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**A Fundamental Approach to Quantitative Equity
Portfolio Management**

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ABSTRACT

The aim of the present paper is to determine the explanatory power of three fundamental factors in cross-sectional stock returns. In order to do so, these three factors were combined with the Carhart four factor model. Results revealed that from 2006 to 2015, the *Size* factor of Fama and French and the twelve month *Momentum* of Jegadeesh and Titman had no statistical power in explaining the cross-sectional stock returns. Conversely, the *Value* and *Market Beta* factors of Fama and French, and the fundamental factors *EBITDA/Sales*, *CFO/Capex*, *Price/CFO* have demonstrated to be all statistically significant in explaining the cross-sectional stock returns in the period in analysis. It was also found that portfolios constructed monthly, using a Long/Short strategy in which one buys the top quintile and sells the lowest quintile, are able to produce statistically significant abnormal returns, or alpha. The abnormal returns are determined using as control factors, or benchmark, the returns of the Fama and French three factor strategy in the European market. Furthermore, the Long/Short strategy is negatively and positively exposed to the Size portfolio and to the Value portfolio, respectively, of the Fama and French three factor model.

Abordagem fundamental à gestão quantitativa de portfólios de capitais próprios

João Pedro de Jesus

ABSTRACTO

O objectivo da presente dissertação é determinar o poder explanatório de três factores fundamentais ao explicar os retornos *cross-sectional* de acções. Para tal, os três factores foram combinados com o modelo de quatro factores *Carhart*. Os resultados demonstraram que, de 2006 a 2015, o factor *Size* de *Fama* e *French* e o factor *Momentum* de 12 meses de *Jegadeesh* e *Titman* não foram estatisticamente significantes, a explicar os retornos das acções. Contrariamente, os factores *Value* e *Market Beta* de *Fama* e *French*, e os factores fundamentais, *EBITDA/Sales*, *CFO/Capex*, *Price/CFO*, demonstraram ser todos estatisticamente significantes a explicar os retornos *cross-sectional* das acções, no período em análise. Foi também concluído que, portfólios construídos mensalmente, usando uma estratégia *Long/Short* na qual se compra o melhor quintil e se vende o pior quintil, são capazes de produzir retornos anormais, ou alfa. Os retornos anormais são determinados usando como factores de controlo, ou referência, os retornos da estratégia de três factores de *Fama* e *French* para o mercado europeu. Para além disso, a estratégia de *Long/Short* é negativa e positivamente exposta ao portfólio de *Size* e ao portfólio de *Value*, respectivamente, do modelo de três factores de *Fama* e *French*.

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I. Introduction

Quantitative Equity Portfolio Management models have become one of the major drivers of asset allocation and return forecasting in the investment industry. Almost all the major financial institutions and an increasing number of individual investors recur to the statistical strength of these models in order to achieve their investment objectives. Currently there are a numerous amount of theories to value securities and many of them were created before the generalization of quantitative portfolio models that provide a better match to the needs of investors. Therefore, it is commonly accepted that these theories are chosen and adapted to the specific investment needs and environment in which they will be applied.

This dissertation focus on the widely used Carhart four factor model, which builds on the Fama and French (1992) three factor model and the Jegadeesh and Titman (1993) twelve month momentum factor. Using these models as a starting point, for this study, one will combine them with three key metrics present when performing a fundamental analysis on a firm specific scenario. These fundamental firm specific factors are based on: firms' lagged profitability, as in Fama and French (2006), defined as earnings before interest, tax, depreciation and amortization (EBITDA) divided by the sales volume of firms, providing a measure of the operational efficiency of firms; investment capacity and overinvestment problems as argued by Richardson (2006), Fairfield, Whisenant and Yohn (2003), and Titman, Wei and Xie (2004), defined as cash flow from operations (CFO) divided by capital expenditures (Capex) of firms, indicating the ability of firms to invest and create future growth opportunities; and a factor which aims at capturing the cheapness of buying one unit of cash flow generated by the operating entity, defined as the Price to cash flow from operations (CFO), which provides information on whether the operating entity is more undervalued, and which serves as an indicator of investor's perspectives on the future of the firm.

In order to do so, the present dissertation will focus on mimicking the approach used in Asness, Moskowitz and Pedersen (2013) to the stock market, augmenting it, in order to take in consideration the three firm specific factors. Firstly, the statistical significance of all factors in explaining the cross sectional stock returns will be determined using the same methodology as in Fama and MacBeth (1973). Then it will be created an equal weighted portfolio consisting of the relevant factors in explaining the cross-sectional

returns of stocks, which will be confronted with the widely used Fama and French three factor model as a model that captures the main market anomalies and compensation to investors for bearing systemic risk. The Fama and French returns for the European market will be used in order to determine if the multi-factor strategy being analysed provides statistically significant superior risk adjusted returns, or alpha.

The main results of this analysis have revealed the Size and the Momentum factors do not help to explain stock returns in the period being analysed. These results support the main findings of Hung, Azad and Fang (2014) who argue that the Fama and French three factors and the Momentum factor tend to be less explanatory of stock returns during crisis periods. On the other hand, the Market Beta, Value, EBITDA to Sales, CFO to Capex and Price to CFO factors are statistically significant in explaining stock returns. On the second part of the analysis, it is revealed that a strategy comprising only the statistically relevant factors to predict stock returns was able to deliver abnormal risk adjusted returns. This strategy is based on buying the twenty percent stocks with the highest expected returns and short selling the twenty percent stocks with the lowest expected returns. The presence of alpha was ascertained by confronting the returns yielded by this strategy against the returns yielded by the Fama and French three factor model in the European market.

This dissertation is organized as follows. Section II, provides a comprehensive literature review on the main market anomalies relevant for this paper and an historical framework of the development of Quantitative Equity Portfolio Management theories. Section III, presents the specific factors of model being used in this dissertation, as well as, insights and the main reasons behind the usage of the three fundamental factor in analysis. Section IV, provides a step by step guide on the methodology used and modelling process. In section V, it is presented the empirical results and analysis of the implementation of the methodology outlined previously. Section VI, provides information regarding the robustness of the empirical results and further tests conducted on a specific factor basis. In section VII, it is discussed the limitations of this paper, as well as, propositions of topics for further research. Section VIII presents the main findings of the study and justifications for the observed market anomalies. Sections, IX and X, display, respectively, all the relevant tables and figures for the analysis of the study. Finally, Section XI presents all the references used in the writing and preparation of this dissertation.

II. Literature Review

The first developed and widely accepted theory on how prices and returns of securities move through time is the Efficient Market Hypothesis. This theory states that if markets are of strong form efficiency, then, security prices reflect all public and private, available information. The practical implication of this, is that prices should change instantaneously and only change, as new information arises, meaning that it is impossible for active investors to earn consistently higher risk adjusted returns by exploiting information. In the case that this hypothesis holds, there is no need or informational gain in studying historical stock price movements. At the heart of this hypothesis is the Random Walk Hypothesis, developed by Kendall and Hill (1953), where it is stated that in a time series, stock prices tend to demonstrate random changes, positive and negative, being the correlations between prices and returns very low. Therefore it is not possible to predict future returns using past information. One of the most comprehensive test to the Efficient Markets Hypothesis was performed in Fama (1970). Eugene Fama defined three levels of market efficiency: the first, weak form efficient markets, where security prices fully reflect all market data and that is the only information available; semi strong form efficient markets, where security prices fully reflect all market and public information, as financial statements and other announcements; the strong form efficient markets where all market, public and private information is fully reflected on securities prices. In this study, Fama concluded that the hypothesis of strong form efficient markets, holds quite extensively in the USA market for many different securities, despite some scenario specific pitfalls.

