TESTING MULTIFACTOR ASSET PRICING MODELS IN THE STOCK MARKET

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Abstract

Although the superiority of Fama-French (FF) five-factor model in capturing the United States (US) equity returns, this model performs poorly in other stock markets (Fama & French, 2017). Using the monthly data of nearly 600 Vietnamese published firms from 2008 to 2022, the primary purpose of this paper is to analyze and examine the performance of four famous multifactor asset pricing models: the capital asset pricing model (CAPM), the Carhart four-factor model, and the FF three-factor and five-factor models. We document the preference for the Carhart four-factor model over other models in producing a precise description to Vietnamese stock returns. The CAPM cannot give a reasonable explanation to the variation of Vietnamese stock returns, implying that market risk only accounts for a small proportion of the risk of holding Vietnamese stocks. Furthermore, adding the profitability and investment factors does not improve the explanatory power of asset pricing models in Vietnam, inconsistent with the result reported in the US stock market (Fama & French, 2015, 2020).

Keywords: Capital Asset Pricing Model, Multifactor Models, Expected Returns, Asset Pricing, Stock Market

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1. INTRODUCTION

A primary question in finance is how the expected return of a stock is affected by its risk. To answer this question, Sharpe (1964) develops the capital asset pricing model, which is known as the CAPM. In this model, the expected return of an asset is a linear function of the excess market return, representing the market risk. Although the CAPM is able to explain several anomalies in the United States (US) stock market during 1924–1963, there are many return patterns unexplained by this model (Fama & French, 2004). As a result, numerous researchers and academics have developed new models that more accurately capture the relation between risk and return. Fama and French (1992) prove that stock returns are strongly interacted with the book-to-market ratios (B/M) and market capitalizations. They argued that market capitalizations and B/M ratios should proxy for risk level. Small capitalization and high B/M may imply a high default risk level. Therefore, the CAPM is augmented with the size and value factors, leading to the Fama-French (FF) three-factor model. Carhart (1997) extends the FF three-factor model by adding the momentum factor, knowns as the Carhart four-factor model. Motivated by the dividend discount model of Miller and Modigliani (1961), Fama and French (2015) argue that both the expected profitability and the expected investment of a firm have significant impacts on its expected stock returns. Therefore, they represent the FF five-factor model, in which the expected stock return is a linear function of the risk-free rate, the market excess return, the size, value, profitability, and investment factors. Although the FF five-factor model is success in explaining the monthly stock returns in the US during 1963–2014 (Fama & French, 2015), Fama and French (2017) show that the five-factor models perform poorly on regional portfolios in Europe, Japan, and Asian Pacific.

Following this line of work, emerging market research is still sparse. Far fewer studies report mixed evidence about the application of multifactor asset pricing models (Cakici et al., 2013; Leite et al., 2018; Foye, 2018; Mosoeu & Kodongo, 2022). Well-accepted asset pricing models in developed markets could be challenged in emerging markets with different characteristics and dynamics. Hence, investigating performance of multifactor asset pricing models using emerging market data is crucial to understand the applicability of these models.

This paper aims to test the ability of four well-known models to explain the variations in Vietnamese equity returns. The main research question is:

RQ: Which asset pricing model procedure the best description of expected stock returns in Vietnam?

As an important manufacturing hub in Southeast Asia, Vietnam is one of the fastest developing emerging markets. In 2008, the Vietnam's gross domestic product (GDP) is roughly $90 billion, raking 61st in the world. In 2022, the Vietnam's GDP reaches $400 billion, ranking 40th in the world. The total market capitalization of the Vietnamese equity market is about $250 billion by 2022, with approximately 740 listed companies (Nguyen & Vo, 2023). The number of foreign individual and institutional investors are around 25,000 and 3,200, respectively, compared to about 2,000,000 domestic individual investors and 9,000 domestic institutional investors. There are 40 investment funds with a net asset value of more than $1 billion. Despite the substantial growth of the Vietnamese stock market during the last decade, the literature regarding the application of asset pricing models in Vietnam is sparse. Therefore, this article contributes to the scarce literature by: 1) analyzing and examining the performance of four famous multifactor asset pricing models in Vietnam, and 2) investigating which factors capture the variations of Vietnamese stock returns (that could be applied for other emerging markets in Southeast Asia).

