteroscedasticity and autocorrelation of errors will be corrected by the robust standard error estimator of Newey-West Heteroskedasticity and Autocorrelation consistent standard errors - HAC, which is consistent with the heterocedasticity and autocorrelation.

The explanatory power of risk factors for the expected return for each model will be defined by R^2 adjusted coefficient, so the comparison between models will be made using the R^2 adjusted values (R^2a). The significance of the models will be verified by statistical F, while the significance of each parameter intercept and slope (alpha and beta) risk factors *RM-RF, SMB, HML* and *WML* are assessed by t-test, following the methodology of Fama and French (1993).

4. ANALYSIS AND DISCUSSION OF RESULTS

The following presents and discusses the results for the tests of hypotheses concerning the search for a model that best explains the expected average returns giving a market portfolio average variance, as a starting point, analyzing the mean and standard deviation as well as the correlation matrix between risk factors (explanatory variables). For models in analysis, it was confirmed absence of multicollinearity by VIF statistics.

For the choice of risk factor variables, Fama and French (1993) took as a criterion the fact that the variables are not redundant in relation to the expected return. Table 1 shows the statistics of the risk factors and the Pearson correlation matrix between the independent variables. It was found that the correlation between the variables is low, which indicates absence of multicollinearity (Gujarati & Porter, 2009). The market risk premium for the eurozone is 0.5%, the size risk premium was 0.1%, that is, small businesses do not offer ex ante higher risk premium than large companies with same level

[3] Arghyrou and Kontonikas (2012) pointed out in March 2009 as the beginning of a period in which the global financial crisis turned into sovereign financial crisis for the eurozone countries. Taking this date (March 2009) as a reference, a stability test shall be used to verify the behavior (change / structural stability) of the intercept and the slope parameters of the regression model.

of risk as Fama and French (1993) noted a premium of 0.27% per month. The B/M risk premium was 0.5% higher than that by Fama and French (1993), which was 0.40% for the US market.

Table 1: Statistics monthly risk premium and correlation of risk factors Matrix. Fama and French - Carhart, from February 2000 to April 2014

	Statistics		**Correlation Matrix**			
	Average	*standard deviation*	*RM-RF*	*SMB*	*HML*	*WML*
RM-RF	0,005	0,057	1			
SMB	0,001	0,022	-0,055	1		
HML	0,007	0,027	-0,183	0,084	1	
WML	0,008	0,048	-0,429	0,184	-0,235	1

*Note: SMB (Small minus Big) - the average return on the three small portfolios minus the average return on the three big portfolios; HML (High minus Low) - the average return on the two value portfolios minus the average return on the two growth portfolios; WML (Win minus Lose) – the average return on the two high prior return portfolios minus the average return on the two low prior return portfolios over the last 3 to 12 months; and (RM - RF) - market risk premium.

From the analysis of table 1, it appears that large companies have higher performance than expected, likely due to the low transaction costs for these companies in contrast to small businesses or because of underestimation of the respective betas (Pires, 2008).

Next it will be analyzed the results for each model, taking into account the statistical t test, and values of determination coefficients (R^2) of each stock and adjusted R^2, which will be the reference for comparing the performance of risk factors that suggest best fit to the models in consideration, as Fama and French (1993; 1996).

4.1. Validation of the CAPM model for PSI Geral Portfolios

The table 2 shows the results of simple regression whose explanatory variable is the market risk (RM-RF), for a portfolio of eighteen stocks for the period of February 2000 to April 2014. As can be seen, 6 stocks (33.33%) present statistical significance different from zero, which suggest effective higher returns than expected. The market risk factor is statistically significant for 9 stocks. The adjusted coefficient of determination (R^2a) lies between -0.5% and 20.2%. the mean is 5.39% and standard deviation is 6,52%. The average coefficient of determination (R^2) is 6.52% (standard deviation is 6.37%). The statistical Chow test indicates that 2 stocks (11.11%) present evidence for structural changes of sample parameters.