When looking for common factors present across different countries, sectors and firms, one must bear in mind that there are two mainly accepted sources of risk. Market risk, which has an impact across all industries, sectors and countries. And unique risk, which is the specific risk to the firm in analysis and can be diversified away by increasing the size of the portfolio and by adding different securities, and thus creating the market portfolio, consisting on all the securities in the market. According to Markowitz (1952), the optimal portfolio for any investor, maximizes the level of expected return for a given level of risk. The main drivers of returns are the level of systemic risk investors are willing to take, their leverage ability and the level of correlation between securities. By fully diversifying the portfolio, investors are able to obtain the maximum expected

return for the lowest level of standard deviation. Being the standard deviation of the whole portfolio, lower than the standard deviation of the individual securities.

Building on Markowitz (1952) work, the capital asset pricing model (CAPM) is one of the most widely used models in order to price securities. The CAPM was developed by Sharpe (1964), Lintner (1965) and Black (1972), independently. This model has dictated the way risk and return should be linked and taken into consideration when pricing securities for decades. In a CAPM world, the market portfolio is the efficient portfolio in terms of the risk-return trade-off. The practical implications of this, is that, expected returns of stocks should be a linear function of their market risk, or systemic risk, as it assumes that the market portfolio fully diversifies away the specific risks associated with each security. Furthermore, the risk free rate is used as a constant in the model and the expected overall market return, in excess of the risk free return, is used as a factor loading of the systemic risk.

$$E(r_i) = r_f + \beta_i [E(r_m) - r_f] \quad (1)$$

$E(r_i)$ – Expected return of security i

r_f – Risk-free rate

β_i – Sensitivity of asset i to changes in the market

$E(r_m)$ – Expected return of the market

However, empirical tests of the CAPM have failed to support the model. This is due to different factors, such as: the weak historical relationship between the beta of the assets and the asset historical returns; the market capitalization of firms, or the size effect, where firms with lower market capitalization experience higher returns, as explored by Banz (1981); the value effect, as primarily demonstrated by Stattman (1980) and Rosenberg, Reid, and Lanstein (1985), that firms with low market-to-book ratios earn higher returns than firms with high ratios; momentum which states that stocks with a positive past performance will perform well in the future, as demonstrated by Jegadeesh and Titman (1993); the fact that firms with high price-to-earnings ratios have lower returns than firms with lower price-to-earnings ratio, as shown by Basu (1977); and finally, stocks with higher dividend yields that tend to have higher returns, as demonstrated by Basu (1983).

Some of the main criticisms of the CAPM are its failure to recognize the behavioural biases that investors demonstrate in certain asset classes as well as its failure to recognize other risk factors apart from market risk, not taking into consideration other macroeconomic, financial, industry specific or product specific factors. Following on these critics, the arbitrage pricing theory, APT, was developed in order to incorporate different factors, usually systemic, that have impact on the long term performance of securities. The APT uses several common risk factors to predict different asset's returns, under the assumption that the common risk factors are indeed common risk factors and have an impact on all securities returns being analysed, as demonstrated in Roll and Ross (1984). One of the most widely known examples of this model is the Chen, Roll and Ross (1986) five factor model, where they conclude that the broadest and most pervasive factors that explain asset returns are changes in industrial production, changes in expected inflation, changes in unexpected inflation, excess returns of long term government bonds and the excess return of long term government bonds over treasury bills.

However, despite all the limitations of the CAPM, it remains widely accepted due to its simple nature and ease to understand, serving in many scenarios as a benchmark or indicator on the expected returns of different securities. Furthermore, due to the freedom given by the APT, the CAPM is usually incorporated into the APT, through the usage of the risk free interest rate, the asset beta, a measure of the relationship between the asset returns and the market returns, as well as, the usage of the premium returns expected to be obtained in the broad market.

$$r_i = E(r_i) + \beta_{i1}F_1 + \dots + \beta_{ik}F_k + \varepsilon_i \quad (2)$$

For $i = 1$ to N securities:

r_i – Return on security i

$E(r_i)$ – Expected return on security i

β_{ik} – Sensitivity of security i to changes in a common factor

F_k – Surprise factor in stock returns

ε_i – Specific effect on security

When comparing the CAPM with APT, both models are widely used as benchmarks and differentiate between systemic and diversifiable risk, being the systemic risk the only type of risk for which investors should be rewarded for bearing. However, there are significant differences between them. Regarding market equilibrium: the CAPM assumes that this is achieved by holding a mean-variance efficient portfolio; under the APT through arbitrage opportunities exploited by investors, meaning, investors should take advantage and exploit opportunities when securities are mispriced. As for the benchmark or market portfolio: CAPM uses the market portfolio, which can be very ambiguous; the APT provides no guidance regarding the benchmark portfolio, being very flexible to the nature of the factors employed.

One of the most widely used models, based on the APT, is the Fama and French three factor model. The reasons that led to the development of this model, according to Fama and French (1992) are persistent anomalies in the market. The size effect, as demonstrated by Banz (1981), where companies with smaller market capitalization experience higher returns than firms with larger market capitalization, the leverage effect, where firms with higher levels of debt experience lower returns than firms with lower levels of debt, as in Bhandari (1988), the value effect, where firms with high book-to-market ratios, value stocks, experience higher returns than growth stocks, firms with low book-to-market ratio, as confirmed by Rosenberg, Reid and Lanstein (1985), and the lastly, the earnings-to-price ratio relationship with stock returns, where firms with higher earnings-to-price ratios tend to have higher levels of risk and expected returns, as demonstrated by Basu (1983).

$$r_{it} - r_{ft} = \alpha_i + \beta_i(r_m - r_{ft}) + S_iSMB_t + h_iHML_t + \varepsilon_{it} \quad (3)$$

For $i = 1$ to N securities:

r_{it} – Return of security i during time t

r_{ft} – Return on the risk free asset in time t

α_i – Excess return on the portfolio during time t

β_i – Sensitivity of security i to changes in the market

r_m – Return of the market during time t

S_i – Factor loading on the Size portfolio

SMB_t – Return on the Size portfolio

h_i – Factor loading on the Value portfolio

HML_t – Return on the Value portfolio

ε_{it} – Specific effect on portfolio

When considering the Fama and French three factor model, one must bear in mind, that the main driver of returns is risk. The investment strategy designed by Fama and French tries to target pervasive sources of risk, as size and value. This risk based explanation, is consistent with the findings of Liew and Vassalou (2000) which suggest that value and size are fundamental macroeconomic factors of GDP growth that have the effect of adjusting the price of securities to the sentiment of investors regarding GDP growth. Furthermore, Petkova and Zhang (2005), have found that betas of growth firms have a positive correlation with GDP growth, and that betas of value firms have a negative correlation with GDP growth. This means that the value and size portfolios returns can be used to make inferences regarding the expectations of investors on the whole economy and that regardless of the economic cycle, boom or recession, the size and value portfolio will create a natural hedge on both scenarios and provide superior risk adjusted returns.

Another explanation for the superior risk adjusted returns of the Fama and French three factor model is of behavioural nature, as demonstrated by Porta et al. (1997). It states that investors are too optimistic regarding the future of firms when the past performance has been positive, leading to the increase of the price of already highly priced securities, especially around earnings announcements. Also when there are surprises, whether positive or negative, it leads to sharp corrections, particularly when the announcements are negative.