Based on the monthly data of 595 listed firms, we compare four multifactor asset pricing models using the Gibbons, Ross, and Shanken (GRS) test of Gibbons et al. (1989) and three statistics of Fama and French (2017). Redundancy tests of Hou et al. (2019) are also conducted to identify redundant factors. Accordingly, we find that the CAPM cannot produce a reasonable explanation to the variation of Vietnamese stock returns during the sample period. It indicates that market risk only accounts for a small proportion of the risk of holding Vietnamese stocks. We also document that the four-factor model is the best-performing asset pricing model. In Vietnam, momentum is the most powerful factor, perhaps supported by the market and size factors. Due to the herding behavior of individual investors and their overreaction (Vo & Phan, 2019), momentum plays an essential role in affecting stock returns. Meanwhile, the concepts of aggressive and conservative stocks (or robust and weak stocks) are relatively unfamiliar in Vietnam (Nguyen & Nguyen, 2019), making the profitability and investment factors insignificant. These empirical findings lead to two essential contributions of this paper. Firstly, the risk-return relationship in the Vietnamese stock market is better defined, leading to managerial implications for calculation of the cost of equity for not only domestic investors but also more than 28,000 foreign investors. Secondly, the profitability and investment factors contain no incremental information on expected returns relative to the other factors, inconsistent with the results reported in the US stock market (Fama & French, 2015). Hence, a gap remains between developed and emerging equity markets in terms of the risk factors driving expected stock returns, making a fundamental contribution to the literature of asset pricing on Asian emerging markets.

The rest of the paper is structured as follows. Section 2 gives a brief presentation of the literature review. The data sample and methodology are described in Section 3. Next, empirical findings are summarized in Section 4. Discussion and conclusion are drawn in Section 5 and Section 5.

2. LITERATURE REVIEW

In order to determine the risk-return relationship of a financial asset, Sharpe (1964) represents the CAPM, which is considered as the birth of asset pricing. To the present day, the CAPM is widely utilized to evaluate the portfolio performance and the company' cost of equity. In the CAPM, the risk is captured by *beta*. A higher absolute value of *beta* indicates a higher market risk. Although offering a powerful prediction of the relation between the expected return and risk, many return patterns in the US during the post–1963 period are unexplained by the CAPM. Fama and French (1992) prove that stock returns are strongly interacted with the B/M ratios and market capitalizations. During 1963–1990, the cross-sectional returns on the US stocks are analyzed accurately by size and B/M variables. Small capitalization and high B/M may imply a high default risk level. According to Liew and Vassalou (2000), size and the B/M ratio might also capture several aspects of business cycle risk. Therefore, the CAPM is augmented with the size and value factors, leading to the FF three-factor model. A number of studies demonstrate the explaining power of FF three-factor model in developed markets (Fama & French, 1993, 1996, 1998; Griffin, 2002; Walkshausl & Lobe, 2014; Mishra & O'Brien, 2019). However, the FF three-factor model is unable to give a reasonable explanation to several anomalies such as: 1) the low average returns associated with high *beta*, 2) high return volatility, and 3) large share issues (Fama & French, 2017).

Carhart (1997) extends the FF three-factor model by adding the momentum factor. Investigating the stock data in the US between 1962 and 1993, Carhart (1997) declared that the four-factor model seems to be a better model compared to the CAPM and FF three-factor models. Similarly, Fama and French (2012), and Foye (2016) demonstrate that the momentum factor could comparatively enhance the three-factor model. Motivated by the dividend discount model of Miller and Modigliani (1961), Fama and French (2015) develop the FF five-factor model by adding two new factors: the profitability and investment factors. If all other factors remain unchanged, the higher the expected profitability, the higher the expected dividend to shareholders, leading to the higher expected stock returns. Similarly, a lower expected investment indicates a higher expected cash flows for shareholders, increasing expected returns. Fama and French (2020) point out that the FF five-factor model augmented with momentum perform a bit better than the FF five-factor. Replicating the FF five-factor regression in the US during 2006–2018, Chen and Gao (2020) demonstrate the explanatory power of this model. The value factor provides additional impacts in comparison to the investment and profitability factors. Although the FF five-factor model successfully explains the monthly stock returns in the US, several papers offer evidence that it might be incomplete in other stock markets (Fama & French, 2017; Huynh, 2018; Gonález-Sánchez, 2022).

Despite numerous studies on developed markets, far fewer papers examine emerging markets. Based on stock data of 18 emerging markets in three regions — Asia, Latin America, and Eastern Europe — Cakici et al. (2013) point out that the three-factor model performs better than the CAPM. Furthermore, the economic performances across the three- and four-factor models are virtually equal. Later on, a test of the FF five-factor model in these 18 markets is conducted by Foye (2018). Although outperforming the FF three-factor in Latin America and Eastern Europe, the FF five-factor model fails to provide a meaningful improvement over the three-factor model in Asia. Except for the value factor, all factors are redundant. Leite et al. (2018) also investigate 12 emerging stock markets in Asia, Latin America, and Eastern Europe from 2009 to 2017. They document that the four- and five-factor models have much better performance than the three-factor model in most tests. The size factor is the most important factor explaining stock returns, whereas the value factor appears to be somewhat redundant in the presence of profitability and investment factors. Similarly, according to Singh et al. (2023) and Zhou et al. (2022), the FF five-factor outperforms the FF three-factor in India and China. The investment factor has no explanatory power if the profitability is included in the asset pricing model. Mosoeu and Kodongo (2022) state that profitability seems to be the strongest factor in eight emerging markets. Furthermore, the market factor is insignificant for a number of portfolios and the five-factor is rejected using the GRS test. Thalassinos et al. (2023) find that the FF five-factor is better than the FF three-factor for capturing variation Pakistan stock returns.