Table 2: Regression Model for the single factor CAPM

$$R_{it} - R_{ft} = \alpha_i + \beta_i \left(R_{mt} - R_{ft}\right) + \varepsilon_{it} \qquad \alpha = 0$$

Stocks	***ALFA***	***T STAT***	***RM-RF***	***T STAT***	***R^2***	***R^2 a***	***CHOW STAT***	***P-VALUE***
CPR	-0,002	−0,290	0,279	1,769	0,032	0,0267	0,012	0,988
CFN	-0,007	−0,775	0,926	3,830	0,118	0,113	1,308	0,273

COMAE	-0,029	**−2,591**	0,325	0,9731	0,008	0,002	0,847	0,430
COR	0,000	0,035	0,485	4,912	0,120	0,115	6,023	**0,003**
ESO	-0,011	−1,648	0,202	1,145	0,009	0,003	1,112	0,331
FCP	-0,014	**−2,101**	2,516	2,516	0,025	0,019	0,921	0,400
GLINT	-0,034	**−2,594**	0,869	4,489	0,092	0,086	2,089	0,127
GPA	-0,014	−1,485	0,612	1,550	0,033	0,028	0,872	0,420
IBS	-0,002	−0,411	0,728	6,322	0,207	0,202	0,604	0,547
INA	-0,026	**−3,264**	0,894	4,615	0,176	0,171	1,377	0,255
LIG	-0,031	**−2,191**	0,207	0,863	0,004	-0,002	2,081	0,128
NBA	-0,008	−1,100	-0,041	−0,292	0,001	-0,005	0,539	0,584
RED	-0,023	−1,829	0,249	1,548	0,010	0,004	0,815	0,445
SCP	-0,014	−1,746	0,459	3,744	0,053	0,047	1,144	0,321
SCT	-0,006	−0,687	-0,011	−0,077	0,000	-0,005	2,562	0,080
SUCO	-0,010	**−2,149**	0,504	3,389	0,103	0,098	9,916	**0,000**
SVA	-0,010	-1,251	0,276	1,890	0,019	0,014	1,345	0,263
VAF	-0,015	−0,7048	0,693	2,077	0,019	0,013	1,235	0,293

**Note*: T Stat - t statistic; RM-RF - risk premium on the market euro area; R^2 - adjustment coefficient of the regression model; R^2a - adjusted coefficient of determination; Stat F - F statistic; Chow Stat – statistic Chow test

For the three factors CAPM model (see Table 3), which includes the SMB and HML risk factors in addition to market risk premium (RM-RF), it appears that alpha coefficients are statistical significant for 3 stocks (16.67%). Market risk factor behavior keeps statistically significant for 10 stocks. Regarding the SMB risk factor, this is statistically significant for 6 stocks (33.33%). In relation to HML risk factor, it is statistically significant for 4 stocks (22.22%). The determination coefficient is between 1.2% and 25.8%, with an average of 7.48% (standard deviation = 8.71%) with an average of adjusted coefficients of determination (R^2a) of 9.1% (standard deviation = 8.53%). It is also observed that according to the statistic Chow test, all stocks show no structural changes in the sample parameters.

Table 3: regression Model for the CAPM three factors

$$R_{it} - R_{ft} = \alpha_i + \beta_{im}\left(R_{im} - R_{ft}\right) + \beta_{is}\left(SMB_t\right) + \beta_{ih}E\left(HML_t\right) + \varepsilon_{it} \qquad \alpha = 0$$

*Stocks **	*Alfa*	*T Stat*	*RM-RF*	*T Stat*	*SMB*	*T Stat*	*HML*	*T Stat*	R^2	R^2a	*F*	*Stat Chow*
CPR	-0,004	−0,727	0,276	1,979	0,696	1,976	0,199	0,703	0,063	0,046	**7,149**	2,598
COMAE	-0,020	−1,503	0,439	1,372	0,045	0,066	-1,301	−1,639	0,037	0,019	1,941	0,317
COR	0,001	0,186	0,524	**5,509**	0,780	**3,647**	-0,266	−0,783	0,175	0,160	**13,412**	2,235
ESO	-0,016	**−2,327**	0,155	0,934	0,461	1,225	0,647	**2,091**	0,033	0,0161	1,866	2,324
FCP	-0,014	−1,882	0,266	**2,287**	0,406	1,539	-0,027	−0,072	0,034	0,017	2,320	1,655
GLINT	-0,022	−1,561	1,036	**5,277**	0,492	0,945	-1,806	**−2,557**	0,185	0,175	**10,022**	4,187
IBS	-0,002	−0,2838	0,764	**6,621**	0,742	**2,537**	-0,230	−1,040	0,244	0,231	**17,842**	1,609
CFN	-0,003	−0,261	1,011	**3,989**	1,035	1,918	-0,737	−0,973	0,158	0,143	**5,966**	2,444
GPA	-0,016	−1,533	0,577	1,568	-0,441	−0,604	0,291	0,814	0,038	0,021	0,940	0,552
INA	-0,032	**−4,531**	0,871	**4,432**	1,613	**3,532**	0,657	**2,644**	0,272	0,258	**8,258**	0,824
LIG	-0,036	**−2,632**	0,203	0,765	1,507	**2,292**	0,403	0,816	0,035	0,0177	1,966	1,404