After the work of Fama and French, Mark Carhart, a doctoral student of Eugene Fama, developed a new model based on another market anomaly, momentum. This market anomaly was first discovered by Jegadeesh (1990), who found that there is strong statistical correlation between past returns and future returns of securities, especially in a twelve-month period. Besides this, he has found other market anomalies, such as evidence of short term reversals, being the most pervasive, the January effect. Following his previous work, Jegadeesh and Titman (1993) back-tested a strategy of

buying securities that have performed well in the past and selling securities that have performed poorly in the past, finding conclusive evidences that this trading strategy, yields consistent superior risk adjusted returns. Furthermore, they have confirmed the existence of short term reversals, being most persistence on the portfolio with a twelve month holding period, in the last month, $t-1$, where stocks tend to revert previous gains or losses. And stocks that have previously performed well, outperform stocks that have previously poorly performed, during earnings season, especially in the following seven months to the earnings announcement. However, Jegadeesh and Titman (1993) have also demonstrated evidence of long term reversals, stocks that have performed poorly in the past, outperform stocks that have performed well in the past in the thirteen months after the first seven months, following the portfolio formation, prior to the earnings season.

When looking at conclusive evidences of this market anomaly, one of the most comprehensive momentum back test in Europe was performed by Rouwenhorst (1998). He found that this anomaly is persistent and pervasive in twelve European stock markets, Austria, Belgium, Denmark, France, Germany, Italy, Netherlands, Norway, Spain, Sweden, Switzerland and the United Kingdom, by mimicking the momentum strategy employed by Jegadeesh and Titman (1993). These results are very similar to the ones obtained in the American market. Meaning, that the results were particularly relevant in the twelve month holding portfolio, and that when one takes measures for controlling market risk or the size factor, the abnormal returns increase. Furthermore, Moskowitz, Ooi and Pedersen (2012) have demonstrated that momentum is a market anomaly with a global presence, being present in the Australian, French, German, Italian, Japanese, Dutch, Spanish, British and American equity indices in a twenty-five years' period, ranging from January 1986 to December 2009.

The most widely accepted justifications for the momentum anomaly, in a risk perspective, is that momentum is simply the compensation investors should expect to obtain from bearing portfolios with high macroeconomic risk, (Chordia and Shivakumar (2002)). This means that securities that have performed well in the past are highly sensitive and are more sensitive than past losers to changes in the economic environment as market swings, economic growth or growth of industrial production, as demonstrated by Liu and Zhang (2008). As for behavioural explanations for the superior risk adjusted returns of the momentum portfolio, Barberis, Shleifer and Vishny (JFE,

1998) argue that traders take too much time processing information, as during the earnings season. However, they do overreact when they process the new information, whether it is positive or negative. Other possible justification is that traders overreact when new information confirms or denies previous information, and therefore in the long run, reversals must occur to correct the overreaction of investors, as argued by Daniel, Hirshleifer and Subrahmanyam (1998).

After developing the concept of the momentum factor, Mark Carhart developed the Carhart four factor model. This model builds on the Fama and French three factor model and adds to it the momentum factor. This was developed and published for the first time in 1997. This is based on the premises that Fama and French three factor model does not capture the momentum factor, which is supported by Jegadeesh and Titman (1993 and 2001), as well as Asness, Moskowitz and Pedersen (2013) which go a step further and state that there is presence of a premia related to value and momentum in every asset class. Fama and French (2012) state that there is a premium stocks related to value and momentum, except in Japan, and that these premia are also related with the size factor, having smaller firms a bigger premium than larger firms. However, it has faced some critic, being one of the most supported ideas that the momentum anomaly tends to fade out, and is even related and already captured by the Fama and French three factor model (Fama and French, 1996).

The Carhart four factor model defined as,

$$r_{it} - r_{ft} = \alpha_i + \beta_i(r_m - r_{ft}) + S_iSMB_t + h_iHML_t + m_iMOM_t + \varepsilon_{it} \quad (4)$$

r_{it} – Return of security i during time t

r_{ft} – Return on the risk free asset in time t

α_i – Excess return on the portfolio during time t

β_i – Sensitivity of security i to changes in the market

r_m – Return of the market during time t

S_i – Factor loading on the Size portfolio

SMB_t – Return on the Size portfolio

h_i – Factor loading on the Value portfolio

HML_t – Return on the Value portfolio

m_i – Factor Loading on the Momentum portfolio

MOM_t – Return on the Momentum portfolio

ε_{it} – Specific effect on portfolio

III. Model Specifications

One of the major divisions in the marketplace is between fundamental and technical analysts: fundamental analysts value the operating business of the firm and trade according to its valuation and market value; technical analysts search for trends and patterns, and execute trades based on them. This leads stock prices to levels different to those suggested by the fundamentals of the firms, as suggested by Hong and Stein (1999). The fundamental approach, to value firms and determine expected returns, can be done by employing a discounted cash flows valuation. This is centred in the analysis of the financial statements issued by the firm and in the financial theory of time value of money. However, to do so, one must make several assumptions in order to forecast future cash flows, growth rates, cost of capital and other key indicators required to build the model, being the model highly sensible to the forecasted values.

This paper focuses on three fundamental factors: Earnings Before Interest Taxes Depreciation and Amortization (EBITDA) to Sales, as a proxy of the operational efficiency of the firm and its ability to generate earnings from sales; Cash Flow from Operations (CFO) to Capital Expenditures to measure the firm's ability to invest and create the necessary conditions to obtain a sustainable growth in the future; finally, the Price to Cash Flow from Operations (CFO) will be used in order to pinpoint and identify firms that appear to be cheap, meaning, companies in which one unit of Cash Flow from Operations is cheapest to buy. However, these factors may have different impacts on different stocks and through time as well. Therefore, before constructing the portfolio and determining the trading strategy one must first ensure that the factors are relevant, i.e., that they are statistically significant and influence the returns of all stocks in the time period being analysed.

The Earnings Before Interest Tax Depreciation and Amortization to sales ratio is used as an indicator of the operating efficiency of the firms. This indicator will be used also

to rank the firms according to their operating efficiency as the firms with the highest values are viewed as the best firms to invest, as operating profitability is widely considered to be one of the key drivers of stock returns. As demonstrated in Fama and French (2006) lagged profitability is highly relevant in explaining stock returns for the one year period. Besides this, Chan et al. (2006) have demonstrated that there is a strong positive relationship between earnings, especially of good quality, and stock returns. However their research focus on accruals, the difference between accounting earnings and cash flows. Since EBITDA is a widely accepted proxy for cash flow, it will be used since the present analysis does not focus on the accounting quality of firms but on the predictive power of three fundamental metrics to forecast returns of stocks. Furthermore, EBITDA does not include most of the items under the discretion of managers and accountants, such as depreciation and others. And, when computed as the ratio of EBITDA to sales, it can be seen as a critical indicator of a firm's ability to generate sustainable earnings of good quality.