To the best of our knowledge, there is no empirical research comparing the four famous models (CAPM, FF three-factor, Carhart four-factor, FF five-factor) on the Vietnamese stock market. Quach et al. (2019) examine the performance of the FF three-factor model. Although the market, size, and value factors are statistically and significantly explanatory to the expected returns, they do not fully capture the equity returns. Hence, there are other significant factors affecting the Vietnamese stock returns. Ryan et al. (2021) test the FF five-factor using the Vietnamese stock data between 2007 and 2015. However, this study is conducted for all common stocks, including financial stocks. Due to high financial leverage, financial stocks are excluded in FF multifactor models (Fama & French, 1993). Furthermore, their data sample includes stocks traded in the Unlisted Public Company Market (UPCoM). Most of firms listed in the UPCoM are small-sized companies with a charted capital less than $1 million and manipulated financial statements. As a results, their trading volume is very low, leading to the non-trading bias for asset pricing models[1].

3. DATA AND METHODOLOGY

3.1. Data

Since the paper concentrates on the Vietnamese stock market, firms published in the Hanoi Stock Exchange (HNX) and Ho Chi Minh Stock Exchange (HOSE) are taken into account. As discussed in Section 2, stocks traded in the UPCoM are excluded due to the non-trading bias. Following Fama and French (1993), we remove all financial stocks (commercial banks, insurers, and financial institutions) from the data sample. As suggested by Ince and Porter (2006), we also remove extreme return observations. If the absolute weekly return of a stock is more than 35%, it is also removed from the sample during that week. Sample stocks must not delist or relist over time. Our final sample includes 105 stocks in June 2008 and 595 stocks in June 2022, representing more than 80% of the total market capitalization.

The adjusted monthly stock prices are collected from the Fiin Group, a leading Vietnamese financial information company. They are adjusted for the dividends, stock splits, or similar corporate actions by Fiin Group. Financial statements are also collected from Fiin Group. We omit firms for the specific year that their financial statements are unaudited.

3.2. Construction of factors

To explain stock returns in emerging market, using local factors is better than using the US and global factors (Cakici et al., 2013, Leite et al., 2018). Therefore, the chosen market portfolio is the weighted average of VN-Index and HNX-Index. They are the stock indexes in the HOSE and HNX, implying the variation of all stocks listed in both exchanges. As a result, the weighted average of these indexes is likely to be the reasonable market portfolio. The one-year Vietnamese government bond is considered as the riskless asset. Thanks to being issued by the Vietnamese State Bank, it virtually has no default risk. The market premium (*MKT*) is the market return minus the risk-free rate.

Following Fama and French (2015), the value, profitability, and investments factors are created using portfolios double-sorted on market

[1] According to Damodaran (2012), the non-trading bias arises because the returns in non-trading periods are zero, although the market might move up or down significantly in those periods. Hence, using illiquid stocks might lead to the downward bias in the estimation of their *betas*.

capitalization and the relevant characteristic (B/M, operating profit, and growth in total assets). Firstly, stocks are initially divided as big (small) group based on their market capitalization. Secondly, sample stocks are independently categorized as having high, medium, or low B/M based on the 30th and 70th percentiles. Taking the intersection of two size and three B/M portfolios generates six size-B/M portfolios (*BG*, *BN*, *BV*, *SG*, *SN*, *SV*). Then, the *value factor* (*HML*) is:

$$HML = \frac{BV + SV - BG - SG}{2} \quad (1)$$

The profitability and investment factors are created in a similar fashion. The only difference is that stocks are categorized as having high, medium, or low operating profit or the growth rate in total assets. Taking the intersection of two size and three profitability portfolios generates six size-profitability portfolios (*BR*, *BN*, *BW*, *SR*, *SN*, *SW*). Similarly, we build six portfolios rom the intersection of the two size and three investment portfolios (*BC*, *BN*, *BA*, *SC*, *SN*, *SA*). Then, the *profitability* and *investment factors* (*RMW* and *CMA*) are:

$$RMW = \frac{BR + SR - BW - SW}{2} \quad (2)$$

$$CMA = \frac{BC + SC - BA - SA}{2} \quad (3)$$

The *size factor* (*SMB*) is the return difference between the average returns on the small and big portfolios:

$$SMB = \frac{SG + SN + SV}{3} + \frac{SR + SN + SW}{3} + \frac{SC + SN + SA}{3} - \frac{BG + BN + BV}{3} - \frac{BR + BN + BW}{3} - \frac{BC + BN + BA}{3} \quad (4)$$

