

Examining the Adaptation of the Fama-French Three-Factor and Five-Factor Models in the US Market

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Abstract. The adaptability of the Fama-French three-factor and five-factor models in distinct markets is currently a key research topic. Some researchers are investigating whether the FF3FM and FF5FM are reasonable frameworks for explaining excess returns in stock markets by testing them with data from different markets. This paper mainly explores the adaptability of FF3FM and FF5FM in the US stock market, and adds CAPM to the comparison. This article uses the daily factors' data and the daily average value weighted returns in 6 portfolios formed on size and book-to-market in the Kenneth French database website to construct a linear regression model to study the explanatory power of FF3FM and FF5FM in the US stock market. In order to determine whether these factors are parts of an effective asset pricing model, this paper assesses the efficacy, robustness, and reliability of factors in explaining asset returns using the Durbin-Watson test, the correlation matrix, and the sub-period analysis, which also confirm whether these factors have statistical significance, economic significance, and stability. It is found that the explanatory power of FF5FM is stronger than that of FF3FM in the US stock market. While both profitability and investment factors have relatively modest explanatory power, size and value factors offer significant explanatory power for stock returns.

Keywords: Fama-French Three Factor Model, Fama-French Five Factor Model, US Stock Market, Linear Regression.

1. Introduction

The belief that there is a positive correlation between risks and returns is generally held by investors. Since modern financial markets have become more sophisticated and more complex financial products have been created, participants in the economy and financial markets have been highly concerned about how to diversify risks and rationalize returns associated with risks. And they have been trying to simulate the market with theories and models, trying to analyze the reasonable relationship between risk and return, and combine these theories with reality to make a reasonable investment portfolio. According to Karp and Vuuren, asset pricing models are useful for evaluating a company's cost of equity, capital budgets, and capital structure decisions from the standpoint of corporate investment [1]. Additionally, they can be used by individual investors to evaluate and decide the composition of their portfolios based on their preferences.

Economists have been focusing on asset pricing models for a long time. Markowitz rejected the classical pricing theory's assumption of a single investor's expectation and proposed a mean-variance theory of asset portfolios based on the theory and reality of asset portfolios [2]. Sharpe and Litner proposed the capital asset pricing model (CAPM) based on this, which in order to maximize investors' utility, the return on a single asset or portfolio of assets was represented by a linearly compositional form of the risk-free return and the risk premium in market equilibrium [3, 4]. Based on the CAPM, the arbitrage pricing theory (APT) was explored by Ross to explain the shortcomings of the risk premium explanation in the CAPM, for example, arbitrage opportunities in the market were ignored [5]. The core idea of the APT was that the expected return of an asset is related to the risk of the asset and that risk was priced through arbitrage opportunities in the market. In addition, a consumption-based CAPM model to link asset returns to macroeconomic variables was explored by Breeden [6].

At the same time, pricing models for derivatives were also evolving by leaps and bounds. Black & Scholes based on the notion that risky assets in the market moved according to geometric Brownian motion and that there were no opportunities for arbitrage in financial markets [7].

Asset pricing models have moved from single-factor models to multi-factor models progressively to increase the models' capacity for explanation and prediction. As an extension of the CAPM, Fama & French created Fama-French Three Factor Model (FF3FM), showcasing three parameters, including excess market returns, a book-to-market or value factor, and a size factor, could be used to anticipate higher returns [8]. Three factors in concert explained most of the returns are due to risk exposure [9]. They discovered that three factors can effectively describe the average return on stocks, as indicated by the regression analysis's intercept, which is close to 0 (Alpha is close to 0). However, FF3FM's logic of modeling size value effects as risk premiums has also met with some objections. Advocates of a behavioral explanation contend that investors' excessive extrapolation of previous portfolio performance into the future was what causes the book-to-market effect [10]. Instead of being the outcome of remuneration for investors who are willing to take on risk, this would result in growth stocks being overpriced and value firms being underpriced [10].

Several studies have found possible differences in the explanatory power of the FF3FM across sample time periods and market capitalization subgroups. The Fama-French Five Factor Model (FF5FM), developed by Fama & French, was enhanced by the addition of a profitability factor and an investment fact to address this problem [11]. Two additional factors explained the change of stock return more comprehensively. These factors can capture differences in corporate profitability and investment behavior. What's more, the model's fit to the actual data was improved, which meant that the model provides a more thorough explanation for the differences in stock returns observed in the market. Similarly, the FF5FM has drawbacks, such as increasing the complexity of the model. This may increase the difficulty and uncertainty of parameter estimation and require more data to verify the validity of the model. Some scholars have proposed similar multifactor models, such as the Hou-Xue-Zhang (HXZ) model, to solve the problem of complexity and parameter estimation.