The Cash Flow from Operation to Capital Expenditures ratio will be used to assess the investment behaviour of firms. This ratio will indicate which firms are able to invest sustainably without compromising the normal cash flows from operations and without creating constraints to the firm's choice of investment projects as well as to its normal operations. The problem associated with overinvestment by firms has been long documented, as Richardson (2006) as demonstrated. For the USA publicly listed companies, there is a wide spread phenomenon of overinvestment, being one of the main conclusions that firms, on average, invest 20 percent more than their available free cash flow. Previously to this, Fairfield, Whisenant and Yohn (2003) concluded that there is a negative correlation between the growth of net operating assets and the returns of firms, when the growth in net operating assets is due to capital expenditures. Furthermore, Titman, Wei and Xie (2004) have demonstrated that investors tend to underreact to announcements of large amounts of capital expenditures, especially when they are viewed as empire building, increasing the firm size, and not increasing the potential value or growth of the firm in the future. Concluding, according to past research, there is a negative relationship between overinvestment by firms and their returns, meaning that firms that are able to invest without compromising both future growth and current efficiency, are deemed more attractive for investors and should earn higher returns.

The price to cash flow ratio, as studied by Fama and French (1993) should be regarded as a proxy for all the components not captured and present in the Fama and French three factor model. Furthermore, this ratio tends to be higher for riskier firms leading to higher expected returns for investors, as investors demand higher risk premiums for holding the stock. Previously, Ball (1978) argues that the Earnings to Price ratio should be used to capture all the factors not present in the model being analysed. Besides this, Basu (1983) has demonstrated that, in the USA market, the Earnings to Price factor is significant in explaining returns of stocks. In this analysis, a more fundamental factor will be evaluated, and thus, less subject to fluctuations and judgment by analysts and accountants. This factor is Price to Cash Flow from Operations, which will allow us to determine the price investors will pay for one unit of the cash flow being generated by the operating entity. The cash flow generated from the operations of the firm is less susceptible to manipulation and judgement by analysts following the firm and the accountants responsible by preparing the firm's financial statements too. This factor will be used to determine which of the different firms being analysed rank in terms of how expensive these cash flows are when compared to the other firms. Building on the work previously mentioned, this factor should also be considered as a proxy that captures all the information not present in the baseline model.

Instead of considering these three fundamental factors on their own in order to explain stock returns, the model builds on the widely accepted Carhart four factor model and augments it by adding the three fundamental factors to the analysis. The reason behind this is that it is widely accepted that the Carhart four factor model captures and takes into account the most pervasive and relevant market inefficiencies. Having this model as a base case or as an indicator of the widely accepted risk and return trade-off, one can use it to better assess the relevance of the factors being studied as well as their statistical and economic significance, their prevalence, accuracy and added value in explaining the cross sectional stock returns.

The model is defined as:

$$r_{it} - r_{ft} = \alpha_i + \beta_i(r_m - r_{ft}) + S_iSMB_t + h_iHML_t + m_iMOM_t + es_iEBITDASALES_t + cc_iCFOCAPEX_t + pcf_iPRICECFO_t + \varepsilon_{it} \quad (5)$$

r_{it} – Return of security i during time t

r_{ft} – Return on the risk free asset in time t

α_i – Excess return on the portfolio during time t

β_i – Sensitivity of security i to changes in the market

r_m – Return of the market during time t

S_i – Factor loading on the Size portfolio

SMB_t – Return on the Size portfolio

h_i – Factor loading on the Value portfolio

HML_t – Return on the Value portfolio

m_i – Factor Loading on the Momentum portfolio

MOM_t – Return on the Momentum portfolio

es_i – Factor Loading on the EBITDA/Sales portfolio

$EBITDASALES_t$ – Sensitivity of the portfolio to changes in the EBITDA/SALES portfolio

cc_i – Factor Loading on the CFO/Capex portfolio

$CFOCAPEX_t$ – Sensitivity of the portfolio to changes in the CFO/CAPEX portfolio

pcf_i – Factor Loading on the PRICE/CFO portfolio

ε_{it} – Specific effect on portfolio

IV. Methodology

The basic premise of this paper is that the factor premia, for each individual stock or portfolio, is assessed using an historical regression analysis. Furthermore, the expected return of each stock will be the sum of the factor exposures, each multiplied by the respective factor premium. The factor premium corresponds to the benefits associated with the factor exposure of the stock and the factor exposure corresponds to the risk, or sensitivity, of a stock to a particular factor.

As previously stated, this paper will focus on the Carhart four factor model as basic risk pricing model, adding to it the three fundamental factors in analysis. To do so, the selected universe to implement this strategy was the firms present in the Stoxx Europe 600, from the 1st of January of 2006 to the 31st of December 2015, comprising 10 years of data. This index represents the 600 biggest firms trading in the European region, including Austria, Belgium, Czech Republic, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, The Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and the United Kingdom. All these securities are quite liquid and possess a high trading volume, and besides this, there are no high transaction costs in the markets being analysed.

After choosing the universe and time period of analysis, data was retrieved using the Datastream application of Thomson Reuters and Worldscope, namely monthly observations of stock prices, market capitalization, market to book value ratio and the return of the market, defined as the Stoxx Europe 600, in order to construct the Carhart four factor model. Using the same methodology, data was retrieved, regarding the fundamental factors, Earnings Before Interest Tax Depreciation and Amortization (EBITDA), sales, cash flow from operations, capital expenditures (Capex) and the price to cash flow ratio. The returns of the stocks are adjusted in order to reflect stock dividends and stocks splits that may have occurred during the period in analysis,

providing a more accurate description of the real returns associated with holding the stock.

The first step is to compute the monthly returns of all the firms present in the Stoxx Europe 600, which will be used as a dependent variable in the regression analysis. Therefore the returns are calculated from the 1st of February of 2006 up to the 1st of January of 2006. Returns are lagged one month in order to assess the power of the variables being analysed, at time t-1, to explain stock returns in time t. In this manner it is assumed that investors have all information available when constructing portfolios.

The returns are computed by using the following formula:

$$r_t = \ln(\text{Price}_t / \text{Price}_{t-1}) \quad (6)$$

r_t – Return of the stock at time t

Price_t – Adjusted price of the stock at time t

Price_{t-1} – Adjusted price of the stock at time t-1

After doing so, the market capitalization figures were obtained from Thomson Reuters Datastream. The book to market ratio is obtained by computing the inverse of the market to book ratio obtained from Thomson Reuters for all firms across time. Following evidence shown by Banz (1981) and by Asness, Moskowitz and Pedersen (2013), using contemporaneously prices in the value portfolio does not change the results significantly, only increases the negative relationship between value and momentum. The momentum portfolio is constructed using the classic methodology of Jegadeesh and Titman (1993) and later of Asness, Moskowitz and Pedersen (2013), by using the sum of the twelve months return of each stock less the return of the immediately previous month, being therefore the sum of the returns of the stock of t-12 to t-1. This is due to the evidence, as previously stated, of short term reversals, specifically the one month reversal, as documented in Jegadeesh and Titman (1993). The last factor exposure in the Carhart four factor model is the market beta. The market return of the Stoxx Europe 600 is computed monthly and adjusted for dividends and stock splits. The risk free rate, this is obtained from the Fama and French database for Europe's risk free rate during the ten years in analysis. After this, it is computed the market return minus the risk free rate for each month. Finally, the monthly market

returns above the risk free rate are then regressed against, as independent variables, against the returns of each individual stock, dependent variable.

As for the fundamental factors, the Earnings Before Interest Tax Depreciation and Amortization (EBITDA) is divided by the sales of each firm, every month. Then the ratio of cash flow from operations to capital expenditures is computed again for every firm, across the time period in analysis. The last factor is the price to cash flow from operations, which is calculated and obtained from Datastream using prevailing market values as well as the cash flow from operations of each firm at each monthly observation. The main drawback of this is that the fundamental variables in analysis only change once a year, in the beginning of the year. However, as the trading strategy is monthly it is necessary to have monthly observations for all factors. Therefore, twelve equal observations are obtained, for every firm, for the fundamental factors as these will interact with factors that change monthly.

