Proceedings of the 7th International Conference on Economic Management and Green Development
DOI: 10.54254/2754-1169/37/20231845

An Empirical Research of Asset Pricing Models in the US Market under COVID-19

Fujia Sun [1,a,*]

[1]*College of Literature, Science and the Arts, University of Michigan, Ann Arbor 48109, USA*
a. grayi@umich.edu
**corresponding author*

Abstract: Asset pricing theory has been a key area of research in finance. Since the introduction of CAPM, asset pricing models have been very widely used. Re-searchers have discovered many phenomena that cannot be explained by the CAPM model, so they have made many refinements to the asset pricing model and developed various improved versions that can better explain stock returns. The Fama and French three-factor model (FFTFM) and the five-factor model (FFFFM) are two of the most classic and most used asset pricing models. However, as time goes by and financial markets continue to evolve, many scholars have questioned whether traditional asset pricing models are still valid. Starting from the theoretical explanation of CAPM, FFTFM, and FFFFM factor selection, this paper uses the stock market data from 2000 to March 2023 to divide stocks into six portfolios based on their size and book value and conduct regressions according to the above three models respectively to evaluate and compare the recent performance of these models. In addition, this paper also performs separate regressions using data from the novel coronavirus epidemic period in particular to verify the robustness of the model to different market environments. According to the results of this paper, the FFFFM model has the best explanatory power. The role of the factors in the model on stock returns varies with portfolio selec-tion, i.e., firm size and book value, and the market environment also has an impact on the significance of the factors, leaving room for improvement in the model to cope with particular markets, but overall, FFFFM is still effec-tive in explaining present market stock prices.

Keywords: asset pricing model, explanatory power, the US stock market

1. Introduction

Asset pricing models, which are used to explain asset price formation and return forecasting, have long played an important role in investment decision making and risk management. However, with the continuous development of financial markets, the variety and number of financial assets are rapidly increasing, and the complexity and uncertainty of financial markets are growing day by day. Coupled with the incompleteness of asset pricing models in covering various risk factors in the market and the shortcomings in considering nonlinear risks, there are more and more controversies about the applicability of traditional models in the new era. Therefore, the validation of these models is of great theoretical and practical importance.

The Sharpe-Lintner CAPM states that stock returns depend only on non-diversifiable risk [1,2]. However, many other scholars have argued that risk is multidimensional and market returns should

DOI: 10.54254/2754-1169/37/20231845

be driven by multiple factors. Fama and French suggest that small-cap firms and high book-to-value firms are more likely to get a higher return than other firms [3]. Firms and high book-to-value stocks are riskier and historically provide higher returns than large-cap firms and low book-to-value stocks, thus introducing the size and value factors in the mod-el. Carhart added the momentum factor, which represents the speed of asset price change, to the FFTFM and established the Carhart Four-Factor Model [4]. In 2015, Fama & French again suggested that stocks with a greater operating profit-ability and companies that require little ongoing capital investment to maintain and grow usually perform better, so they continue to add profitability and in-vestment factors to the FFTFM and establish the Fama and French five-factor model (hereafter referred to as FFFFM [5]. Since then, other scholars have continued to explore risk factors not covered by FFFFM and abnormal returns not explained by the model. Luyanda M.Q investigated whether ESG could be a missing factor in FFFFM, but concluded that stock returns are not significantly affect-ed by ESG scores [6].

In 2017, Fama and French validated the validity of FFFFM using data from North America, Europe, Japan, and the Asia Pacific, which are international markets [7]. With data from the Chinese stock market, Tzu-Lun analyzed the performance of conventional asset pricing models including the CAPM and FFTFM, pointing out that the FFFFM performs the best, but there are still some pitfalls affecting the explanatory power due to the specificity of the Chinese stock market [8]. Lewellen et al. also suggested that the empirical results of the model are significantly affected by portfolio selection [9]. Due to being represented by portfolios, Fama and French factors might even raise the possibility of specification errors [10]. Therefore, it remains to be further verified whether the asset pricing model is still applicable due to the changes in financial markets and environmental shocks such as epidemics in recent years.

This paper validates and compares the performance of CAPM, FFTFM, and FFFFM models based on data from 2000 to March 2023 to assess their effective-ness in stock return assessment. This paper will construct regression models using market data and stock data to assess the fit and explanatory power of the models by analyzing the regression coefficients and statistical significance of each model. The paper will also use data from 2020-2023 as the sub-period to assess the robustness of models under the anomalous market environment of the epidemic shock. The validation of the asset pricing model will help financial practitioners to more accurately assess the risk and return of assets and provide a more reliable basis for their investment decisions.

