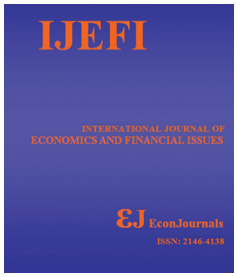

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A Comparative Study of the Fama-French Three Factor and the Carhart Four Factor Models: Empirical Evidence from Morocco

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ABSTRACT

This paper investigates the validity of the Fama-French Three Factor (FF3F) and the Carhart Four Factor (C4F) models in Morocco. Monthly returns of Casablanca Stock Exchange-listed companies are extracted from Reuters DATASTREAM over a 5 years' period (2013-2017). Market, size, value and momentum effect-mimicking exogenous variables are formed and regressed against the returns of size and value-sorted portfolios over a total of 8 multivariate linear regressions. While the size and value effects were found to partially hold, the momentum effect was found to be insignificant. Additionally, the C4F Model did not exhibit a better explanatory power compared to the FF3F Model. It appears that both models cannot be fully relied on in order to predict cross-sections of return in the Casablanca Stock Exchange (CSE), as they both only partially hold in the latter. Ultimately, this study brings value to the existing literature by testing two widely explored asset pricing models in an emerging market where equity research-oriented inquiries are relatively scarce or basic. Even if the models do not fully hold in the Moroccan context, this study posits whether the individual anomalistic factors hold in the CSE, which might be useful for future asset pricing models augmenting endeavors.

Keywords: Capital Asset Pricing Model, Fama-French Three Factor Model, Carhart Four Factor Model, Emerging Market, Casablanca Stock Exchange
JEL Classifications: G3, G24

1. INTRODUCTION

The prediction of cross-sectional sets of returns has always been a source for major discourse among finance professionals and academics. In that scope, many authors have tried to link return and diverse risk factors, with varying degrees of effectiveness. The first serious attempt at doing so famously consists of the Capital Asset Pricing Model (Sharpe, 1964), that provides an intuitive way of linking the expected return on a risk-bearing security and the expected return on the market. Despite being extensively criticized for its unrealistic underlying assumptions, the CAPM is still widely used in both investment and capital budgeting for both its simplicity and its ability to provide an initial framework for decision making.

A cornerstone of modern financial economics, the CAPM has also served as a basis for more advanced asset pricing models. A famous extension of the CAPM, the Fama-French (FF) Three Factor Model (Fama and French, 1993) essentially adds size and value risk factors to the already existing market counterpart. While the model displayed better explanatory power compared to its predecessor, it was proven to fail at capturing diverse significant market anomalies amongst whom accruals (Sloan, 1996), net share issues (Ikenberry et al., 1995; Loughran and Ritter, 1994), volatility (Ang et al., 2006), and most importantly momentum. For that reason, Carhart (1997) notably incorporated a momentum-mimicking risk factor in the FF Three Factor model equation and introduced the Carhart Four Factor Model.

While the robustness of both the FF Three Factor and the Carhart Four Factor models in explaining cross-sections of average stock returns was empirically posited to be better than that of the CAPM, literature seems to be divided on which is better. When it comes to

developed countries, Czapkiewicz and Wójtowicz (2014) contend that the Carhart Four Factor Model has better explanatory power than the FF Three Factor model, in the Warsaw Stock Exchange at the very least. Sakowski et al. (2015) even argues that the four-factor model of Carhart can be quite robust approach for cross-sectional return prediction in most developed markets. When it comes to emerging countries however, Osagie and Osamwonyi (2017) for instance argue that the Carhart Four Factor Model has better predictive power compared to the FF Three Factor counterpart in the Nigerian Stock Market. Shaker and Abdeldayem's (2018) findings suggest the contrary with regards to the Egyptian context. Subsequently, it appears that the validity of both the Fama-French Three Factor and the Carhart Four Factor Models in emerging markets is country-specific. Boamah (2015) argues that the inconsistency of such findings might be related to the characteristics of emerging markets, namely volatility, illiquidity, accounting manipulation, and so on. For that reason, one cannot systematically conclude whether these models can be of use in a specific country, especially in an emerging one, unless they are tested in such context.

In this study, the Fama-French Three Factor and the Carhart Four Factor models are tested in Morocco or more specifically in the Casablanca Stock Exchange, an inefficient market that is illiquid and mostly rumor-driven. First, a review of the existing literature on cross-sectional stock returns prediction is presented in section 2. The study's research objectives and contribution are put forward in section 3. The data and methodology used are described in section 4. Results and practical implications are presented in section 5. Lastly, limitations and recommendations are provided along with a concluding note in section 6.