NBA	-0,006	−0,857	-0,037	−0,276	-0,496	−1,737	-0,158	−0,617	0,014	-0,003	1,146	1,135
RED	-0,025	−1,795	0,263	1,479	0,886	**2,014**	0,053	0,098	0,027	0,009	**3,552**	0,597
SVA	-0,010	−1,165	0,317	**2,309**	0,924	**2,983**	-0,251	−1,089	0,056	0,039	**4,899**	1,035
SCP	-0,012	−1,299	0,492	**3,519**	0,401	1,219	-0,283	−0,648	0,064	0,047	**4,975**	1,220
SUCO	-0,005	−1,106	0,582	**4,082**	0,486	1,732	-0,780	**−2,766**	0,175	0,159	**9,949**	1,846
SCT	-0,005	−0,556	0,012	0,086	0,397	0,086	-0,174	−0,532	0,006	-0,012	0,355	2,626
VAF	-0,011	−0,644	0,746	**2,209**	0,276	0,452	-0,536	−0,896	0,022	0,004	1,843	3,032

Note: Stat: t statistic; RM-RF: eurozone market risk premium; SMB: size risk premium; HML: B/M index risk premium; R^2: determination coefficient of the regression model; R^2a: adjusted determination coefficient; F (3, 167): F-statistic. (Observed value ≥ 3.19524 gives the statistical significance of the model set of explanatory variables – there is at least βi ≠ 0for 5% of significance); Chow test: F statistic-Stat (4, 163) observed value ≥ 2.86523 indicate the structural failure of alpha and beta, the parameters model, to a 5% confidence level.

Finally we present below, in Table 4, the results of multiple regressions for the four factors CAPM. As can be seen, 3 stocks (16.67%) suggest an effective higher average return than expected, since alpha is statistically significant at 5% significance level. Market risk factor (RM-RF) keeps statistically significant for 8 (44.44%) stocks. The SMB risk factor is statistically significant for 7 (38.89) stocks, while for the HML risk factors it presents statistical significance only for three stocks (16.67%). In relation to WML risk factor all the stocks - eighteen (100%) - do not show statistical significance. This finding contributes to the result of the F statistic which suggests no statistical significance of the model. The adjusted coefficient of determination (R^2a) lies between 1.8% and 25.5%, with a mean of 7.37% (standard deviation = 8.88%). The average coefficient of determination is 9.56 %, (standard deviation = 8.67%). The statistic Chow test, like the three factors CAPM model, indicates that, all the stocks do not exhibit structural changes of the sampling parameters during the period.

Table 4: Regression model for the four-factor CAPM

$$R_{it} - R_{ft} = \alpha_i + \beta_{im}\left(R_{im} - R_{ft}\right) + \beta_{is}\left(SMB_t\right) + \beta_{ih}E\left(HML_t\right) + \beta_{iw}E\left(WML_t\right) + \varepsilon_{it} \qquad \alpha = 0$$