Among so many models, this paper will focus on FF3FM and FF5FM, with the aim of exploring their adaptability in the American market.

2. Methodology

2.1. Data selection

In this paper, the relevant data are from the Kenneth R. French data library, which is a database website maintained by Kenneth French from the Tuck School of Business at Dartmouth, and it provides data for FF3FM and FF5FM. The data of three factors and five factors in this paper are obtained from the US stock database. In terms of time range, the data of the paper started from September 29, 2000 and ended on September 29, 2023, with a daily frequency, with a recorded total of 5786 factor-related data.

All NASDAQ, AMEX, and NYSE companies are included in $R_m - R_f$. For the period July of year t to June of $t+1$, SMB, HML, RMW, and CMA comprise all NYSE, AMEX, and NASDAQ stocks for which is used market equity data for December of $t-1$ and June of t . What's more, (positive) book equity data are taken for SMB, HML and RMW.

2.2. Modeling

2.2.1. Introduction to the model

Fama and French proposed FF3FM which size and book-to-market ratio significantly affected stock returns based on CAPM [8]. In subsequent empirical studies, researchers found that the three risk factors could not fully explain all excess returns. A five-factor model is expanded by Fama and French inserting an investment and a profit factor to the three-factor model [11].

FF3FM is as follows:

$$R_{it} - R_{Ft} = a_i + b_i(R_{Mt} - R_{Ft}) + s_iSMB_t + h_iHML_t + e_{it} \quad (1)$$

FF5FM is as follows:

$$R_{it} - R_{Ft} = a_i + b_i(R_{Mt} - R_{Ft}) + s_iSMB_t + h_iHML_t + r_iRMW_t + c_iCMA_t + e_{it} \quad (2)$$

‘t’ stands for in the period of t.

R_{it} stands for return on assets and R_{Ft} stands for risk-free return rate; hence $R_{it} - R_{Ft}$ is the excess market return rate.

R_{Mt} stands for the market yield; hence $R_{it} - R_{Ft}$ is the market risk premium.

SMB_t represents the market capitalization size factor and s_i is coefficient of it.

HML_t represents the book-to-market ratio factor and h_i is coefficient of it.

RMW_t represents the profitability factor and r_i is coefficient of it.

CMA_t represents the investment factor and c_i is coefficient of it.

a_i is the intercept and e_{it} is the residual value.

2.2.2. Factor construction

For FF3FM, Table 1 is displayed. First of all, listed firms are categorized into two groups, designated as small (S) and big (B), based on their market value. Next, it is recorded as low (L), medium (M), and high (H) based on the book-to-market ratio of listed businesses at the end of the year, which is sorted equally 33%. Ultimately, a cross portfolio of stocks may be acquired, and a daily averaged weighted returns (weighted by the entire market value) can be computed out as SL, SM, SH, BL, BM, BH.

For FF5FM, still listed companies are categorized into large market value (B) and small market value (S) groups according to the market value, and the quantiles of 30% and 70% of the indicators required for each factor are divided into three groups; Among them, when grouped according to the book-to-market ratio, it can be separated into three groups: high (H), neutral (N) and low (L), and then six groups, BH, BN, BL, SH, SN and SL, can be obtained by crossing. According to profitability, it can be divided into three groups: robust (R), medium (N) and weak (W), and six groups can be obtained by crossing BR, BN, BW, SB, SN and SW. According to the investment attitude, it is divided into three groups: aggressive (A), neural(N) and conservative (C), and six groups can be obtained by crossing over, such as BA, BN, BC, SA, SN and SC. Each period is then calculated. The market value of the portfolio divided by the weighted average logarithmic return rate, and the difference of return rate between the portfolios is finally used as the value of each factor.

Table 1. 2 × 3 Factor Construction Method

Model	Formula
FF3FM	$SMB = (SL + SN + SH)/3 - (BL + BN + BH)/3$
	$HML = (SH + BH)/2 - (SL + BL)/2$
FF5FM	$SMB_{B/M} = (SL + SN + SH)/3 - (BL + BN + BH)/3$
	$SMB_{OP} = (SR + SN + SW)/3 - (BR + BN + BW)/3$
	$SMB_{INV} = (SC + SN + SA)/3 - (BC + BN + BA)/3$
	$SMB = (SMB_{B/M} + SMB_{OP} + SMB_{INV})/3$
	$HML = (SH + BH)/2 - (SL + BL)/2$
	$RMW = (SR + BR)/2 - (SW + BW)/2$
	$CMA = (SC + BC)/2 - (SA + BA)/2$

2.2.3. Testing

Testing the various factors in the FF3FM and FF5FM is to evaluate their effectiveness and reliability in explaining asset returns. The purpose of these tests is to verify whether these factors

have statistical significance, economic significance, and stability, in order to determine whether they are the factors of an effective asset pricing model.