2. THEORETICAL BACKGROUND

Since its release in 1964, the Capital Asset Pricing Model (CAPM) has been and is still extensively used, studied and criticized within the framework of studying cross-sections of average stock returns. The model, that stems from Markowitz's Modern Portfolio Theory (Sharpe, 1964), essentially suggests that the expected return of an individual asset or portfolio is directly related to what is known as "non-diversifiable" or "systematic" risk, that is a risk that cannot be reduced or eliminated through diversification (Coffie, 2014). However, substantial evidence was found against the validity of the latter. Roll (1977) argues that the model cannot be truly tested because the market portfolio, that constitutes the core of the model, is theoretically and empirically indefinable. Furthermore, literature actually shows that diverse variations in asset and portfolio returns are not captured by the single-period Capital Asset Pricing Model (CAPM) and are therefore due to different factors or parameters (Barry 1998). For instance, Banz (1980) demonstrates that smaller firms — in the New York Stock Exchange — have on average higher risk adjusted returns than larger firms, potentially suggesting a "size" effect. Additionally, Basu (1983) provides evidence that book-to-market equity plays a significant role in explaining U.S. stock returns, suggesting that publicly available Price-to-Book (P/B) ratios are actually holding relevant information content. Leverage is also found to have significant explanatory power with regards to the variations in the average common stock returns in both the U.S and Japan (Bhandari, 1988).

Nonetheless, no model that incorporated some or all of the previously mentioned variables (Size, Price-to-Book ratio, Leverage) existed at that time. Taking that into consideration, one of the first serious attempts at augmenting the classical Capital Asset Pricing Model consists of the Fama-French Three Factor Model (FF3FM). The Fama-French Three Factors Model fundamentally ties the variations in average stock returns with size and value in addition to the systematic risk associated with the CAPM (Fama and French, 1993). It is based on two observations: on one hand, firms with high Book Equity-to-Market Equity ratio are more likely to have low earnings on assets — or equivalently firms with a low Book Equity-to-Market Equity ratio are more likely to have high earnings on asset — (Fama and French, 1993). On the other hand, firms with a small market capitalization tend to have lower earnings on assets than those with a high market capitalization (Fama and French, 1993). These earning patterns are proven to subsist for a minimum of five years before after book-to-market equity and market capitalization are measured. Ultimately, the Fama-French Three Factors Model ties variations in portfolio excess returns to the following three factors: the excess return on the market portfolio, the difference between small-capitalization stocks and big-capitalization stocks portfolios, and the difference between high book-to-market equity stocks and low book-to-market equity stocks portfolios (Fama and French, 1993).

Eventually, the model's validity in explaining cross-sections of average stock returns was heavily tested in literature, especially given the lack of empirical evidence of whether the size and value premium exist in emerging equity markets (Bundoo, 2008). On one hand, Connor and Sehgal (2001) empirically examine the Fama French Three-Factor Model in India and find solid evidence for market, size and book-to-market effects in Indian stock returns. Similarly, Drew and Veeraraghavan (2002) test the model in Malaysia and infer that it holds in the country, explaining returns in an economically meaningful manner. Bundoo (2008) even provides empirical evidence that size and value effects are international in character, being present in Mauritius (an African emerging equity market). Naturally, results from the same author show that the Fama French Three-Factor Model holds in the Mauritian stock exchange. On the other hand, Karp and Vuuren (2017) posits that the model performs poorly because of "the inadequate market proxy measures, market liquidity restrictions, un-priced risk factors and volatility" (Karp and Vuuren, 2017), that are associated to emerging market environments. Similarly, Aguenaou et al. (2011) inspect the model's validity in the Casablanca Stock Exchange (CSE) and find evidence for pervasive market and value risk factors but none for size, which shows that the model does not fully hold in the Moroccan Stock Market. Chowdhury (2017) also finds that, even though positive, the Fama-French Three Factor Model has weak explanatory capacity on stock returns at the Chittagong Stock Exchange (Bangladesh). In fact, even Fama and French (1996) eventually establish that the main drawback of their three-factor model lies in its inability to capture short-term momentum of return. To be more precise, it was found that "strategies which buy stocks that have performed well in the past and sell stocks that have performed poorly in the past generate significant positive returns over 3-12-month holding periods" (Asness, 1995; Jegadeesh and Titman, 1993), which could not be

explained by the three-factors framework. The latter phenomenon was then considered as an anomaly — nay the main anomaly — in the model and was referred to as the "momentum effect." Other anomalies, in this context, were identified in the course of time amongst whom, most notably, accruals (Sloan, 1996), net share issues (Ikenberry et al., 1995; Loughran and Ritter, 1995), and volatility (Ang et al., 2006).

Several researchers attempted to address the latter pitfalls by incorporating or replacing the model's original explanatory variables with others that would capture, to a certain extent, more significant risk factors or effects. For instance, Liu (2006) combines the systematic risk factor and an adjusted number of zero daily trading volumes over a trailing twelve months period as a liquidity factor into a two-factors model in the aim of capturing multiple aspects of liquidity such as trading volume, speed, and costs. The model is tested on NYSE data using a sample covering a period of over 40 years (1963-2003). Results show evidence for a highly significant liquidity premium that is further enhanced after adjusting for the Fama-French three factor model, indicating that liquidity risk/effect holds in the NYSE. Within the same scope, Hearn and Piesse (2008) replace the Fama-French Three Factors Model's value factor with a liquidity one and test it on both the well-regulated and active Johannesburg and Nairobi Stock Exchanges on one hand, and the two fledgling Swaziland and Mozambique Stock Exchanges on the other over the period ranging from 1990 to 1995. In this case however, results show evidence for a highly consistent liquidity risk premium in the larger stock markets, but not in the two smaller counterparts. To be more precise, the authors trace the model's poor results in Swaziland's and Mozambique's Stock Exchanges back to the severity of illiquidity in such markets that remains too extreme for any form of the Fama French Three Factors Model to predict excess returns with any degree of confidence. As such, it remains safe to say that, to a certain extent, illiquidity is one of the most important risk components of asset pricing, especially in emerging markets.