After arranging all the data it is required to assess the statistical significance of these factors to explain stock returns, meaning, how all the factors, lagged by one month, at time t-1, explain stock returns at time t. In order to do so, it is used the same methodology as in Fama and MacBeth (1973). This is done in two stages: in the first stage, the return of each firm, at time t, is regressed with all the firm specific factors. These factors include the Carhart four factor model and the three fundamental factors in analysis. This methodology allows for a cross-sectional analysis of all the factors in the analysis, to determine the firm's specific factor betas, or factor loadings, at time t; in the second stage, after doing this regression, for each firm at time period t, this methodology allows for a time-series analysis, meaning, that the same regression is performed for all the periods being analysed.

The regression performed is defined as:

$$r_{it} = \beta_1 MrkCap_{it} + \beta_2 BM_{it} + \beta_3 MoM_{it} + \beta_4 (r_m - r_{ft})_{it} + \beta_5 ES_{it} + \beta_6 CC_{it} + \beta_7 PCF_{it} + \beta_0 + \varepsilon_{it} \quad (7)$$

r_{it} – Return of security i during time t

β_1 – Sensitivity of security i to changes in the Market Capitalization

$MrkCap_{it}$ – Market capitalization of firm i at time t

β_2 – Sensitivity of security i to changes in the Book to Market ratio

BM_{it} – Book to Market ratio of firm i at time t

β_3 – Sensitivity of security i to changes in Momentum

MoM_{it} – 12 month Momentum return of firm i at time t

β_4 – Sensitivity of security i to changes in the Market Beta

$(r_m - r_{ft})_{it}$ – Excess return above the risk free rate of the Stoxx Europe 600 at time t

β_5 – Sensitivity of security i to changes in the EBITDA to Sales ratio

ES_{it} – EBITDA to Sales ratio of firm i at time t

β_6 – Sensitivity of security i to changes in the CFO to Capex ratio

CC_{it} – CFO to Capex ratio of firm i at time t

β_7 – Sensitivity of security i to changes in the Price to CFO ratio

PCF_{it} – Price to CFO ratio of firm i at time t

β_0 – Constant term at time t

ε_{it} – Error term of the regression at time t

The second stage of the Fama and Macbeth regressions consists on testing whether the three fundamental factors in analysis provide statistically significant abnormal risk adjusted returns. Meaning that the returns obtained through investment strategies using these factors compensate more the investor than the compensation investors would expect to earn if they had invested using the Fama and French three factor model. In order to perform the Fama and Macbeth second stage regressions, the returns of the Fama and French three factor model are firstly obtained, for the European market. The returns of the Size, Value and Market Beta portfolio returns are obtained from the Fama and French database for the time period in analysis.

After obtaining the control variables, it is required to construct portfolios which contain all the statistically relevant factors in explaining stock returns. This will be referred as a multi-factor portfolio, which contains only the statistical relevant factors obtained from the first regression of Fama and MacBeth.

The expected returns of each individual stock are then defined as:

$$r_{it} = \beta_1 BM_{it} + \beta_2 Mrkt_{it} + \beta_3 ES_{it} + \beta_4 CC_{it} + \beta_5 PCF_{it} \quad (8)$$

r_{it} – Return of security i during time t

β_1 – Sensitivity of security i to changes in the Book to Market ratio

BM_{it} – Book to Market ratio of firm i at time t

β_2 – Sensitivity of security i to changes in Market Beta

$Mrkt_{it}$ – Excess return above the risk free rate of the Stoxx Europe 600 at time t

β_3 – Sensitivity of security i to changes in the EBITDA to Sales ratio

ES_{it} – EBITDA to Sales ratio of firm i at time t

β_4 – Sensitivity of security i to changes in the CFO to Capex ratio

CC_{it} – CFO to Capex ratio of firm i at time t

β_5 – Sensitivity of security i to changes in the Price to CFO ratio

PCF_{it} – Price to CFO ratio of firm i at time t

After doing so, from the 600 stocks, five quintiles are created where the firms are sorted every month according to their expected returns, from the lowest to the highest. Furthermore, a portfolio consisting on a Long/Short strategy is created. This entails buying the 20% firms with the highest expected returns (fifth quintile) and selling the 20% firms with the lowest expected returns (first quintile). This means that every month, $t-1$, one forms six different portfolios based on the expected returns of each firm, as in equation (8). Using the factor loadings and factor exposures of each firm in the previous month, $t-1$, the same methodology as Fama and French (1992) is applied. Finally, the returns of each portfolio, in excess of the risk free rate (dependent variable), are regressed against the returns of the Fama and French three factor model in the European market (independent variable), to test for the presence of positive alpha or abnormal risk adjusted returns. By running this regression, it will be possible to determine the presence of alpha and the exposure of the different portfolios to the Fama and French three factor model. The exposure to these factors will be tested using the Newey-West test, which takes into consideration autocorrelation and heteroscedasticity.

This will provide a strong statistical evidence on the robustness of alpha and the exposures to the control factors.

V. Results

Table I presents the time series average of each one of the beta coefficients as well as the constant term. Besides this, a t-test is performed to check if each one of the beta coefficients is significantly different from zero, corresponding the value 0 to the null hypothesis that the beta coefficient is equal to zero and the value 1 to the rejection of the null hypothesis, meaning that the beta coefficient is significantly different from zero. Besides this, Table I also displays the p-values and t-statistic values for each one of the estimated coefficients. The t-statistic value is computed as the average beta coefficient divided by the time series standard error. Using a significance level of 5%, the critical values of the t-statistic to reject the Null Hypothesis are -1.96 up to 1.96, and the higher the value, the higher the statistical significance. A common rule of thumb is having a value of two, meaning that the average coefficient is at least twice the standard error. As for the p-value, the critical value, at a 5% significance level, is 0.05.

As one can observe from Table I, the book to market ratio, the market exposure, the constant term and the three fundamental factors, EBITDA to sales, CFO to Capex and price to CFO demonstrate to possess significant statistical power to explain the stock returns in the next time period. This means that the firm specific factors, at t-1, help to explain stock returns observed at time t. These results support the Fama and French factors of market exposure as well as the book to market ratio, as these factors are significantly different from zero and the critical values of both the p-value and the t-statistic allow to confirm this hypothesis.

However, this analysis also demonstrates that the size factor is not a good explanatory variable of stock returns in the next month. Furthermore, the twelve month momentum

factor, as developed by Jegadeesh and Titman (1993), also demonstrates to have low explanatory power, and no statistical significance, in explaining stock returns. These findings corroborate and support the results of Hung, Azad and Fang (2014), where they demonstrate that most of the variables included in the Fama and French three factor model and the momentum factor tend to lose their statistical significance in explaining the cross-sectional stock returns in crisis periods. However they also find that the most pervasive factor, during crisis and non-crisis period,s is the value factor or the book to market ratio. Particularly, O’Keeffe and Gallagher (2014) concluded that in the Irish stock exchange, after the 2008 financial crisis, the strong and pervasive market anomaly, which momentum represents, tended to dissipate, earning insignificant returns driven by a short-selling strategy which was banned in Ireland in 2008.