As suggested by Carhart (1997) and Fama and French (2012), momentum is also added to the FF three-factor model. The *momentum factor* (*WML*) is built from the intersections of two portfolios formed on market capitalization and three portfolios formed on the past returns (*BW*, *BN*, *BL*, *SW*, *SN*, *SL*):

$$WML = \frac{BW + SW - BL - SL}{2} \quad (5)$$

Table 1. Descriptive statistics for factors

Descriptive statistics	*MKT*	*SMB*	*HML*	*RMW*	*CMA*	*WML*
Mean (%)	0.192	0.262	0.118	0.225	0.183	0.312
Std. dev. (%)	4.287	6.591	5.186	4.353	4.121	4.643
Minimum (%)	-17.52	-18.08	-16.73	-18.75	-19.53	-17.74
Maximum (%)	19.38	24.09	11.631	24.969	19.67	29.671
Skewness	0.523	1.29	1.303	-0.577	-0.254	0.987
Kurtosis	4.94	5.37	3.505	4.887	4.826	4.821

Table 2. Correlations among factors

Factors	*MKT*	*SMB*	*HML*	*RMW*	*CMA*	*WML*
MKT	1	-0.053	0.112	-0.071	-0.185	-0.135
SMB	-	1	0.342	-0.603	0.154	-0.563
HML	-	-	1	-0.384	0.512	-0.428
RMW	-	-	-	1	-0.314	0.619
CMA	-	-	-	-	1	-0.211
WML	-	-	-	-	-	1

Table 1 presents the descriptive statistics of all factors. All factors have a positive mean, indicating a reasonable risk premium. The highest premium belongs to the momentum factor (*WML*), at 0.312% per month; while the monthly value premium (*HML*) is lowest, at only 0.118%. According to Table 2, since the absolute correlations among factors are less than 0.7, there is little evidence of multicollinearity.

3.3. Tests for asset pricing model

To examine the explanatory of four asset pricing models, we use a double-sorted sets of portfolios as testing assets. The double-sorted set is based on size-B/M. We first divide all sample stocks into three portfolios based on their market capitalization using breakpoints at the 33rd and 67th percentiles. Then, each size portfolio is further partitioned into three sub-portfolios based on B/M, leading to nine size-B/M portfolios. Their characteristics are summarized in Table 3.

Table 3. Characteristics of double-sorted portfolios

Size	*Growth*	*Neutral*	*Value*	*Growth*	*Neutral*	*Value*
	Annual average return (%)			*Average B/M*		
Big	-8.87	-4.35	7.51	0.205	0.833	1.266
Medium	-2.24	1.51	12.28	0.398	1.023	1.722
Small	1.05	2.33	16.93	0.704	0.943	2.564
	Average market capitalization ($ million)					
Big	149.47	84.14	57.06			
Medium	74.52	51.62	19.38			
Small	37.29	22.36	8.58			

We run four asset pricing models. The formula of CAPM:

$$R_{it} - R_{ft} = \alpha_i + \beta_i * (R_{mt} - R_{ft}) + \varepsilon_t \quad (6)$$

The FF three-factor model:

$$R_{it} - R_{ft} = \alpha_i + \beta_i * [R_{mt} - R_{ft}] + s_i * SMB_t + h_i * HML_t + \varepsilon_t \quad (7)$$

The Carhart four-factor model:

$$R_{it} - R_{ft} = \alpha_i + \beta_i * [R_{mt} - R_{ft}] + s_i * SMB_t + h_i * HML_t + w_i * WML_t + \varepsilon_t \quad (8)$$

The FF five-factor model:

$$R_{it} - R_{ft} = \alpha_i + \beta_i * [R_{mt} - R_{ft}] + s_i * SMB_t + h_i * HML_t + r_i * RMW_t + c_i * CMA_t + \varepsilon_t \quad (9)$$

where, R_{it} is the return on the testing asset at time t. R_{mt} and R_{ft} are the returns on market portfolio and the riskless rate at time t. SMB_t, HML_t, RMW_t, CMA_t, WML_t are the returns on the size, value, profitability, investment, and momentum factors created in Section 3.1. Regression results are given in Section 4. To compare the performance of four asset pricing models, firstly we estimate the GRS statistic of Gibbons et al. (1989):

$$GRS\ statistic = \frac{\sqrt{1+\widehat{\theta^{*2}}}}{\sqrt{1+\widehat{\theta_p}^2}} - 1 \sim iF(N, iT - N - L) \quad (10)$$

where, $\widehat{\theta^*}$ is the ratio of the maximum excess sample mean return to sample standard deviation and $\widehat{\theta_p}$ is the ratio of average excess return on market portfolio to its standard deviation.