Besides liquidity, researchers obviously attempted to augment the Fama-French Three Factors model with risk factors standing for other potentially significant phenomena. For instance, Pati et al. (2019) incorporates an additional risk factor that accounts for volatility into the standard model and tests it on the Indian stock market over the period ranging from 2008 to 2017. Same as for the size and value factors, the volatility-mimicking factor in this case consists of the difference between the simple average of returns on the two high-sensitivity-to-volatility index innovations portfolios and the average of returns on the two low-sensitivity-to-volatility index innovations portfolios. Ultimately, the study provides a strong evidence for volatility effect. To be more precise, the Indian Stock Exchange's sensitivity to the "volatility index" ends up being a priced risk factor during high volatility periods, but remains insignificant during low volatility periods. Nonetheless, it remains safe to say that the addition of a volatility risk factor did enhance the standard three factors model's explanatory power, especially in this particular case.

Eventually, Fama and French (2016) also attempted to augment their three factor model and ended up designing a Five-Factors Model that adds profitability and investment factors to the initial three. More specifically, the new explanatory variables incorporated are defined the same way the risk factors of the three-factors predecessor were: on one hand, the profitability factor consists of the difference between a high operating profitability portfolio of stocks and a low profitability counterpart (Robust versus Weak). On the other, the investment factor consists of the return of a low-investment portfolio minus a high-investment portfolio (Conservative versus Aggressive). This time, however, Fama and French (2016) mention that the Five-Factor model's main caveat lies in its inability to explain the low average returns on aggressive small-capitalization stocks that exhibit low profitability, which was also the case for its predecessor. The model was tested internationally on 23 countries from four different regions (North-America, Japan, Asia-Pacific, and Europe) over a time period of 26 years (1990 to 2015). Results obtained show significant explanatory power of all five factors on average returns in North American markets, but could not extend this power to other regions (Fama and French, 2017).

Other risk-augmented variants of FF three-factors model rely on momentum. Among those, one of the most notable — if not the most notable — consists of Carhart's (1997) mutual fund performance study. More precisely, the study was designed to investigate whether mutual fund performance did reflect superior stock-picking skill or not. For that reason, Carhart (1997) incorporates a momentum effect-mimicking risk factor to the standard Fama-French Three Factors model under the assumption that mutual fund investors usually follow a survivor bias. Overall, the results obtained indicate that wealth-maximizing mutual fund investors should avoid funds with persistently poor performance, while highlighting the fact that funds with high returns last year have higher-than average expected returns next year, but not systematically in the years thereafter (Carhart, 1997). In this context, Nwani (2015) investigates the robustness of Carhart's Four Factor Model by testing it in the London Stock Exchange, using monthly data of randomly selected stocks over an 18 years period (January 1996-December 2013). Accordingly, a momentum effect-mimicking risk factor that follows the same structure as the size and value effect and consists of the difference between the simple average of returns on two different size winner (i.e., best performers) portfolios and the average of returns on two low different size loser (i.e., worst performers) portfolios is incorporated into the standard three factors model. Results most importantly exhibit significant evidence for a momentum effect in large market capitalization stocks only. A similar study by Czapkiewicz and Wójtowicz (2014) indicates that the momentum effect holds in the Warsaw Stock Exchange, with Carhart's model describing returns variation much better than the three-factor counterpart. It is worth to mention however that these studies were conducted in developed markets.

Concerning emerging markets, literature is divided on the Carhart Four Factor Model's robustness compared to the Fama-French Three Factor counterpart. Osagie and Osamwonyi (2017) argue that size, value and momentum effects are pervasive, and the Carhart Four Factor Model has better explanatory power than the Fama-French Three Factor Model in the Nigerian Stock Exchange. In contrast,

both Boamah (2015) and Shaker and Abdeldayem (2018) contend that adding a momentum factor to the traditional Fama-French Three Factor Model does not yield a noteworthy improvement in the latter's predictive power, when it comes to South-Africa and Egypt respectively. In this context, Boamah (2015) suggests that such results might be attributable to the characteristics of African emerging markets such as, most notably, volatility. Others argue that a possible explanation might be that the underlying momentum strategy in the Carhart Four Factor Model is too simple or basic, among whom Chen, Chun-Da & Demirer, Riza (2017) who posits that a herding-adjusted momentum strategy yields better results than its traditional counterpart in the Taiwan Stock Exchange.