This paper will firstly create a correlation matrix between factors to understand the linear correlation between these factors. The correlation matrix can display the strength and direction of linear relationships between different factors. By observing the magnitude and sign of the correlation coefficient, we can infer whether the factors are highly correlated, negatively correlated, or irrelevant. At the same time, it can detect whether there is multicollinearity between the measurement factors and explain the high correlation between variables, which may lead to the instability of regression results and a decrease in the explanatory power of the model. Moreover, it can evaluate the importance and complementarity of different factors in explaining asset returns, and lower correlations may mean that they provide independent information or complementary predictive power.

Afterwards, the Durbin-Watson test will be performed to check for sequence correlation in the data. The main purpose of DW test is to test whether there is autocorrelation in the residuals of regression models. The value range of DW test is from 0 to 4, and the statistic DW close to 2 indicates that there is no first-order autocorrelation in the residual sequence. When DW is less than 2, it indicates the existence of positive autocorrelation. When DW is greater than 2, it indicates the presence of negative autocorrelation.

Next, the effectiveness of three asset pricing models will be tested, respectively CAPM, FF3FM, and FF5FM. Finally, the sub-period analysis will be used to test the robustness. A more detailed description of the data will be presented in the next section.

3. Empirical Results

3.1. Descriptive Statistics

With Table 2 providing the mean, standard deviation, 25 percentile, 50 percentile (median), 75 percentile, maximum, and minimum for each factor, and Table 3 demonstrating correlations between these factors, these two tables summarize the statistical data for the risk factors built in the models. The market excess return's (MKT) daily mean is 3.46%, as can be shown. In light of this, the average value-weighted market return exceeds the risk-free rate, suggesting that the US stock market has a prosperously rising trend during the setup phase. But because the standard deviation hits a high of 124.94% daily, the trend is highly erratic.

The occurrence known as the size effect in the investment industry describes how smaller companies with a market capitalization than larger organizations tend to have higher long-term average returns. The size factor, SMB, has an average daily return of 0.96%, which is significantly less than the market factor. As a result, US stock average returns tend to decrease as market capitalization increases.

The value effect is defined that stocks with low valuations tend to achieve higher long-term average returns than stocks with high valuations, which investors in the market are generally more likely to overestimate growth stocks and underestimate value stocks. The value factor, HML, has a mean of 0.79% and a standard deviation of 78.23%. This means that value stocks have an average return rate that is somewhat greater than growth stocks', and that there is more volatility in the price differential between value and growth stocks.

For a profitability factor, the mean of RMW is 2.35%, indicating the yield of the robust group is 2.35% higher than that of the weak group and its volatility is 51.57%, which is the second lowest volatility among these factors. For an investment factor, the mean of CMA is 1.11%, indicating the yield of the conservative group is 2.35% higher than that of the aggressive group and its volatility is 43.33%, which is the lowest volatility among these factors. Overall, the standard deviation of these five factors is relatively high, which means that the US market has a high volatility and suffers from risks.

The asset pricing model's correlation matrix is displayed in Table 3. Every factor generally has relationships with other factors. RMW and CMA have a negative correlation and a positive

correlation, respectively, with the SMB. It is well recognized that growth stocks with poor profitability, limited investments, and low B/M are typically small-cap stocks. However, when the size is increasing, more investment will be made, reflecting positive correlation between SMB and CMA. This action may bring more risks, which leads to a decreasing RMW. Furthermore, the positive association shown between HML and RMW suggests that a firm's value increases with its profitability. In addition, CMA is strongly correlated with HML with a correlation of 0.4908, which means higher value of the firm may choose a more conservative investment choice. As can be seen from the coefficient matrix, there is only a slight association between any of the factors and the other factors. In fact, there is very little correlation between MKT and HML or SMB and CMA. The number and duration of the chosen samples could be to blame for this.