The variable EBITDA to Sales ratio demonstrates to have an average coefficient of 0.0157 across all the securities in analysis with a t-statistic value of 3.2102, significant at a 1% confidence level. The practical implications of this, is that the ratio is capturing information not captured by the other factors and is a good explanatory variable of stock returns in the next month. The main explanation behind the high average factor exposure and statistical significance of this ratio is that it is widely accepted and used to price securities across many different financial institutions, from banks to hedge funds and asset management firms. Therefore, the information provided by this ratio should be incorporated, at least in part, into stock prices.

The second fundamental factor in analysis, cash flow from operations to capital expenditures, appears to be statistical significant and pervasive. With an average coefficient of 0.0029 across all securities, a t-statistic value of 2.3024 and a p-value significant at a 5% significance level. One of the explanations for the predictive power of this factor is that it is highly regarded when firms incur on capital expenditures and search for funding, both in the equity or debt markets and by investors aiming to assess the ability of firms to embark and fund new projects by its operations. Besides this, the ratio also incorporates significant information regarding future growth of firms, and their ability to grow in a sustainable manner.

The last fundamental factor, price to cash flow, has an average coefficient of almost zero across the six hundred stocks. The low average factor loading is corroborated by the low t-statistic value of 2.0955 and a p-value statistically significant at a 5% confidence level. Despite the low coefficients, the factor is statistically significant and

different from zero. The low value of this coefficient can be explained by the fact that this factor incorporates mainly past information and may become irrelevant to assess future performance. However this factor is significant and captures information not being captured by the other factors. A possible reason behind this result is the fact that this ratio is widely used in practice by many financial institutions to rank and analyse securities. This ratio is also often used as a basis for forecasting future cash flows of firms, reflecting information regarding expectations on future cash flows of firms.

After assessing the statistical significance of all the factors in analysis, due to the low explanatory power of the twelve month Momentum factor and of the Size factor, these will not be taken into consideration when computing expected returns, as in equation (8). Regarding control factors, given the low explanatory of the Momentum factor and that it is considered as an individual market anomaly, it will not be used as a control factor to check for the presence of alpha in the multi-factor strategy. As for the Fama and French three factor model, despite the low statistical significance of the Size factor, these three market anomalies are widely used together, and are perceived to capture different, but complementary, pervasive market anomalies. Therefore, the returns of the Fama and French three factor model strategy in the European market will be used to assess if the multi-factor strategy delivers alpha, or abnormal risk adjusted returns, which are not priced in the Fama and French three factor model. Besides this, it is also worth noting that given the size of the sample, six hundred stocks, with monthly observations, during ten years, makes it a very large sample that tends to dilute the possible effects of market inefficiencies, meaning that even with low average coefficients or t-statistics, the factors being analysed are highly pervasive across the eighteen European stock exchanges present on the sample.

In the second stage of the Fama and Macbeth regressions, the returns earned by each of the six portfolios, in excess of the risk-free rate (dependent variable) are then regressed against the returns of Fama and French returns (independent variable). This is done to check for the presence of alpha and to determine the exposure of the multi-factor strategy to the returns of the Fama and French three factor model.

The model, after the first step of the Fama and MacBeth regressions, is defined as:

$$r_{it} - r_{ft} = \alpha_i + \beta_i(r_m - r_{ft}) + s_iSMB_t + h_iHML_t + \varepsilon_{it} \quad (9)$$

r_{it} – Return of portfolio i during time t

r_{ft} – Return on the risk free asset in time t

α_i – Excess return of portfolio i during time t

β_i – Sensitivity of portfolio i to changes in the excess market return

r_m – Return of the market

s_i – Sensitivity of portfolio i to changes in the Size portfolio

SMB_t – Return of the Size portfolio

h_i – Sensitivity of portfolio i to changes in the Value portfolio

HML_t – Return of the Value portfolio

ε_{it} – Specific effect on portfolio

In Table II it are presented the descriptive statistics of the multi-factor strategy. These include: the average return of the quintiles across the ten years, standard deviation, the annualized Sharpe ratio, the t-statistic value of the returns and the average number of stocks composing each quintile. The most relevant information provided in Table II is the Long/Short strategy, which includes all the factors in analysis, buying the 20% stocks with highest expected returns and short selling the 20% stocks with the lowest expected returns. This strategy is able to deliver an average 0.82% monthly return above the risk free rate with a standard deviation of 3.41%. Besides this, the annualized Sharpe ratio is 0.84. The t-statistic value of 2.64, implies that these returns are statistically significant and are not due to chance.

In Table III are presented the results of the regression analysis of the returns earned by the multi-factor strategy and the coefficient of each of the Fama and French three factor model. When analysing this table it is worth noting that quintiles 2, 3, 4, 5 and the Long/Short strategy provide positive alpha. However, only the Long/Short strategy demonstrates to be able to deliver highly statistically significant alpha. Demonstrating the ability of this strategy to deliver abnormal risk adjusted returns, after accounting for widely accepted systemic risk factors. Besides this, the Long/Short strategy has significant negative exposure to the Size portfolio returns of the Fama and French three factor model. This means that the multi-factor strategy returns move in the opposite direction of the returns of the Size portfolio during the ten years in analysis. The Long/Short strategy also has significant positive exposure to the Value portfolio returns

of the Fama and French three factor model. This entails that the multi-factor strategy returns move in the same direction of the returns of the Value portfolio during the period in analysis. Regarding the Market Beta factor, the multi-factor strategy has a positive exposure to it, although it is not statistically significant. Therefore, one cannot ascertain the relationship between the multi-factor strategy returns to the returns of this portfolio.

One final remark on the findings is the explanatory power of the Fama and French three factor model for the returns of all quintiles included. This means that the control factors have a high explanatory value of the returns of the multi-factor strategy different quintiles. As for the Long/Short strategy, the adjusted R squared of the regression is 52%, meaning that the control factors are able to explain only 52% of the returns of the Long/Short multi-factor strategy. In Table III one can observe the alpha values of the multi-factor strategy when its returns are regressed against the returns of the control factors. It is important to highlight that the alpha values have been corrected for autocorrelation and heteroscedasticity by using the Newey West t-statistic to ascertain their statistical relevance. The main result observed is that the Long/Short strategy is able to deliver a positive alpha, of statistical significance, of 0.99% per month. Figure I presents a graph with the cumulative returns of the multi-factor strategy as if it was applied in reality during the time period in analysis.

VI. Robustness

In order to ascertain the robustness of the findings stated previously, it is applied the same methodology but using the natural logarithm of every factor in analysis. The results obtained from these tests are fairly similar to the ones obtained without the normalization of the variables in analysis. These results confirm the robustness and validity of the present outputs.

Furthermore, it is also conducted an individual analysis to each one of the three fundamental factors in analysis. Results can be observed in Tables IV, V, VI, VII, VIII and IX. This analysis is conducted on the basis of constructing portfolios for each one of the factors in analysis. Meaning constructing portfolios where the only factor in determining the constitution of the portfolio is only the specific factor in analysis, not taking into account any of the other relevant factors in explaining the cross-sectional returns of stocks. This analysis is conducted to check whether the three factors are able to provide individually superior risk adjusted returns, or alpha.

By looking to each factor individually one can observe that all of them, when applying the Long/Short strategy, are able to deliver positive and statistically significant returns and have Sharpe ratios higher than 1. All the three fundamental factors are able to produce statistically significant abnormal returns using the Long/Short strategy, and these alphas are even higher than the alpha provided by the multi-factor strategy. However, when looking at the R squared measure, one can observe that: for the Price to CFO factor, it is fairly high, ranging from 68% to 78%; in the CFO to Capex factor, it ranges from 68% to 74% in the five quintiles, but is only 11% on the Long/Short strategy; and in the EBITDA to Sales factor, it ranges from 70% to 74% in every quintile but is only 53% in the Long/Short strategy. This means that each factor individually is able to produce abnormal risk adjusted returns. However, the way these returns are explained by the Fama and French three factor model differs in each fundamental factor.