3. RESEARCH OBJECTIVES AND CONTRIBUTION OF THE STUDY

3.1. Research Objectives

While Bundoo (2008) argues that the Fama-French Three Factor Model seems to be international in character, Boamah (2015) and Sakowski et al. (2015) suggest that it might need to be augmented with additional risk factors for emerging markets. As such, it might be of interest for decision makers and finance professionals to test whether the latter holds in the Moroccan context or, in other words, in the Casablanca Stock Exchange as it remains a better alternative to the Capital Asset Pricing Model (Fama and French, 1993). Furthermore, it might be of interest to test Whether Carhart's Four-Factor model yields more power of explanation of average returns than the corresponding FF Three-Factor model. If this test turns out to be positive, the inclusion of momentum – the fourth factor added by Carhart to FF – in investors' strategies could be considered as potentially relevant in the Moroccan equity market.

Hence, this study aims at answering the following research questions:

- Q1: Is there evidence for market, size, value and momentum effects in the Casablanca Stock Exchange during the period under investigation?
- Q2: Do small capitalization stocks outperform big capitalization stocks in the Casablanca Stock Exchange during the period under investigation?
- Q3: Do growth stocks outperform value stocks in the Casablanca Stock Exchange during the period under investigation?
- Q4: Do winner stocks outperform loser stocks in the Casablanca Stock Exchange during the period under investigation?
- Q5: If the first three proposition are true, does the Fama-French Three Factor Model fully hold in the Casablanca Stock Exchange during the period under investigation?
- Q6: If the first four propositions are true, does the Carhart Four Factor Model fully hold in the Casablanca Stock Exchange during the period under investigation?
- Q7: Does the momentum factor bring any addition to the explanatory power of the Fama-French Three Factor Model during the period under investigation?

3.2. Contribution of the Study

This study adds value to the existing literature by testing FF and Carhart's models in the CSE, an important emerging market. The relevance of the study is even greater considering the relative scarcity of similar research in emerging markets, and in relation to the CSE in particular. To the best of our knowledge, Aguenaou et al. (2011) is the only study that addresses the applicability of Three-Factor FF in the Moroccan context. Our work updates the findings of the latter study using more recent data, and adds the comparison with Carhart's momentum-driven model. Furthermore, it could pave the way to deeper analyzes of cross-sectional returns' prediction in the Moroccan equity markets. Besides its contribution to the empirical understanding of the asset pricing dynamics in the Moroccan market, the study provides practitioners (finance professionals and decision makers) with insights useful in developing more accurate asset pricing models.

4. METHODOLOGY

4.1. Data

As per the literature on the Fama-French Three Factors Model (1993) and the Carhart Four Factors Model (1997), the data set under consideration exclusively consists of a five-years period (2013-2017) of monthly data on Moroccan publicly-traded companies listed in the Casablanca Stock Exchange. All relevant data was extracted from the Casablanca Stock Exchange's official website and DATASTREAM.

4.2. Data Adjustment

To avoid any potential type of bias during portfolio construction, companies associated with missing or incomplete data were omitted. Additionally, companies that joined the Casablanca Stock Exchange after the start of the period under consideration or, in other words, after 2013 were also excluded. Lastly, companies that happened to fall on a median during market capitalization, book-to-market or financial performance partitioning were excluded as well. Eventually, while the original sample consisted of 75 Moroccan publicly-traded companies, the final post-adjustment sample consisted of 43 companies only.

4.3. Market Index and Risk-Free Rate

In this study, the Moroccan All Shares Index (MASI) is used as proxy for the market index. It consists of a market capitalization-weighted index, and is eventually preferred over the Moroccan Most Active Shares Index (MADEX) because it engulfs all of the Casablanca Stock Exchange-listed companies' stock. When it comes to the risk-free rate, while the one-month T-bill or government bond rate is usually used, the shortest-term government bond rate available in Morocco consists of the 6 months rate. Accordingly, such rate is retrieved from Bank al-Maghrib's official website and converted to a monthly rate.

4.4. Portfolio Construction

The vast majority of studies devoted to testing FF, Carhart, and similar models follow more or less the same approach in constructing portfolios. In this study, the portfolio construction process is based on Aguenaou et al. (2011) and Nwani (2015)'s methodology.

Step 1. The stocks retained in the sample are first sorted by market capitalization (i), B/M ratio (ii) and monthly returns (iii), respectively.

Step 2. For each sorted list, the underlying stocks are separated into two classes:

(i) Big (B) stocks above the market capitalization median value, and small (S) stocks below it.
(ii) High value (H) stocks above the B/M ratio median value, and low value (L) stocks below it.
(iii) Winner (W) stocks above the monthly return median value, and loser (Lc) stocks below it.