2. Research Methodology

2.1. Data Selection & Portfolio Construction

The data in this paper are selected from January 2000 to March 2023 stock market day data, including all NYSE, AMEX, and NASDAQ equities for which data are available for market equity for December of t-1 and June of t, as well as (positive) book equity data for t-1, all from the Fama and French database.

The portfolios are created at the end of each June by intersecting two market equity, ME, portfolios based on size, and three other portfolios. The median NYSE market equity (BE/ME) serves as the size breakpoint for year t. The median NYSE market equity at the end of June in year t serves as the size breakpoint for that year. The book equity for the most recent fiscal year is BE/ME for June of year t. The NYSE percentiles 30th and 70th represent the BE/ME breakpoints. The size factor SMB, value factor HML, profitability factor RMW, and investment factor CMA are calculated as the average return on the small stock portfolios less the big stock portfolios, the value portfolios less the growth portfolios, the robust operating profitability portfolios less the weak operating profitability portfolios. The risk-free interest rate is equal to the rate on one-month Treasury bills, while MKT-Rf is the excess return on the market (from Ibbotson Associates).

DOI: 10.54254/2754-1169/37/20231845

2.2. Modeling

The CAPM believes that systematic risk is the only factor that influences an as-set's expected return, i.e., it is proportional to the market risk premium, and its scaling factor, the systematic risk factor, evaluates the asset's volatility in relation to the entire market portfolio. The expected return on an asset is therefore, in accordance with the CAPM, the sum of the risk-free rate, the market risk premium, and the systematic risk factor.

In FFTFM, company size, and book value are also considered to have an im-pact on the expected return of the stock, so FFTFM adds size and value factors to the CAPM. According to FFTFM, the expected return on an asset is a function of the excess market return and size and value factors. On the basis of FFTFM, operating profitability and investment factors are also added to the formula to form FFFFM. Thus, the formula for FFFFM is as follows.

$$\mathrm{R} - R_f = \beta_1 (R_m - R_f) + \beta_2 SMB + \beta_3 HML + \beta_4 RMW + \beta_5 CMA + \alpha + \varepsilon \quad (1)$$

Where the independent variable is CAPM when it contains only the first term on the right-hand side of the equation, and FFTFM when it contains only the first three terms.

3. Results

3.1. Descriptive Statistics

Table 1 reports summary statistics, including the mean, standard deviation, 25 percentile, median, and 75 percentile for each of the risk factors.

Table 1: Summary statistics.

Variable	Mean	Std. dev.	p25	p50	p75	Min	Max
MktRF5	0.0277	1.2665	-0.5	0.06	0.62	-12	11.35
SMB5	0.0109	0.6348	-0.35	0.02	0.37	-4.55	5.71
HML5	0.0107	0.7911	-0.33	0	0.325	-5	6.74
RMW	0.0215	0.5526	-0.25	0.01	0.28	-3.01	4.52
CMA	0.0146	0.4490	-0.2	0	0.22	-5.87	2.46

The average market portfolio excess return, or MKT-Rf, is 2.27%, just above the risk-free rate, indicating that the stock market is performing favorably. The aver-age market portfolio excess return (MKT-Rf), which is 2.27 percent on average and slightly higher than the risk-free rate, shows that the stock market is on the rise from 2000 to 2023. The trend is erratic, though, as the standard deviation rises to a peak of 126.65%. The standard deviation for the size factor, SMB, is as high as 63.48% and the average return is 1.09%, demonstrating that returns for small businesses typically outperform those for large ones. The data are relatively fragmented, and the difference between returns on small firms and large firms is large.

Similar to the size factor, the average return on HML, RMW, and CMA are 1.07%, 2.15%, and 1.46% respectively, which means value, robust profitability, and conservative. The variance of these factors is also in the range of 40%-80%, indicating that the data on each factor are relatively disperse and that the returns of different types of companies vary significantly. In addition, since stocks use annualized daily data, there are some extreme values that make the maximum and minimum values

DOI: 10.54254/2754-1169/37/20231845

deviate more from the average. Overall, the results suggest that besides systematic risks, size, value, profitability, and investment effect are all found in the sample market.

Table 2: Correlation matrix among five factors.