Secondly, three statistics of Fama and French (2017) are also calculated. The first is $A(\alpha_i)$, which is the average absolute value of intercepts. The second is $A\alpha_i^2/A\bar{r}_i^2$, which is the average squared intercept over the average squared value of $\bar{r}_i$. $\bar{r}_i$ is defined as the residual value or the difference between the actual return and the fitted return. The third statistic is the proportion of intercept dispersion attributable to sampling error, $As^2(\alpha_i)/A\alpha_i^2$. $As^2(\alpha_i)$ is defined as the average of the squared sample standard errors of the α_i.

Finally, we run redundant tests by regressing each factor on the other factors as suggested by Hou et al. (2019). A statistically significant intercept indicates the importance of this factor in asset pricing models.

4. RESULTS

4.1. Results of the CAPM

Firstly, we run the CAPM regressions. Results are given in Table 4.

Table 4. Results of the CAPM

Size	*Growth*	*Neutral*	*Value*	*Growth*	*Neutral*	*Value*
		α(%)			*t(α)*	
Big	-0.56***	-0.15	-0.03	-4.312	-1.124	-0.261
Medium	0.31**	0.13	-0.07	2.542	0.621	-0.413
Small	0.03	-0.05	-0.04	0.284	-0.234	-0.265
		β			*t(β)*	
Big	0.103	0.499***	0.480***	0.082	6.911	6.829
Medium	0.286	0.493*	0.502***	1.634	1.824	4.582
Small	0.467***	0.508***	0.503***	6.502	5.302	5.567
		Adjusted R^2				
Big	0.122	0.221	0.219			
Medium	0.156	0.181	0.194			
Small	0.209	0.175	0.182			

*Note: t( ) stands for the t-statistic of the coefficient. ***, **, * imply the significance at the level of 1%, 5%, and 10%, respectively.*

From the statistical view, the CAPM cannot explain the variation of portfolio returns. As shown in Table 4, the market premium is an insignificant explanatory variable with low t-statistics in 3 out of 9 regressions. In an ideal asset pricing model, the intercept is considered as the pricing error, which should be equivalent to zero (Fama & French, 1993). However, the intercept for the Big–Growth is statistically significant, at -0.56% with a high t-statistic of -4.312. The intercept for the Medium-Growth is also significantly different from zero, at 0.31%. More importantly, the CAPM is unable to give a reasonable explanation to portfolio returns. Although the value portfolios generate a substantially higher average return than the neutral (see Table 3), the estimated *betas* for them are nearly the same, at around 0.5. Therefore, *beta* is likely to be an inappropriate risk measurement, which is only able to explain a portion of the value premium. Then, the average adjusted R^2 is 0.184, implying that only 18.4% of the variation of the portfolios' returns is explained by the market risk. In accordance with Fama and French (2004), the reason behind the failure of CAPM might be not to capture the added risk, leading us to the multifactor asset pricing models.

4.2. Results of the Fama-French three-factor model

According to Table 5, the FF three-factor model performs a better job than the CAPM in describing the excess returns of 9 formed portfolios. The average adjusted R^2 is 0.378, double the average adjusted R^2 for the CAPM. At the significance level of 5%, the market, size, and value factors are significant in all regressions. Except for the Big–Growth, intercepts of all regressions are indistinguishable from zero. The FF three-factor also can explain the size and value effects. When we move from the big to the small portfolio, the *SMB* slopes increase. Thanks to a positive mean of *SMB* (see Table 1), higher *SMB* slopes imply higher expected returns for thesmall portfolios. Similarly, the slopes on *HML* rise monotonically from the growth to value portfolios. It is in accordance with Fama and French (1992, 1996, and 2015). Since the *SMB* (*HML*) is designed to capture the difference return behavior between small and big firms (value and growth firms), it should mostly erase the size (value) effect. The average absolute value of intercepts for the FF three-factor model is only 0.11%, dramatically lower than the figure of the CAPM (0.152%). Therefore, adding the *SMB* and *HML* factors into the CAPM leads to a considerable improvement in the explanatory power.