Originally, Fama and French (1996) and Carhart (1997) used the median values for B/M ratio and monthly returns as breaking point to divide their sample firms into three distinct groups, high, medium and low value stocks and winner, neutral and loser stocks, respectively. In this study, the partitioning for value and momentum rather relies on the median to divide the firms into two instead of three groups or, in other words, high value versus low value stocks, and winner stocks versus loser stocks, respectively. The reason behind such choice remains simply associated with the small sample size and the relatively small number of publicly listed companies in the Casablanca Stock Exchange.

Step 3. Eight portfolios are constructed through the intersection of the size classes with the value ones on one hand, and the size classes with the monthly return ones on the other (Table 1).

The resulting portfolios can be described as follows:
S/L portfolio**.** contains small capitalization (S) stocks that are also low value (L) ones.
S/H portfolio. contains small capitalization (S) stocks that are also high value (H) ones.
B/L portfolio. contains big capitalization (B) stocks that are also low value (L) ones.
B/H portfolio. contains big capitalization (B) stocks that are also high value (H) ones.
S/W portfolio. contains small capitalization (S) stocks that are also winner (W) ones.
S/Lc portfolio. contains smalls capitalization (S) stocks that are also loser (Lc) ones.
B/W portfolio. contains big capitalization (B) stocks that are also winner (W) ones.
B/Lc portfolio. contains big capitalization (B) stocks that are also loser (Lc) ones.

4.5. Explanatory Variables

4.5.1. Fama-French three factors model

4.5.1.1. Market factor

The market factor independent variable consists of the MASI index monthly return R_t^M .

4.5.1.2. SMB factor

The Small Minus Big (SMB) factor, that is referred to in literature as the size premium, consists of difference between the monthly returns of an equally-weighted long position on the S/H and B/H portfolio on one hand, and the S/L and B/L portfolios on the other. More specifically, it can be expressed as follows:

$$SMB_t = \frac{1}{2}\left(R_t^{SL} + R_t^{SH}\right) - \frac{1}{2}\left(R_t^{BL} + R_t^{BH}\right) \quad (1)$$

where R_t^{SL} , R_t^{SH} , R_t^{BL} and R_t^{BH} denote the monthly return on portfolio SL, SH, BL and BH, respectively, at time t.

Table 1: Portfolio partitioning summary

Size	Book-to-Market Ratio		Momentum	
	Low (L)	High (H)	Winner (W)	Loser (Lc)
Small (S)	SL	SH	SW	SLc
Big (B)	BL	BH	BW	BLc

4.5.1.3. HML factor

The High Minus Low (HML) factor, that is referred to in literature as the value premium, consists of the difference between the monthly returns of an equally-weighted long position on the S/H and B/H portfolios on one hand, and the S/L and B/L portfolios on the other. More specifically, it can be expressed as follows:

$$HML_t = \frac{1}{2}\left(R_t^{SH} + R_t^{BH}\right) - \frac{1}{2}\left(R_t^{SL} + R_t^{BL}\right) \quad (2)$$

Where R_t^{SH} , R_t^{BH} , R_t^{SL} and R_t^{BL} denote the monthly return on portfolio SH, BH, SL and BL, respectively, at time t.

4.5.2. Carhart four factors model

The Carhart Four Factors Model consists of a momentum-augmented Fama-French Three Factors Model. As such, it comprises all of the previously mentioned explanatory variables, in addition to the WML factor that stands for momentum.

4.5.2.1. WML factor

The Winners Minus Losers (WML) factor, that is referred to in literature as the momentum premium, consists of the difference between difference between the monthly returns of an equally-weighted long position on the S/W and B/W portfolios on one hand, and the S/Lc and B/Lc portfolios on the other. More specifically, it can be expressed as follows:

$$WML_t = \frac{1}{2}\left(R_t^{SW} + R_t^{BW}\right) - \frac{1}{2}\left(R_t^{SLc} + R_t^{BLc}\right) \quad (3)$$

where R_t^{SW} , R_t^{BW} , R_t^{SLc} and R_t^{BLc} denote the monthly return on portfolio SW, BW, SLc and BLc, respectively, at time t.

4.6. Dependent Variables

Based on Aguenaou et al. (2011) and Nwani (2015)'s methodology, the dependent variables consist of the monthly returns of the S/L, S/H, B/L, and B/H portfolios, respectively, for both the Fama-French Three Factor and the Carhart Four Factor Models.

4.7. Statistical Model

4.7.1. Fama-French three factors model

As per Fama and French (1993), the linear regression model is as follows:

$$R_t^p = \alpha + \beta_{MKT} \times R_t^M + \beta_{SMB} \times SMB_t + \beta_{HML} \times HML_t + \varepsilon_t \quad (4)$$

- R_t^p : monthly return of portfolio p, p = {S/L, S/H, B/L, B/H}
- α: intercept.
- β_i: coefficient of factor i, i = { R_t^M , SMB, HML}.
- R_t^M : market factor.
- SMB: size factor.

- HML: value factor.
- ε_t: error term.