Table 2. Summary statistics

variable	mean	std	p25	p50	p75	min	max
MKT	3.46%	124.94%	-48.48%	7.00%	61.40%	-11.99	11.35
SMB	0.96%	61.53%	-35.00%	1.00%	37.00%	-4.55	5.70
HML	0.79%	78.23%	-32.00%	0.00%	32.00%	-5.02	6.73
RMW	2.35%	51.57%	-24.00%	1.00%	28.00%	-3.01	4.20
CMA	1.11%	43.33%	-20.00%	0.00%	21.00%	-5.87	2.46

Table 3. Correlation matrix among the Fama and French five factors

	MKT	SMB	HML	RMW	CMA
MKT	1.0000				
SMB	0.1602	1.0000			
HML	0.0711	0.1801	1.0000		
RMW	-0.348	-0.2249	0.1276	1.0000	
CMA	-0.2545	0.0605	0.4908	0.2673	1.0000

In Table 4, it is clear that most of the values detected by DW testing are less than 2 or close to 2. When DW is less than 2, it indicates the existence of positive autocorrelation, indicating that the observed values are correlated with each other in time, that is, there is a certain linear relationship between adjacent observed values. When DW approaches 2, it indicates that the independent variables in the regression model have been able to explain most of the data variation, and the error term (residual) in the model is basically random, without obvious residual sequence patterns. From Table 4, it can be observed that most values close to 2 appear in FF3FM and FF5FM, indicating a high degree of fit of the model explored in this article.

Table 4. DW testing

Variables	SMALL-LoBM			ME1-BM2		
	(1) CAPM	(2) FF3	(3) FF5	(1) CAPM	(2) FF3	(3) FF5
Durbin-Watson	2.020	1.865	1.913	2.062	1.910	1.918
	SMALL- HiBM			BIG-LoBM		
	(1) CAPM	(2) FF3	(3) FF5	(1) CAPM	(2) FF3	(3) FF5
Durbin-Watson	1.983	2.003	2.005	1.966	1.969	2.012
	ME2-BM2			BIG-HiBM		
	(1) CAPM	(2) FF3	(3) FF5	(1) CAPM	(2) FF3	(3) FF5
Durbin-Watson	1.928	2.048	2.015	1.993	1.899	1.911

3.2. Regression Results

Table 5. Comparison of model performance using 6 portfolios formed on size and book-to-market
(1)

Variables	SMALL-LoBM			ME1-BM2		
	(1) CAPM	(2) FF3	(3) FF5	(1) CAPM	(2) FF3	(3) FF5
MKT	1.1509*** (0.007)	1.0857*** (0.003)	1.0320*** (0.002)	1.0630*** (0.006)	0.9833*** (0.002)	0.9980*** (0.002)
SMB		1.0110*** (0.006)	0.9531*** (0.004)		0.9188*** (0.003)	0.9296*** (0.003)
HML		-0.3250*** (0.004)	-0.2615*** (0.004)		0.1611*** (0.003)	0.1372*** (0.003)
RMW			-0.3393*** (0.006)			0.0663*** (0.004)
CMA			-0.0760*** (0.007)			0.0556*** (0.006)
Constant	-0.0112 (0.009)	-0.0160*** (0.003)	-0.0053** (0.003)	0.0065 (0.008)	-0.0008* (0.002)	-0.0034* (0.002)
Observations	5786	5786	5786	5786	5786	5786
Adj-R ²	0.820	0.974	0.985	0.825	0.989	0.989

Table 6. Comparison of model performance using 6 portfolios formed on size and book-to-market
(2)

Variables	SMALL-HiBM			BIG-LoBM		
	(1) CAPM	(2) FF3	(3) FF5	(1) CAPM	(2) FF3	(3) FF5
MKT	1.0605*** (0.008)	0.9644*** (0.001)	0.9751*** (0.002)	0.9647*** (0.002)	0.9834*** (0.001)	0.9934*** (0.001)
SMB		0.9221*** (0.003)	0.9239*** (0.003)		-0.1064*** (0.003)	-0.0917*** (0.002)
HML		0.5260*** (0.002)	0.5002*** (0.003)		-0.2333*** (0.002)	-0.2398*** (0.002)
RMW			0.0157*** (0.004)			0.0840*** (0.003)
CMA			0.0846*** (0.005)			-0.0140*** (0.004)
Constant	0.0062 (0.010)	-0.0034* (0.002)	-0.0049*** (0.002)	-0.0019 (0.003)	0.0003 (0.001)	-0.0019 (0.001)
Observations	5786	5786	5786	5786	5786	5786
Adj-R ²	0.752	0.992	0.992	0.964	0.991	0.992

Table 7. Comparison of model performance using 6 portfolios formed on size and book-to-market
(3)