Table 5. Results of the FF three-factor model

Size	*Growth*	*Neutral*	*Value*	*Growth*	*Neutral*	*Value*
		α(%)			*t(α)*	
Big	-0.31*	-0.17	0.02	-1.919	-1.696	0.822
Medium	0.23	0.08	-0.04	1.512	0.412	-0.473
Small	-0.06	-0.07	0.03	0.534	-0.456	0.216
		β			*t(β)*	
Big	0.182***	0.420***	0.416***	4.369	7.159	7.369
Medium	0.316***	0.433***	0.425***	4.835	6.608	6.578
Small	0.379***	0.458***	0.411***	5.612	5.823	4.761
		s			*t(s)*	
Big	0.081**	0.089**	0.120**	2.425	2.525	3.519
Medium	0.106**	0.153***	0.122***	3.216	4.482	5.307
Small	0.128***	0.19***	0.165***	4.435	7.294	4.035
		h			*t(h)*	
Big	-0.359***	0.206***	0.224***	-8.76	6.564	5.13
Medium	0.236***	0.241***	0.315***	6.124	5.648	7.425
Small	0.141***	0.256***	0.489***	5.669	6.656	9.293
		Adjusted R^2				
Big	0.372	0.328	0.325			
Medium	0.356	0.293	0.451			
Small	0.340	0.345	0.599			

*Note: t( ) stands for the t-statistic of the coefficient. ***, **, * imply the significance at the level of 1%, 5%, and 10%, respectively.*

4.3. Results of the Carhart four-factor model

Results of the Carhart four-factor model are given in Table 6. Statistically, the Carhart four-factor model does a better job of pricing stock returns than the FF three-factor model. The average adjusted R^2 of four-factor regressions is 0.383, slightly higher than the figure of three-factor regressions (0.378). According to Table 6, all intercepts are indistinguishable from zero, implying an ideal asset pricing model. The market, size, and value factors are significant in all regressions at the level of 5%. Similar to the FF three-factor, the Carhart four-factor can also provide a plausible explanation for the size and value effects thanks to the *SMB* and *HML* slopes. Furthermore, momentum seems to be a significant factor to Vietnamese stock returns. While small and value portfolios tend to move together with the winner portfolio, the big and growth portfolios tend to move together with the loser. Since the momentum factor generates the highest premium, the Small–Value remarkably outperforms the Big–Growth (see Table 3). In conclusion, adding *WML* factor to FF three-factor model slightly improves the explanatory power of the model.

Table 6. Results of the Carhart four-factor model

Size	*Growth*	*Neutral*	*Value*	*Growth*	*Neutral*	*Value*
		α(%)			*t(α)*	
Big	-0.25	-0.16	-0.03	-1.719	-1.513	-0.617
Medium	0.16	0.05	0.02	1.495	0.752	0.843
Small	-0.06	-0.03	0.05	-0.645	-0.438	1.112
		β			*t(β)*	
Big	0.181***	0.420***	0.419***	4.288	7.263	7.514
Medium	0.308***	0.415***	0.437***	4.632	6.721	7.108
Small	0.379***	0.458***	0.369***	5.112	5.648	4.211
		s			*t(s)*	
Big	0.078**	0.084**	0.108**	2.137	2.236	3.092
Medium	0.095**	0.161***	0.116***	2.958	4.134	4.132
Small	0.12***	0.278***	0.121***	4.208	7.588	3.844
		h			*t(h)*	
Big	-0.313***	0.198***	0.217***	-8.159	6.501	4.794
Medium	0.208***	0.234***	0.296***	5.837	5.217	7.012
Small	0.125***	0.244***	0.451***	5.124	5.932	8.828
		w			*t(w)*	
Big	-0.159***	-0.127**	0.158***	-2.679	-2.377	3.284
Medium	-0.102**	0.138**	0.183***	-2.214	2.184	3.871
Small	0.129**	0.152***	0.263***	2.504	3.134	4.171
		Adjusted R^2				
Big	0.379	0.33	0.329			
Medium	0.358	0.292	0.45			
Small	0.339	0.353	0.612			

*Note: t( ) stands for the t-statistic of the coefficient. ***, **, * imply the significance at the level of 1%, 5%, and 10%, respectively.*

4.4. Results of the Fama-French five-factor model

The results of FF five-factor regressions are summarized in Table 7. The FF five-factor model does not perform better than the four-factor model. The average adjusted R^2 falls dramatically, at only 0.281. Significant intercepts of Big–Growth and Big–Neutral portfolios indicate that the five-factor model cannot fully explain their returns. While the market, size, and value factors are significant in all regressions, the profitability and investment factors are only significant in 3 out of 9 regressions.