VII. Conclusions

The aim of this dissertation is to study some of the most widely accepted market anomalies in explaining the cross-sectional returns of stocks and check the validity and impact of three different fundamental factors. In this paper, statistical evidence of the combined explanatory power of the Fama and French three factor model, the twelve month momentum factor, the EBITDA to sales ratio, the CFO to Capex ratio, and the Price to CFO ratio was provided. When these factors are combined, in order to explain the cross-sectional returns of stocks, it is observed that the Size factor of the Fama and French (1992) three factor model and the twelve month momentum of Jegadeesh and Titman (1993) are not statistically significant factors in explaining stock returns. These results are supported by the findings of Hung, Azad and Fang (2014) that demonstrated that the Fama and French (1992) factors and the Jegadeesh and Titman (1993) momentum factor tend to lose their statistical significance in explaining stock returns in periods of high uncertainty and volatility, such as the prolonged crisis lived in Europe since 2008, resultant of the global financial crisis and the European sovereign debt crisis.

Following these findings, it is found that an equal-weighted Long/Short multi-factor strategy, comprising the above stated relevant factors, provides abnormal risk adjusted returns, or alpha. For the time period in analysis, this strategy earned an average 0.82% monthly above the risk free rate, implying an annualized average return of 10.32% above the risk free rate, an annualized standard deviation of 11.80% and a Sharpe ratio of 0.84.

Further to this analysis, when these excess returns were confronted against the systemic risk factors of the Fama and French three factor model, it is found evidence that these returns are not captured or are due to the systemic risk inherent to the model specific factors. The practical implication of this, is that one could be facing a market anomaly, which cannot be explained by some of the most widely accepted risk factors priced in stock exchanges around the world. Besides this it is concluded that this strategy has a negative exposure to the Size portfolio and a positive exposure to the Value portfolio of

Fama and French. Finally, the strategy designed has a statistically significant alpha, with an average 0.99% alpha value per month.

It is worth noting that this strategy has a clear focus on undervalued firms, high Book to Market ratio, which have good levels of operating profitability, EBITDA to sales ratio, with the ability to invest and create growth opportunities and seize them, CFO to Capex ratio, and with perceived cheap cash flows at the operating level, Price to CFO ratio. The main reasons behind the high explanatory power of these factors and their ability to earn abnormal excess returns could be linked to the extensive prior literature on them. Meaning, as Fama and French (2006) have demonstrated past profitability is highly relevant in explaining stock returns and that especially good quality earnings are related with positive stock returns, findings also supported by Chan et al. (2006). Besides this, the problems related with firms overinvesting and engaging on empire building activities have also been long documented. Richardson (2006) has found that firms invest more than their available cash flows, and Fairfield, Whisenant and Yohn (2003), have found a negative relationship between capital expenditures and stock returns. Finally, Titman, Wei and Xie (2004) found that investors underreact to large capital expenditures announcements, leading to lower returns than expected. Regarding behavioural reasons for the predictive power of these ratios are: the fact that operating profitability is widely used to rank firms by investors; the generalized concept that most of the capital expenditures incurred by firms are empire building activities instead of value adding activities; and that price to earnings ratio, or as in this dissertation, the price to CFO ratio, the most widely used ratio of all three factors, is broadly seen as a proxy of the cheapness or expensiveness of firms and of the expectations of investors regarding the future of firms.

Given that this dissertation focus on fundamental firm specific factors to devise an investment strategy there are probably other explanations for the fundamentals factors in analysis. Furthermore, this dissertation is clearly biased towards a fundamental approach to the traditionally market based Quantitative Equity Portfolio Management models. Thus, further research that helps to explain the market anomalies identified in this paper would be of great value added. Especially in times of high volatility and uncertainty in the European stock exchange markets, where finding fundamentally sound and cheap firms, with good growth prospects, is becoming increasingly more difficult.

VIII. Limitations

Although this study provides a comprehensive study on the Fama and French three factor model, the twelve month momentum factor and the three fundamental factors in analysis, further studies should be conducted. These could comprise a different stock universe, such as the S&P 500, an increased time period, beyond the ten years in analysis, and using yearly observations to provide a better match between stock returns and the fundamental observations. Other relevant topics that could be further studied include: the transaction costs associated with the implementation of this strategy, and how these would impact the statistical significance of the superior risk adjusted returns; the impact of short selling stocks, as in this study it is assumed no limitation or restriction on short selling, as occurred during the 2008 financial crisis and later during the European sovereign debt crisis. In these events, most governments throughout Europe imposed bans on trading and selling short. Further, the costs associated with short selling assets, different portfolio formations, as forming deciles instead of quintiles, and assess how this would impact the trading strategy in analysis, would be relevant topics to consider.

IX. Tables

Table I – Fama and Macbeth regressions output

	SMB	HML	Mom	Market Beta	EBITDA/ Sales	CFO/ Capex	Price/ CF	Constant Term
Average Factor Loading	0.002	0	0.0003	0.0108	0.0157	0.0029	0	0.0001
t-test	0	1	0	1	1	1	1	1
p-value	0.5956	0.0037	0.9128	0.0017	0.0017	0.0183	0.0382	0.0028
t-stat	0.5322	-2.9583	0.1098	3.2102	3.2041	2.3024	2.0955	3.0510

Table II – Descriptive statistics of the monthly multi-factor equal-weight strategy

	Average R - Rf	Standard Deviation	Annual Sharpe Ratio	t-stat	Average Number of Stocks
Q1	-0.0006	0.0497	-0.0412	-0.1302	106
Q2	0.0070	0.0448	0.5379	1.7011	106
Q3	0.0058	0.0519	0.3898	1.2326	106
Q4	0.0072	0.0556	0.4501	1.4235	106
Q5	0.0076	0.0706	0.3743	1.1836	105
LS	0.0082	0.0341	0.8357	2.6428	211

Table III – Fama and French Three Factor model Alpha descriptive statistics for the monthly multi-factor strategy equal-weight strategy

	Average alpha	Market Beta	Size Portfolio	Value Portfolio	Adj Rsquared
Q1	-0.0041	0.7204	0.1625	-0.0941	0.6799
t-stat	-1.4925	9.2497	1.1350	-0.6836	
Q2	0.0036	0.6820	-0.0108	-0.1831	0.7098
t-stat	1.6794	15.2245	-0.1112	-1.6220	
Q3	0.0022	0.7715	-0.0381	-0.1134	0.7133
t-stat	0.8547	12.0339	-0.3214	-0.7765	
Q4	0.0046	0.7484	-0.0197	0.2979	0.7539
t-stat	1.8347	14.1412	-0.1821	2.1717	
Q5	0.0057	0.8144	-0.0731	0.7906	0.7296

t- stat	1.6642	9.7419	-0.5201	3.9292	
LS	0.0099	0.0940	-0.2357	0.8847	0.5223
t- stat	3.5811	1.3768	-2.2651	7.2941	