Variables	ME2-BM2			BIG-HiBM		
	(1) CAPM	(2) FF3	(3) FF5	(1) CAPM	(2) FF3	(3) FF5
MKT	0.9645*** (0.004)	0.9530*** (0.003)	0.9832*** (0.003)	1.1441*** (0.008)	1.1047*** (0.003)	1.0504*** (0.003)
SMB		-0.0211*** (0.006)	-0.0044 (0.006)		-0.0179*** (0.006)	-0.0628*** (0.006)
HML		0.2956*** (0.004)	0.2385*** (0.005)		0.9157*** (0.005)	0.9984*** (0.005)
RMW			0.1068*** (0.007)			-0.2708*** (0.007)
CMA			0.1554*** (0.009)			-0.1742*** (0.009)
Constant	-0.0035 (0.005)	-0.0052 (0.003)	-0.0102*** (0.003)	-0.0065 (0.010)	-0.0122*** (0.004)	-0.0022 (0.003)
Observations	5786	5786	5786	5786	5786	5786
Adj-R ²	0.923	0.957	0.961	0.775	0.967	0.976

Tables 5, 6, and 7 compare and test the effectiveness of several asset-pricing models. Standard errors in parentheses *** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$. All investable assets are included in the theoretical market portfolio and are weighted based on their market valuations. Samples based on the six portfolios formed on size and book-to-market are examined in this section. A conventional regression analysis is conducted to assess the effectiveness of various asset-pricing models: (1) the Sharpe -Lintner CAPM, and (2) the FF3FM, (3) the FF5FM. All models attempt to link a single factor or a combination of factors to the average value-weighted return of each portfolio, trying to illustrate the extent to which a single factor or a combination of factors can explain the average value-weighted return of a portfolio. For each group of data, the coefficient term of the factor is represented above, the standard error is represented below, and the asterisk represents their significance level.

This purpose of this section is to investigate the key determinants of US stock returns and identify the asset-pricing model that demonstrates the highest effectiveness. The results are presented in Tables 5-7. Formula (1) and (2) refer to the CAPM and the FF3FM. In a regression model, the coefficient of determination (R^2) quantifies the percentage of the variation of the dependent variable that can be predicted or explained by the independent variables. How effectively the independent variables can explain the variation in the dependent variable is indicated by the R^2 value. The six portfolios' adjusted coefficient of determination (Adj- R^2) ranges from 0.752 to 0.964, and all coefficients are significant within the 99% confidence interval. The result suggests that CAPM (MKT) successfully captures the impact of market risk.

The size factor (SMB) and value factor (HML) are two additional factors added to the CAPM by the FF3FM. When SMB and HML are added to the CAPM, the model's ability to explain the return of the portfolio is more robust, as seen by the significant improvement in the adjusted R^2 of all regressions, which reached a level of 0.957 to 0.992 when compared to the regression results of the six portfolios of a single MKT factor shown above. In the FF3FM, all factors (MKT, SMB and HML) are significant at the 0.01 significance level, denoting that FF3FM successfully captures the impact of market, size and value factors.

The applicability of the FF5FM in the US stock market is tested in formula (3). The FF5FM model identified trends in average value weighted returns that were connected to size, value, profitability, and investment, which improved upon the FF3FM model by adding the profitability factors (RMW) and the investment factor (CMA). The adjusted coefficient of determination (Adj- R^2) for the FF3FM slightly improves with the addition of RMW and CMA, rising to a level of 0.961 to 0.992.

With the exception of the SMB component in the Big-Neutral portfolio, all of the variables across all specifications are significant at the 1% level, demonstrating the substantial correlation between market, size, value, profitability, and investment factors and stock returns in the US market.

The three portfolios classified by BM ratio in the small group will be discussed. In low BM groups, negative coefficients may occur, such as HML, RMW, and CMA in FF3FM and FF5FM; But when the BM ratio increases, it can be found that the coefficients of all factors are positive, that is, the impact of factors on excess returns is positive. Most of the data in the small group has strong statistical significance, except for moderate or weak correlation appearing in the constant term, which represents the average values of some omitted variables and the noise present in the model. However, due to the weak correlation, it does not have a significant impact on the accuracy of the model. But this situation changed in the big group. Regardless of the classification of book to market ratio, FF3FM and FF5FM will exhibit varying degrees of negative factor coefficients. However, in the big group, all data is significant and strongly correlated. Except for the R^2 of CAPM, which are mostly between 0.75 and 0.8, the R^2 of FF3FM and FF5FM are above 0.9 and close to 1, indicating a better fit of the data.

In all portfolios, the coefficient estimate value of the MKT factor is positive, which indicate that the average value-weighted return of the portfolios is positively impacted by the market factor, whilst other factors exhibit either positive or negative effects in different portfolios. Overall, these results demonstrate that the traditional asset pricing model captures US stock returns adequately. The model performs slightly better when the profitability factor RMW and the investment factor CMA are included. Compared to traditional models, the FF5FM has a marginally higher explanatory power.