*Stocks **	*Alfa*	*T Stat*	*Mkt-RF*	*T Stat*	*SMB*	*T Stat*	*HML*	*T Stat*	*WML*	*T Stat*	*R^2*	*R^2 a*	*F*	*Stat Chow*
CPR	-0,001	−0,198	0,191	1,453	0,781	**2,266**	0,130	0,476	-0,258	−1,770	0,078	0,056	**6,515**	2,667
COMAE	-0,023	−1,654	0,524	1,361	-0,040	−0,062	-1,232	−1,655	0,257	0,588	0,040	0,017	1,550	0,399
COR	0,001	0,231	0,515	**4,819**	0,789	**3,572**	-0,274	−0,828	-0,029	−0,242	0,175	0,155	**10,152**	2,154
ESO	-0,015	**−2,002**	0,128	0,672	0,489	1,273	0,625	1,923	-0,082	−0,427	0,034	0,011	1,658	1,703
FCP	-0,014	−1,786	0,255	1,779	0,416	1,588	-0,036	−0,098	-0,032	−0,172	0,035	0,011	1,767	2,019
GLINT	-0,016	−1,209	0,843	**3,276**	0,686	1,287	-1,961	**−2,736**	-0,582	−2,162	0,208	0,188	**12,498**	3,076
IBS	-0,001	−0,239	0,757	**5,620**	0,748	**2,613**	-0,234	−1,078	-0,019	−0,145	0,244	0,226	**16,050**	1,897
CFN	-0,001	−0,064	0,933	**3,168**	1,114	**2,033**	-0,800	−1,109	-0,238	−0,826	0,163	0,142	**5,714**	2,565
GPA	-0,014	−1,335	0,520	1,386	-0,384	−0,521	0,245	0,702	-0,173	−0,853	0,039	0,016	0,838	0,482
INA	-0,031	**−3,954**	0,841	**3,998**	1,643	**3,591**	0,633	**2,373**	-0,089	−0,444	0,272	0,255	**6,591**	2,015
LIG	-0,030	**−2,242**	0,035	0,140	1,676	**2,425**	0,267	0,562	-0,509	−2,074	0,048	0,025	2,036	1,258
NBA	-0,008	−1,099	0,012	0,080	-0,546	−1,824	-0,119	−0,456	0,149	0,960	0,018	-0,005	0,999	1,048
RED	-0,026	−1,958	0,307	1,458	0,841	1,870	0,089	0,166	0,134	0,660	0,029	0,005	**2,782**	0,709
SVA	-0,009	−1,178	0,300	1,670	0,940	**3,059**	-0,265	1,246	-0,050	−0,250	0,056	0,033	**5,482**	0,962
SCP	-0,014	−1,592	0,534	**2,982**	0,359	1,075	-0,249	−0,612	0,127	0,632	0,066	0,043	**4,224**	1,115
SUCO	-0,008	−1,675	0,662	**4,131**	0,405	1,548	-0,715	**−2,641**	0,244	1,781	0,188	0,168	**8,989**	1,691
SCT	-0,006	−0,536	0,021	0,151	0,388	0,743	-0,167	−0,513	0,027	0,092	0,006	-0,018	0,274	2,119
VAF	-0,012	−0,817	0,776	**2,270**	0,246	0,418	-0,511	−0,738	0,092	0,217	0,022	-0,002	1,568	2,939

Note: Stat: t statistic; RM-RF: eurozone market risk premium ; SMB: size risk premium; HML: B/M index risk premium; R^2: determination coefficient of the regression model; R^2a: adjusted determination coefficient; F (3, 167): F-statistic. (Observed value ≥ 3.19524 gives the statistical significance of the model set of explanatory variables – there is at least βi ≠ 0for 5% of significance); Chow test: F statistic-Stat (4, 163) observed value ≥ 2.86523 indicate the structural failure of alpha and beta, the parameters model, to a 5% confidence level.

5. CONCLUSION AND SUGGESTIONS FOR FUTURE RESEARCH

The purpose of this paper was to check if CAPM is valid in Lisbon Euronext exchange – the Portuguese stock market, sought to validate the CAPM model that best describes the expected returns of a portfolio of eighteen stocks, using as horizon of analysis a period of 14 years (from February 2000 to April 2014), testing the CAPM models taking into account as risk factors those proposed by Fama and French (1993, 1996) and Carhart (1997). Data was collected from French (2015) website and Portuguese stock prices from yahoo finance website.

It was observed that for the eighteen stocks of the PSI Geral for the period under analysis, considering the single factor CAPM model, the determination coefficients obtained were relatively significant when compared to the models of three and four factors. However, the increase of risk factors SMB, HML and WML as explanatory variables had little influence in the behavior of the expected average return because the

adjustment coefficient R^2 showed very low explanatory power in a set of variables (27.20%).

The results suggest that the risk factors proposed by Fama and French (1993) and Carhart (1997) are not statistically adequate to explain the expected average return, according to research hypothesis 1 - CAPM market risk fully explains the expected returns - cannot be rejected. This is in line with the arguments of Fama and French (1993) which advocates the use of risk factors in any application that requires estimating future performance, as to guide (a) portfolio selection, (b) evaluating portfolio performance (c) calculate abnormal returns in event studies, and (d) estimate the cost of capital, if the risk factors capture the average return that single-factor CAPM cannot explain. That is, the risk factors proposed by Fama and French - Carhart, for the period under analysis, do not capture the average return that the market risk factor cannot explain.

On the other hand, it must be said that given the sample size and the period, characterized by a global financial crisis with consequences for the stock markets of the eurozone (the Chow test suggests that there is structural break of alpha and beta parameters over period) are limitations that may influence the conclusions of this work. In consequence, it is suggested to proceed in the future with a similar research using other eurozone stocks (like Belgium, French, Spanish or German stocks) in order to confirm or reject the results that present work suggests, and if the dimension of the stock market influences it.

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