4.7.2. Carhart four factor model

As per Carhart (1997), the linear regression model is as follows:

$$R_t^p = \alpha + \beta_{MKT} \times R_t^M + \beta_{SMB} \times SMB_t + \beta_{HML} \times HML_t + \beta_{WML} \times WML_t + \varepsilon \quad (5)$$

- R_t^p : Monthly return of portfolio p, p = {S/L, S/H, B/L, B/H}
- α: intercept.
- β_i: coefficient of factor i, i = { R_t^M , SMB, HML, WML}.
- R_t^M : market factor.
- SMB: size factor.
- HML: value factor.
- WML: momentum factor.
- ε_t Error term.

5. RESULTS AND IMPLICATIONS

5.1. Descriptive Statistics

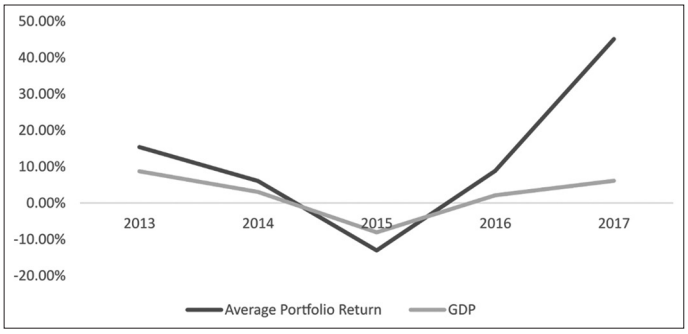
5.1.1. Summary statistics and portfolio returns

All the eight portfolios display a return variation pattern that is more or less similar to that of Morocco's Gross Domestic Product (GDP), as per the graph below (Figure 1). A possible explanation would be that, due to the Casablanca Stock Exchange being a relatively young and growing stock market, coupled with a relatively undeveloped investment culture in Morocco, equity-related transactions are mostly driven by the underlying state of the economy.

*Figure 1 depicts a comparison of the average return on the constructed portfolios and GDP growth in Morocco.

The average monthly return across the six portfolios on its end or, in other words, the average mean monthly return amounts to 1.06%, while the average standard deviation across the six portfolios amounts to 3.70%. The resulting average coefficient of variation (Standard Deviation/Mean) amounts to 347%, which suggests high volatility and potentially an unfavorable risk-to-reward ratio. On a portfolio specific level, while small capitalization stocks do yield higher returns than big capitalization peers, growth stocks turned out to outperform value stocks over the period of interest. As such, while the existence of size effect is suggested, there might not be evidence for value effect. When it comes to the momentum effect however, it appears that, indeed, winner stocks are yielding much better returns than loser peers. On a side note, the higher average return was yielded by the Small Market Capitalization-Winner (SW) portfolio, while the lowest was yielded by the Big Market Capitalization-Loser (BLc) portfolio, which further suggests that the size and momentum effects might hold.

Figure 1: *Portfolio Returns versus Moroccan GDP Growth



The correlation matrix (Table 2 above) shows that the market factor has a very weak, negative correlation with the size factor (-0.004) and the momentum factor (-0.119), and a weak positive correlation with the value factor (0.0951). Furthermore, it shows that the size factor has a moderately weak, negative correlation with the value factor, which partly corroborates Fama and French's (1993) initial findings in which they documented a very weak negative correlation between the latter (-0.08). In this context, the only high correlation documented, however, consists of the positive one between the momentum factor and the value factor (0.4132). One possible explanation for such finding might be that portfolios are adjusted for any kind of size, value or momentum factor-related movement on a yearly basis. Overall, results show that all three risk factors are weakly correlated, which, endorses Fama and French's (1993) model assumptions and, most importantly, implies that there is no evidence for any potential multicollinearity issue.

5.2. Regression Results

Prior to running the regressions, residual analyses and a number of diagnosis tests were conducted and indicated no serious departure from the key assumptions of linear regression. Additionally, data exhibited non-stationarity.

5.2.1. Overall statistical significance of the regression models

Based on the F-tests and P-values (Table 3) obtained, the Fama-French and the Carhart SL, SH and BH regression models are statistically significant.

5.2.2. Statistical significance of the independent variables

Based on the test statistics and P-values in Table 4 the market factor (MKT) is insignificant in both the Fama-French and the Carhart regressions. Similarly, the momentum factor (WML), that is only tested in the Carhart Four Factor Model regressions, is also insignificant through all of it.

In contrast, the size and value effects partially hold. More specifically, the size factor (SMB) only turns out to be significant in the SL and SH regressions, both in the Fama-French and the Carhart regressions. Additionally, the value factor (HML) only turns out to be significant in the SL, SH and BH regressions, again in both the Fama-French and the Carhart regressions.