3.3. Sub-Period Analysis

The robustness of the model's performance over time is further examined in this section. It is critical to determine whether the model's success depends on the quantity of observations or a certain time frame. One of the six investment portfolios was randomly selected as the data source for this analysis. The natural year is determined as the period, and the number of trading days in each natural year is displayed in the N column. Regression analyses with a similar approach are replicated on an annual basis. Table 8 displays the Small-Growth portfolio regression results for each year in the sample period. A line graph of the time series for alpha and adjusted R^2 is shown in Fig. 1.

In the FF5FM, the intercept term represents the portion of excess returns that is not explained by factors such as market, size, and value. As shown in Fig. 1, alpha values change over time, with most alpha values fluctuating below 0, meaning that the return on the portfolio is lower than expected, which suggests that the portfolio performed worse than anticipated. The result could also indicate that the portfolio's risk-adjusted return is not meeting the investor's expectations or that the portfolio is underperforming relative to relevant benchmarks or peers.

According to Fig. 1, the adjusted R^2 of the Small-Growth portfolio's regression results in each year fluctuates slightly above 0.97, which is considered relatively stable. The FF5FM has a strong ability to explain the average value weighted returns of the Small-Growth portfolio from September 29, 2000 to September 29, 2023, which means that the US stock market is considered to be significantly impacted by a few specific events, such as the 2008 Financial Tsunami, does not affect the robustness of the FF5FM.

Table 8. Regression results of Small-Growth portfolio for each year in the sample period

Year	MKT	SMB	HML	RMW	CMA	Constant	N	Adj-R ²
2000	1.1637*** (0.042)	1.1483*** (0.057)	-0.2089*** (0.067)	-0.2313*** (0.043)	0.1966*** (0.060)	-0.0574* (0.032)	64	0.990
2001	1.1243*** (0.017)	1.0732*** (0.029)	-0.1031*** (0.030)	-0.3476*** (0.035)	0.0681* (0.040)	-0.0284* (0.015)	248	0.982
2002	1.0606*** (0.013)	0.9228*** (0.027)	-0.1942*** (0.032)	-0.4371*** (0.023)	-0.0730** (0.032)	-0.0256* (0.015)	252	0.982
2003	1.0430*** (0.014)	0.8846*** (0.024)	-0.1950*** (0.036)	-0.3706*** (0.035)	-0.0446 (0.053)	-0.0195* (0.011)	252	0.981
2004	1.0218*** (0.013)	0.9757*** (0.020)	-0.3810*** (0.023)	-0.2230*** (0.029)	-0.0150 (0.039)	-0.0008 (0.007)	252	0.990
2005	1.0240*** (0.012)	0.9211*** (0.017)	-0.3113*** (0.028)	-0.1822*** (0.027)	0.0763* (0.042)	-0.0176*** (0.006)	252	0.990
2006	0.9942*** (0.012)	0.9071*** (0.016)	-0.4050*** (0.029)	-0.1752*** (0.029)	-0.0535 (0.033)	-0.0251*** (0.006)	251	0.993
2007	1.0099*** (0.007)	0.8469*** (0.016)	-0.3610*** (0.023)	-0.1660*** (0.029)	-0.1968*** (0.028)	-0.0170*** (0.006)	251	0.993
2008	1.0329*** (0.006)	0.8763*** (0.014)	-0.1728*** (0.014)	-0.2905*** (0.030)	-0.2882*** (0.032)	-0.0045 (0.013)	253	0.994
2009	1.0278*** (0.011)	0.8381*** (0.018)	-0.1900*** (0.015)	-0.2466*** (0.033)	-0.2093*** (0.038)	0.0004 (0.012)	252	0.991
2010	0.9695*** (0.011)	0.8762*** (0.017)	-0.3384*** (0.022)	-0.3462*** (0.031)	0.0967** (0.040)	-0.0113 (0.008)	252	0.992
2011	1.0265*** (0.009)	0.8966*** (0.017)	-0.3619*** (0.022)	-0.3566*** (0.034)	-0.1299*** (0.035)	0.0005 (0.008)	252	0.996
2012	1.0427*** (0.013)	0.9362*** (0.022)	-0.3978*** (0.029)	-0.3289*** (0.038)	-0.0221 (0.041)	0.0017 (0.008)	250	0.986
2013	1.0242*** (0.013)	0.9184*** (0.022)	-0.4269*** (0.031)	-0.4698*** (0.040)	0.0374 (0.045)	-0.0005 (0.008)	252	0.983
2014	1.0097*** (0.011)	0.9453*** (0.017)	-0.5979*** (0.028)	-0.4581*** (0.031)	0.1445*** (0.053)	0.0015 (0.008)	252	0.990
2015	1.0604*** (0.009)	1.0037*** (0.018)	-0.5099*** (0.021)	-0.4426*** (0.031)	-0.1187*** (0.042)	-0.0103 (0.008)	252	0.990
2016	1.0594*** (0.015)	1.0348*** (0.021)	-0.4120*** (0.024)	-0.4676*** (0.031)	-0.1315*** (0.038)	-0.0117 (0.011)	252	0.984
2017	1.0371*** (0.022)	0.9379*** (0.022)	-0.4021*** (0.021)	-0.3408*** (0.031)	-0.0886*** (0.032)	0.0067 (0.009)	251	0.972
2018	1.0154*** (0.010)	0.9678*** (0.019)	-0.3088*** (0.022)	-0.2948*** (0.027)	-0.1501*** (0.034)	-0.0095 (0.010)	251	0.987
2019	1.0516*** (0.013)	1.0251*** (0.020)	-0.3421*** (0.020)	-0.3583*** (0.030)	-0.0141 (0.041)	-0.0025 (0.009)	252	0.985
2020	1.0380*** (0.009)	0.9827*** (0.022)	-0.2490*** (0.018)	-0.4184*** (0.037)	-0.1400*** (0.047)	0.0339* (0.017)	253	0.988
2021	1.0044*** (0.015)	0.9878*** (0.020)	-0.2781*** (0.017)	-0.3907*** (0.024)	-0.0816** (0.033)	-0.0049 (0.012)	252	0.986
2022	0.9963*** (0.010)	1.0210*** (0.027)	-0.3039*** (0.021)	-0.3745*** (0.020)	-0.1160*** (0.031)	0.0259** (0.013)	251	0.992
2023	0.9930*** (0.018)	1.0251*** (0.024)	-0.2670*** (0.024)	-0.4080*** (0.031)	0.0745* (0.040)	-0.0270** (0.013)	187	0.983