Table IV – Descriptive statistics of the EBITDA to Sales strategy

	Average R - Rf	Standard Deviation	Annual Sharpe Ratio	t-stat	Average Number of Stocks
Q1	-0.0020	0.0669	-0.1013	-0.3204	106
Q2	0.0054	0.0606	0.3071	0.9710	108
Q3	0.0067	0.0523	0.4423	1.3988	110
Q4	0.0079	0.0462	0.5908	1.8682	110
Q5	0.0080	0.0447	0.6173	1.9522	108
LS	0.0099	0.0295	1.1666	3.6890	214

Table V – Fama and French Three Factor model Alpha descriptive statistics for the EBITDA to Sales strategy

	Average alpha	Market Beta	Size Portfolio	Value Portfolio	Adj Rsquared
Q1	-0.0048	0.8441	0.1622	0.5309	0.7373
t- stat	-1.6534	10.3912	1.1099	2.8984	
Q2	0.0017	0.8543	0.1076	0.1265	0.7319
t- stat	0.6148	12.2698	0.8689	0.7715	
Q3	0.0033	0.7520	0.0294	0.0099	0.7155
t- stat	1.2792	13.3787	0.2306	0.0731	
Q4	0.0052	0.6520	-0.1025	0.0224	0.7010
t- stat	2.2066	11.9699	-0.9958	0.1727	
Q5	0.0054	0.6358	-0.1624	0.0281	0.7209
t- stat	2.3591	12.5016	-1.6447	0.2358	
LS	0.0101	-0.2083	-0.3246	-0.5028	0.5343
t- stat	6.4801	-4.4677	-3.6118	-4.0184	

Table VI – Descriptive statistics of the CFO to Capex strategy

	Average R - Rf	Standard Deviation	Annual Sharpe Ratio	t-stat	Average Number of Stocks
Q1	-0.0012	0.0615	-0.0655	0.2073	106
Q2	0.0039	0.0528	0.2584	0.8173	109
Q3	0.0067	0.0506	0.4570	1.4452	109

Q4	0.0097	0.0499	0.6732	2.1289	109
Q5	0.0072	0.0569	0.4363	1.3796	110
LS	0.0083	0.0182	1.5835	5.0074	216

Table VII – Fama and French Three Factor model Alpha descriptive statistics for the CFO to Capex strategy

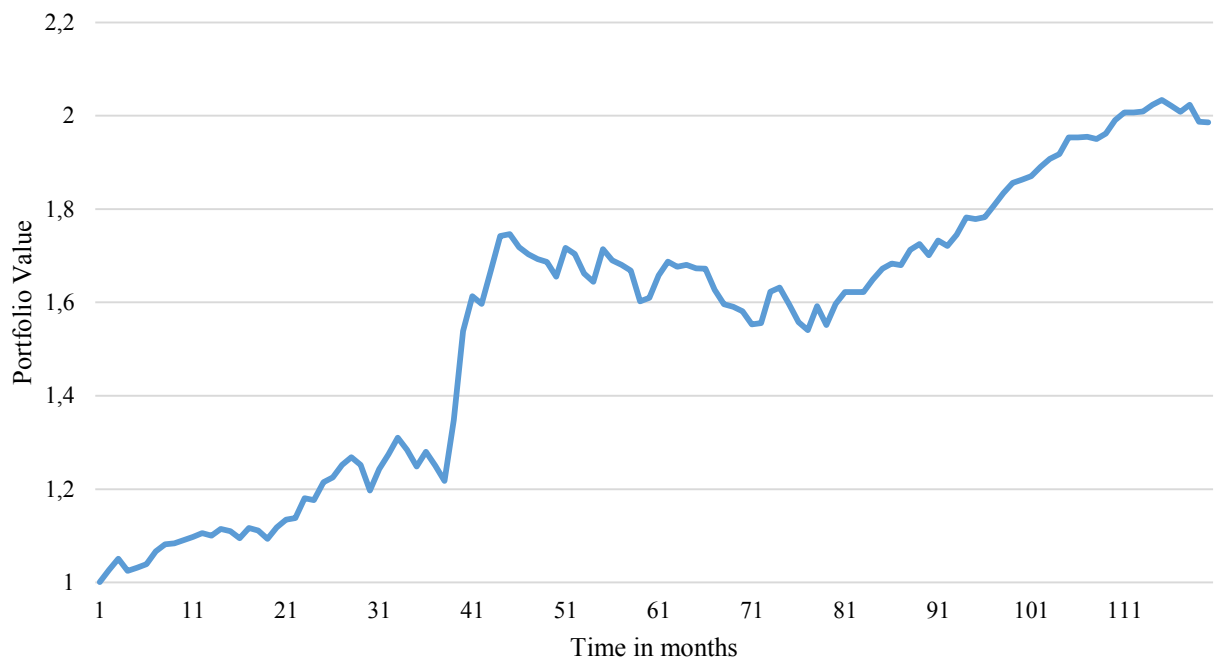
	Average alpha	Market Beta	Size Portfolio	Value Portfolio	Adj Rsquared
Q1	-0.0039	0.7964	0.1455	0.4326	0.7440
t- stat	-1.3278	9.8631	0.9590	2.8658	
Q2	0.0005	0.7724	-0.0291	-0.0061	0.7372
t- stat	0.2266	12.4204	-0.2389	-0.0438	
Q3	0.0033	0.7456	-0.0151	-0.0644	0.7216
t- stat	1.3122	12.6692	-0.1405	-0.4519	
Q4	0.0065	0.7104	0.0151	-0.0283	0.6833
t- stat	2.5467	11.6892	0.1261	-0.1875	
Q5	0.0050	0.7099	-0.0836	0.4362	0.7193
t- stat	1.6991	13.6002	-0.7553	2.9301	
LS	0.0090	-0.0865	-0.2292	0.0036	0.1100
t- stat	4.4255	-1.7113	-2.3841	0.0419	

Table VIII – Descriptive statistics of the Price to CFO strategy

	Average R - Rf	Standard Deviation	Annual Sharpe Ratio	t-stat	Average Number of Stocks
Q1	-0.0075	0.0775	-0.3339	-1.0558	109
Q2	0.0018	0.0556	0.1146	0.3624	111
Q3	0.0072	0.0492	0.5082	1.6071	111
Q4	0.0110	0.0460	0.8277	2.6174	110
Q5	0.0135	0.0456	1.0258	3.2440	110
LS	0.0210	0.0414	1.7535	5.5449	219

Table IX – Fama and French Three Factor model Alpha descriptive statistics for the Price to CFO strategy

	Average alpha	Market Beta	Size Portfolio	Value Portfolio	Adj Rsquared
Q1	-0.0097	0.9223	0.0694	0.9073	0.7791
t- stat	-2.7125	8.3652	0.3528	4.7716	
Q2	-0.0015	0.7843	0.0276	0.0881	0.7211
t- stat	-0.5160	10.9360	0.2165	0.6125	
Q3	0.0040	0.7095	0.0171	-0.0354	0.6989
t- stat	1.6041	14.4582	0.1675	-0.2818	
Q4	0.0078	0.6787	-0.0388	-0.1214	0.6925
t- stat	3.5210	14.7202	-0.3886	-0.9021	
Q5	0.0106	0.6496	-0.0827	-0.0660	0.6703
t- stat	4.5712	13.8001	-0.8873	-0.4332	
LS	0.0203	-0.2727	-0.1521	-0.9733	0.6792
t- stat	8.0828	-3.3923	-1.0180	-7.5474	



X. Figures

Figure I – Cumulative returns of 1€ invested in the equal-weighted Long/Short Multi-Factor strategy

XI. References

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