Looking at the regression intercepts, all of the FF regressions exhibit a positive Jensen's Alpha, meaning that the Fama-French S/L, S/H, B/L, and B/H portfolios have outperformed the market

Table 2: Correlation matrix

	MKT	SMB	HML	WML
MKT	1			
SMB	-0.004	1		
HML	0.0951	-0.1836	1	
WML	-0.119	0.26409	0.4132	1

Table 3: Fama-French Three Factor and Carhart Four Factor Model Regression Models

Models	Fama-French Three Factor Model				Carhart Four Factor Model			
	SL	SH	BL	BH	SL	SH	BL	BH
F-test	18.297	34.519	0.806	5.985	14.149	25.430	0.595	4.856
P-value	2.13E-08	9.11E-13	0.496	0.001	5.3E-08	5.88E-12	0.668	0.002
Significance	Yes	Yes	No	Yes	Yes	Yes	No	Yes

Table 4: Fama-French Three Factor and Carhart Four Factor Model Regression Models Outputs

Portfolios	Fama-French Three Factor Model				Carhart Four Factor Model			
	SL	SH	BL	BH	SL	SH	BL	BH
Coefficients								
Intercept	0.004	0.002	0.002	0.004	-0.001	0.002	0.002	-0.001
MKT	0.227	0.173	0.173	0.227	0.259	0.171	0.171	0.259
SMB	0.824	0.950	-0.050	-0.176	0.760	0.954	-0.046	-0.240
HML	-0.434	1.027	0.027	0.566	-0.554	1.034	0.034	0.446
WML	0.000	0.000	0.000	0.000	0.197	-0.011	-0.011	0.197
t-Stats								
Intercept	0.770	0.440	0.440	0.770	-0.111	0.388	0.388	-0.111
MKT	1.626	1.442	1.442	1.626	1.826	1.388	1.388	1.826
SMB	6.285*	8.432*	-0.441	-1.341	5.359*	7.730*	-0.374	-1.692
HML	-2.457*	6.769*	0.178	3.208*	-2.716*	5.828*	0.189	2.190*
WML	0.000	0.000	0.000	0.000	1.164	-0.074	-0.074	1.164
Regression Statistics								
Multiple R	0.704	0.806	0.203	0.493	0.712	0.806	0.204	0.511
R Square	0.495	0.649	0.041	0.243	0.507	0.649	0.041	0.261
Adjusted R Square	0.468	0.630	-0.010	0.202	0.471	0.624	-0.028	0.207
Observations	60.000	60.000	60.000	60.000	60.000	60.000	60.000	60.000
P-values								
Intercept	0.444	0.662	0.662	0.444	0.912	0.699	0.699	0.912
MKT	0.110	0.155	0.155	0.110	0.073	0.171	0.171	0.073
SMB	0.000*	0.000*	0.661	0.185	0.000*	0.000*	0.710	0.096
HML	0.017*	0.000*	0.859	0.002*	0.009*	0.000*	0.850	0.033*
WML	0.000	0.000	0.000	0.000	0.249	0.942	0.942	0.249

*Statistically significant

benchmark (MKT) during the period under study. Conversely, only the Carhart S/H and B/L regressions exhibit a positive Jensen's Alpha while the remaining exhibit a negative one during the period under study.

To summarize, it appears that there is no evidence for pervasive market and momentum risk factor in the Moroccan stock market during the 2013-2018 period. In contrast, it appears that the size and value effect partially hold in the Moroccan context, during the aforementioned period.

5.3. FF3M versus C4FM

The coefficient of determination (R-square) and the adjusted coefficient of determination (Adjusted R-square) of both the Fama-French and the Carhart regressions are more or less similar (Table 4). The difference in the latter can be considered as marginal. Coupled with the fact that the momentum factor turned out to be insignificant (from both a t-stat and P-value perspective), it appears safe to say that the Carhart Four Factor Model does not add much to the explanatory power of the Fama-French Three Factor Model during the period under study, when it comes to the Casablanca Stock Exchange at the very least.

In comparison with the existing literature, both the size effect and the value effect partially hold in the Casablanca Stock Exchange, which corroborates Aguenaou et al.'s (2011) findings in the Moroccan context. From a global perspective, it also substantiates Connor and Sehgal's (2001), Drew and Veeraraghavan's (2002), Bundoo's (2008) and Karp and Vuuren's (2017) findings in India, Malaysia, Mauritius and South-Africa respectively, which are also emerging countries.

Nonetheless, the findings related to the similarity between the explanatory power of the FF3F and the C4F models go against literature as Czapkiewicz and Wójtowicz (2014), Nwani (2015) and Osagie and Osamwonyi (2017) found significant improvement in explanatory power when incorporating a momentum-mimicking factor, while we did not. For that matter, only few studies agree with our findings amongst whom Boamah (2015) who posits that predictive power of the momentum factor is minimal in the South-African context and Shaker and Abdeldayem (2018) who establish that the momentum factor has no statistical significance at all and argue that the addition of such factor is unnecessary with regards to the Egyptian Stock Market.

5.4. Practical Implications

As mentioned in the previous section, our study's findings only corroborate a part of the existing literature.

Concerning the market factor (MKT), we believe that a possible explanation for it being insignificant throughout all of the FF and Carhart regressions is none other than the market portfolio

not being mean-variance efficient. In other words, demand does not meet supply for some stocks, with some stocks being more active than most others. Another possible explanation might be that a correlation between the portfolios' underlying stocks exists, however, conducting a correlation analysis shows that there is, on average, a weak positive correlation between the stocks listed in the market portfolio, which reinforces our first theory.