Table 7. Results of the FF five-factor model

Size	Growth	Neutral	Value	Growth	Neutral	Value
	α(%)			t(α)		
Big	-0.33**	-0.25**	-0.11	-2.699	-2.002	-0.886
Medium	-0.12	0.04	0.07	-1.243	0.816	0.982
Small	-0.07	-0.03	-0.08	-0.605	-0.478	-2.292
	β			t(β)		
Big	0.181***	0.420***	0.416***	3.381	7.212	7.469
Medium	0.294***	0.388***	0.423***	3.923	5.418	6.492
Small	0.379***	0.458***	0.310***	5.613	4.937	4.904
	s			t(s)		
Big	0.119***	0.089**	0.118**	4.093	2.541	3.467
Medium	0.126**	0.145***	0.124***	3.143	3.924	4.845
Small	0.083**	0.286***	0.111***	2.444	7.208	3.724
	h			t(h)		
Big	-0.369***	0.216***	0.193***	-8.937	7.097	5.504
Medium	0.169***	0.251***	0.308***	5.782	4.892	6.069
Small	0.238***	0.237***	0.479***	5.348	4.944	8.267
	r			t(r)		
Big	-0.089**	-0.034	-0.069	-2.522	-0.791	-1.569
Medium	-0.136	-0.09	0.028	-1.707	-1.095	0.413
Small	0.005	0.103**	0.139**	0.123	2.124	2.679
	c			t(c)		
Big	-0.032	0.094**	0.102**	-0.958	2.278	2.565
Medium	0.102	0.116	0.118	1.463	1.699	1.596
Small	0.043	0.117**	0.051	1.105	2.527	1.442
	Adjusted R^2					
Big	0.174	0.213	0.322			
Medium	0.213	0.261	0.247			
Small	0.256	0.328	0.515			

*Note: t( ) stands for the t-statistic of the coefficient. ***, **, * imply the significance at the level of 1%, 5%, and 10%, respectively.*

4.5. Results of asset pricing tests

In an ideal asset pricing model, the intercept should be indistinguishable from zero in the time-series regression of any asset's excess returns (Fama & French, 2017). Therefore, the GRS statistic of Gibbons et al. (1989) is used to test whether all intercepts jointly equal to zero. The lower the GRS statistic, the better the model. We also estimate three statistics of Fama and French (2017) to compare four asset pricing models. The first is $A(\alpha_i)$, which is the average absolute value of intercepts. Secondly, Fama and French (2017) declared that the lower the value of $A\alpha_i^2/A\bar{r}_i^2$, the better the asset pricing model since its intercept dispersion is low compared to the dispersion of assets' returns. The higher the third statistic of $As^2(\alpha_i)/A\alpha_i^2$, the better the asset pricing model since much of the dispersion of intercepts is sampling error rather than dispersion of the true intercepts (Fama & French, 2017). Estimated statistics are displayed in Table 8.

Table 8. Results of asset pricing tests

Models	GRS statistic	$A(\alpha_i)$(%)*	$A\alpha_i^2/A\bar{r}_i^2$	$As^2(\alpha_i)/A\alpha_i^2$
CAPM	1.531	0.152	0.739	0.273
FF three-factor	1.322	0.112	0.732	0.283
Carhart four-factor	1.267	0.09	0.613	0.341
FF five-factor	1.403	0.122	0.689	0.309

*Note: * Because the value of $A(\alpha_i)$ is extremely small, it is quantified in percentiles.*

Furthermore, we also run redundancy tests to identify significant factors. After regressing each factor on the other factors, we test the significance of the regression' intercept. A significant intercept implies that the factor contains additional information. Results of redundancy tests are shown in Table 9.

Table 9. Results of redundancy tests for six factors

Dependent variables	Intercept (%)	$R_m - R_f$	SMB	HML	RMW	CMA	WML	Adj. R^2
$R_m - R_f$	0.173*	-	-0.906***	0.188**	-0.295**	-0.189**	0.169	0.338
	(1.955)	-	(-6.131)	(2.729)	(-4.015)	(-2.499)	(1.797)	
SMB	0.114**	-0.292***	-	0.133**	-0.101**	0.069	0.214*	0.329
	(2.139)	(-5.92)	-	(3.325)	(-2.515)	(1.541)	(1.929)	
HML	0.132**	0.077**	0.169***	-	-0.654***	0.209***	0.229	0.239
	(2.167)	2.566	(-5.316)	-	(-4.39)	(4.553)	(1.274)	
RMW	0.028	-0.114**	-0.121**	-0.576***	-	0.099*	0.215**	0.468
	(0.468)	(-3.682)	(-2.392)	(-6.011)	-	(1.813)	(2.11)	
CMA	0.037	-0.067**	0.076	0.232***	0.97*	-	-0.185**	0.483
	(0.221)	(-2.248)	(1.569)	(5.317)	(1.94)	-	(-3.243)	
WML	0.163**	0.162**	0.162*	0.057	0.177*	-0.128	-	0.231
	(2.461)	(2.711)	(1.894)	(0.841)	(1.954)	(-1.566)	-	

*Note: ***, **, * imply the significance at the level of 1%, 5%, and 10%, respectively. t-statistics are in brackets.*