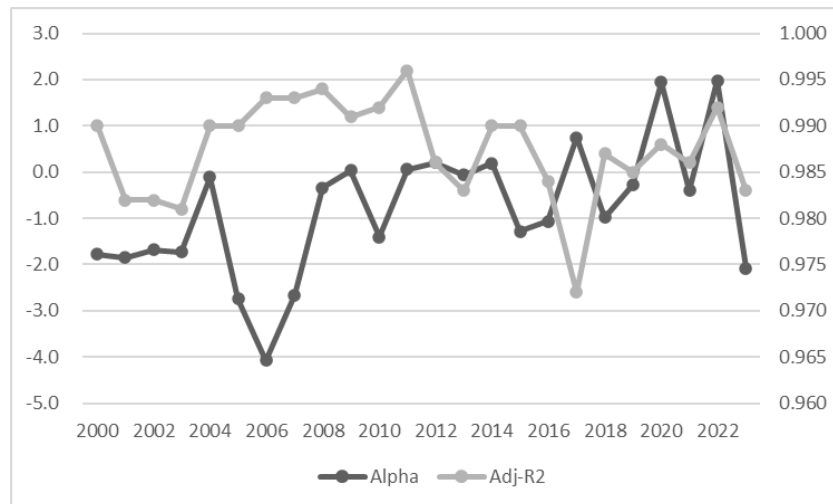


Figure 1. Time Series of Adj-R² and Alpha during the sample period (Photo/Picture credit: Original)