When it comes to the Fama-French Three factor model, a possible explanation for the weak explanatory power exhibited in the Casablanca Stock Exchange might be that the latter consists of an inefficient market that is rumor-driven, as it was argued by Chowdhury (2017) for the Chittagong Stock Exchange. Another possible explanation might be that the Moroccan investment culture is characterized by risk aversion. Most notably, such behavior can especially be observed in Moroccan banks whose backing for the development and financial support of start-ups and green entrepreneurs is known to be conservatively selective (El Hamma and Ejbari, 2013). Due to a high degree of risk aversion, Moroccan investors are often more likely to purchase the stocks of high-quality, successful companies that are already established (growth stocks) rather than those of start-ups and companies that need the broader market to recognize their full potential (value stocks), which goes against the Fama-French Three Factor Model assumptions and was hinted through our study's results.

As far as the Carhart Four Factor Model is concerned, we initially believed that, since Moroccans are more likely to invest in Winner stocks rather than Loser ones, the momentum factor should be significant. Surprisingly, it did not turn out to be, during the period under study at the very least. A possible explanation to such a finding might be that portfolios were only sorted according to size and value, and not to other asset characteristics. Another possible explanation might be that the momentum factor is based on behavioural finance arguments, that are relatively harder to perfectly quantify or incorporate in a model that consists of efficient market-based factors. Also, a more elaborate approach to momentum, that would account for additional parameters such as the herding phenomenon, that is key for momentum strategies to succeed, might have yielded different results. For instance, it was found that little to no evidence for the presence of the momentum effect exists in the Taiwan Stock Market, while the latter does however present itself conditional on the level of herding (Riza, 2017).

Ultimately, it appears that both the Fama-French Three Factor Model and the Carhart Four Factor Model cannot be fully relied on in order to predict cross-sections of return in the Casablanca Stock Exchange, for the period extending from 2013-2018.

As such, the answers to our study's research questions can be phrased respectively as follows:

- A1: Yes, there is evidence for size and value effects, but none for market and momentum during the period under investigation in the Casablanca Stock Exchange.
- A2: Yes, small capitalization stocks outperform big capitalization stocks during the period under investigation in the Casablanca Stock Exchange.
- A3: No, growth stocks do not outperform value stocks during the period under investigation in the Casablanca Stock Exchange.
- A4: Yes, winner stocks outperform loser stocks during the period under investigation in the Casablanca Stock Exchange.
- A5: Only the first two propositions are true. Therefore, the Fama-French Three Factor Model only partially hold in the Casablanca Stock Exchange during the period under investigation.
- A6: Only the first, second and fourth propositions hold. Therefore, the Carhart Four Factor Model only partially hold in the Casablanca Stock Exchange, during the period under investigation at the very least.
- A7: Based on the results of our study, the momentum factor does not bring any addition to the explanatory power of the Fama-French Three Factor Model during the period under investigation in the Casablanca Stock Exchange.

6. CONCLUSION

In this study, the Fama-French Three Factor and the Carhart Four Factor Models were tested in the Casablanca Stock Exchange over a 60 months period (2013-2017). Results obtained show that, while the size and value effect partially hold, the momentum effect is insignificant over the period under investigation. Moreover, the Carhart Four Factor Model does not exhibit a better explanatory power compared to the Fama-French Three Factor Model as their R-squared are roughly similar. Based on such findings, it appears that both the Fama-French Three Factor Model and the Carhart Four Factor Model cannot be fully relied on in order to predict cross-sections of return in the Casablanca Stock Exchange (CSE) for the period ranging from 2013 to 2017.

In this context, we believe that the non-value adding incorporation of a momentum factor to the FF Three-Factor model and the relatively weak explanatory power of both models (FF3M and C4FM) might be attributed to sample-specific limitations such as the low sample size and small time frame used, the inefficiency of the Casablanca Stock Exchange, and potentially a number of risk factors that both models fail to capture.

For future research, we recommend trying to adopt a larger sample period along with running Seemingly Unrelated Regressions (SUR) rather than simple linear regressions, even if it means breaching the Fama-French Three Factor and Carhart Four Factor model specifications. We also recommend regressing the Carhart Four Factor Model's independent variables against the B/W, B/Lc, S/W, and S/Lc portfolios' returns to have an additional insight on the existence of the momentum effect in the Casablanca Stock exchange. Furthermore, considering or incorporating other risk-mimicking factors might yield better results, as demonstrated by Taha and Elgiziry (2016) in the Egyptian context. In that regard, we recommend prioritizing some that would be more specific to the Moroccan context, such as liquidity, volatility, accounting manipulation, and potentially more advanced behavioral finance-based risk factors. Lastly, an extension to the MENA region might not only be of value as a way to deal with the previously mentioned low sample size issue, but also a valuable contribution

to the asset pricing literature in the aforementioned region, that is relatively scarce.

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