5. DISCUSSION

Since the CAPM is found to be invalid for explaining Vietnamese stock returns, adding the size, value, and momentum factors significantly improves the explanatory power of the asset pricing models. However, the profitability and investment factors seem to be irrelevant to Vietnamese stock returns, which contradicts the US market evidence presented by Fama and French (2015). Thus, famous factors with validity and applicability in developed equity markets might be insignificant in emerging markets such as Vietnam. It is in line with the research conducted by Fama and French (2017). They stated that the evidence of the investment factors' explanatory power to the average returns is mixed. Furthermore, the concepts of aggressive and conservative stocks (or robust and weak stocks) are relatively unfamiliar in Vietnam. Most Vietnamese stock companies and investors focus on the price-to-earnings (P/E), the dividend, cash flow and profitability of firms rather than their increase in total assets (Nguyen & Nguyen, 2019). Therefore, the number of institutional and individual investors who have strong investment tilts is very limited. As a result, the profitability and investment factors have little impact on stocks' returns.

According to Table 8, the Carhart four-factor model beats other models in terms of description of average returns. Its GRS statistic is 1.267 with the p-value of 0.312, substantially higher than the significance level of 0.05. Therefore, we accept the null hypothesis that all intercepts are equal to zero or there is no pricing error for the Carhart four-factor model. The smallest average absolute value of intercept belongs to the four-factor model, at only 0.09%. The estimate of $A\alpha_i^2/A\bar{r}_i^2$ for four-factor is lowest, at 0.6134. Thus, in units of return squared, the model fails to explain about 60% of the dispersion of average returns. Its $As^2(\alpha_i)/A\alpha_i^2$ is highest, at 0.3417, implying that one-third of the unexplained dispersion of average returns is sampling error.

As shown in Table 9, intercepts of the size, value, and momentum factors are statistically positive at the level of 5%. The intercept of market factor has a t-statistic of 1.955, indicating that it is marginally significant at the level of 10%. By contrast, intercepts of the profitability and investment factors are insignificant with very low t-statistics. In conclusion, while the market, size, value, and momentum factor appear to be important explanatory variable for Vietnamese stock returns, the profitability and investment factors should not be added to the asset pricing model.

6. CONCLUSION

Although multifactor asset pricing models are extensively investigated in developed markets as well as several emerging markets, to the best of our knowledge, the number of studies examining asset pricing models in Vietnam is limited. As a result, the key objective of this paper is to testing the explanatory power of four competing asset pricing models in the Vietnamese stock market. Empirical results show that the CAPM is unable to give a reasonable explanation to portfolio returns. Only 18.4% of the variation of the portfolios' returns could be attributed to the market risk. In contrast, the FF three- and four-factor models can capture nearly 40% of the dispersion of average returns. These two models also successfully explain the size and value effects. Since the concepts of aggressive/conservative stocks and robust/weak stocks are relatively unfamiliar in Vietnam, adding the profitability and investment factors does not improve the explanatory power of asset pricing models. The average adjusted R^2 falls dramatically, at only 0.281 and the profitability and investment factors seem to be insignificant explanatory variables.

Thanks to the lowest GRS statistic, the Carhart four-factor model beats other models in terms of description of average returns. Three statistics of Fama and French (2017) also document the superiority of the Carhart four-factor model over the FF three-factor and four-factor models in explaining the returns of portfolios. While the market, size, value, and momentum factors are significant factors in describing stock returns, the profitability and investment factors are absorbed by the other factors. Hence, they are redundant in the Vietnamese stock market, inconsistent with the result reported in the US stock market (Fama & French, 2015, 2020). Given these backdrops, the Carhart four-factor model provides the best description of average stock returns. Although the famous FF five-factor proves its power in developed markets, it performs poorly in Vietnam. Hence, to accurately estimate expected returns for Vietnamese stocks, the Carhart four-factor model should be used in future research. Furthermore, future studies on asset pricing models in Vietnam should find other relevant factors instead of the profitability and investment factors.

There are several caveats applying to the findings of this research. The first limitation is the disregard of transaction costs and income taxes. In fact, transaction costs could be considerable, significantly reducing the portfolio's returns. Similarly, the income taxes on the stock dividends and capital gains may also have a great impact on the actual portfolio's return (Nguyen, 2023). Secondly, the chosen market portfolio is also disadvantageous to some extent. In Vietnam, a great deal of fund is placed in the foreign currency (USD), bank deposits or financial derivatives (Doan & Ta, 2023). Thus, the market portfolio should consist not only the stock market indexes but also other financial assets. The final limitation is that the stock market bubble is not taken into account. Since the asset pricing models such as CAPM and multiple-factor models depend on historical data, stock market bubbles may lead to the inappropriate estimation of *betas* and factor' slopes.

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