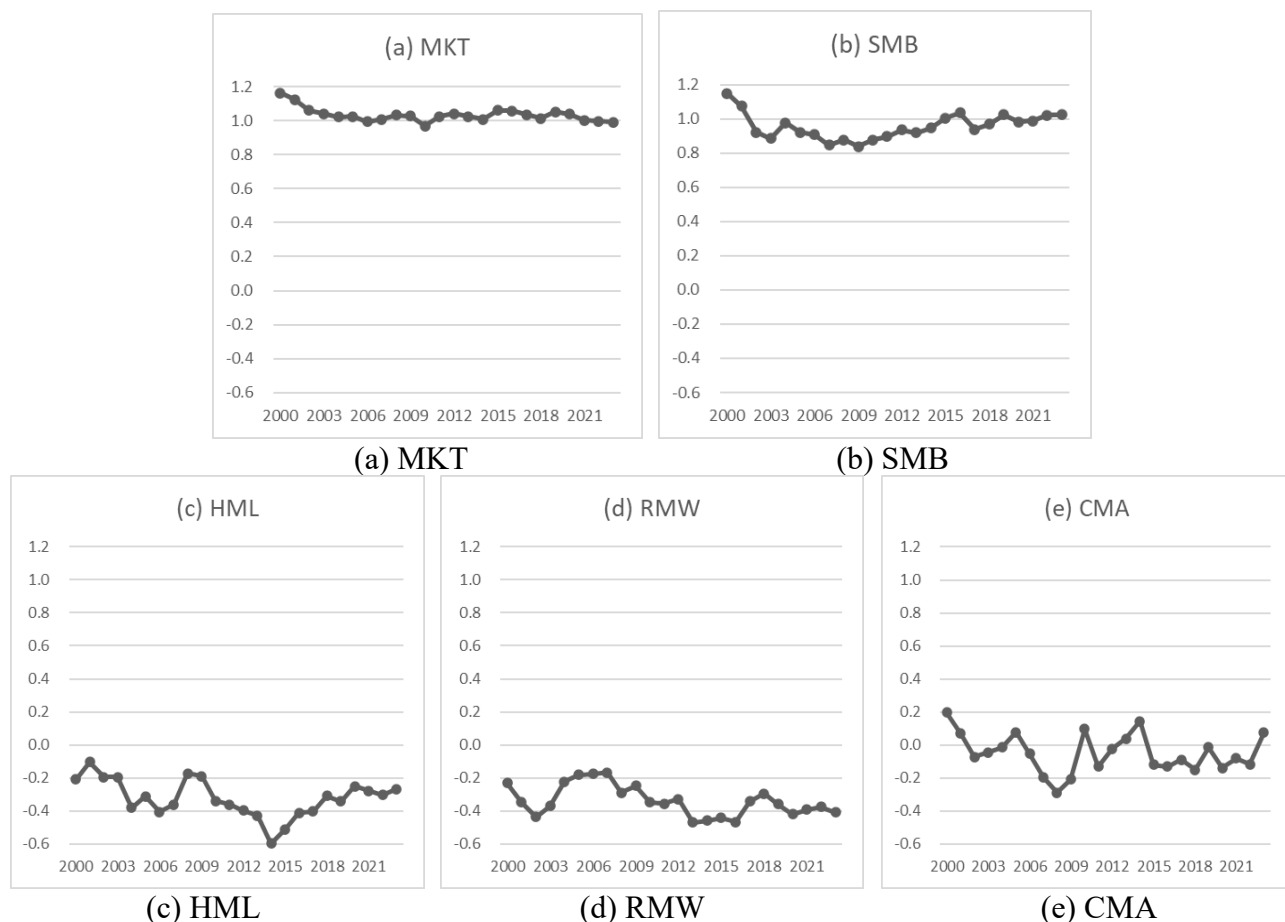


Figure 2. Time series of asset pricing factor coefficients during the sample period (Photo/Picture credit: Original)

Fig. 2 shows the dynamics of these factor coefficients. It can be easily observed from the line charts that the influence of market and size factor, known as MKT and SMB, are relatively stable. The coefficient on value factor (HML) and profitability factor (RMW) are generally negative. Demonstrating that the portfolio's performance has been worse to those of firms with low book-to-market ratios (growth stocks) and low operating profitability when owning value stocks with high book-to-market ratios. The investment factor (CMA) coefficients' sign fluctuates around 0. Overall, these patterns validate the empirical results.

4. Conclusion

This study assesses the effectiveness of traditional asset pricing models, including the CAPM, the FF3FM, and the FF5FM, with a specific focus on the US stock market. Overall, the FF3FM outperforms the CAPM model in the US stock market, and the FF5FM outperforms the FF3FM. The model performs significantly better with the value and size factor added, suggesting that both parameters have additional explanatory power for stock returns. However, after including investment and profitability parameters in the model, the performance slightly improved, indicating that these two factors have explanatory power on stock returns, but their explanatory power is not strong. Period analysis shows that there is a slight variation in the FF5FM's explanatory power over time.

This paper has examined the adaptation of the FF3FM and FF5FM in the US stock market through 6 types of portfolios. However, due to a number of limitations of the study, many questions remain unanswered. The daily average value weighted returns of 6 portfolios from September 29, 2000 to September 29, 2023 is used in this paper, which does not fully represent the actual situation of the US stock market, so the results may be biased. Moreover, this paper used a method of randomly selecting one of six investment portfolios to conduct sub-period analysis, the results cannot represent the true situation of all investment portfolios, so the universality of the sub-period test has yet to be verified. Therefore, research on FF3FM and FF5FM based on returns that fully represent the US market would be interesting topics.

Authors Contribution

All the authors contributed equally and their names were listed in alphabetical order.

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