	MktRF5	SMB5	HML5	RMW	CMA
MktRF5	1				
SMB5	0.1511	1			
HML5	0.0342	0.1356	1		
RMW	-0.362	-0.2779	0.177	1	
CMA	-0.2785	0.0359	0.5062	0.3057	1

Table 2 reports the correlation among the risk factors. Factors are found to be correlated with one another to a moderate degree, where MKT is weakly correlated with HML and SMB with CMA. The negative correlation between SMB and RWM is reasonable due to the relatively weak market competitiveness and profitability of small companies. The SMB is positively correlated with the CMA because of the lower efficiency of the company's hourly size and the investment is more inclined to a conservative strategy of small size.

3.2. Regressive Results

In Table 3 and Table 4, six portfolios with small-scale low-mid-high book value and large-scale low-mid-high book value are regressed on CAPM, FFTFM, and FFFFM, respectively. CAPM successfully captures the effect of market risk, but especially for small portfolios and high book value portfolios, CAPM can only explain 70%-80% of the excess returns, which is not satisfactory. After including the size and value factors, the model's explanatory power significantly increases, and the FFTFM model is able to account for 95% or more of stock prices across all types of portfolios, showing that these two factors are crucial for understanding stock returns in the sample market and are capable of accommodating outlier prices that aren't caused by market risk. After adding profitability and investment factors, there is a further small improvement in the R-squared, indicating that the newly added factors have a positive effect in absorbing the remaining unexplained anomalous prices, and overall FFFFM outperforms FFTFM.

In all models, all variables are significant at the 99% confidence level, but the extent and direction of stock returns affected by the variables are influenced by firm size and book value. Among small-sized firms, stock returns are more affected by MKT and SMB and less affected by HML, RMW, and CMA, indicating that small firms are more likely to receive market sentiment changes and scale effects. At low book value, returns are negatively correlated with HML, RMW, and CMA, i.e., more aggressive investments lead to higher returns, while as book value increases, returns turn to be positively correlated with them, i.e., conservative investment strategies lead to higher returns. the effect of HML on returns presents a substantial increase in portfolios with high book value. Among large-scale companies, stock returns are still higher affected by MKT, i.e., large-scale companies are still more influenced by the overall market trend, while the influence by SMB is substantially weaker compared to small-scale companies and changes from positive to negative correlation, indicating that after having a certain scale, the positive effect of market influence and stability of large-scale companies on their returns exceeds the impairment of expected returns by risk reduction. Returns are still less affected by HML, RMW, and CMA, but in a high book value portfolio, the impact of HML will increase substantially to a level similar to MKT. In low book-value companies, returns remain

DOI: 10.54254/2754-1169/37/20231845

negatively correlated with HML and become positive as book value increases, while the impact of RMW on returns is positive at lower book values and turns negative at higher book values, in contrast, to small-size companies.

Table 3: Regressive results of 3 small-size portfolios.

Portfolios	SMALLLoBM	ME1BM2	SMALLHiBM
Var.		CAPM	
MKT	1.1559***	1.0507***	1.0423***
	0.0073	0.0064	0.0079
Constant	-0.0029	0.0154*	0.0168*
	0.0093	0.0081	0.0100
R-squared	0.8101	0.8211	0.7493
Var.		FFTFM	
MKT	1.0893***	0.9820***	0.9640***
	0.0031	0.0020	0.0013
SMB	0.9926***	0.8774***	0.9038***
	0.0061	0.0040	0.0026
HML	-0.1154***	0.3636***	0.7231***
	0.0049	0.0032	0.0020
Constant	-0.0075**	0.0066***	0.0042***
	0.0038	0.0025	0.0016
R-squared	0.9675	0.9826	0.9935
Var.		FFFFM	
MKT	1.0334***	0.9979***	0.9763***
	0.0024	0.0018	0.0016
SMB	0.9511***	0.9170***	0.9081***
	0.0045	0.0035	0.0031
HML	-0.2605***	0.1470***	0.5051***
	0.0041	0.0031	0.0028
RMW	-0.3227***	0.0870***	0.0334***
	0.0056	0.0043	0.0038
CMA	-0.0508***	0.0610***	0.0842***
	0.0074	0.0058	0.0051
Constant	0.0007	0.0026	0.0014
	0.0027	0.0021	0.0018
R-squared	0.9843	0.9884	0.9915
Observations		5849	

DOI: 10.54254/2754-1169/37/20231845

Table 4: Regressive results of 3 big-size portfolios.

Portfolios	BIGLoBM	ME2BM2	BIGHiBM
Var.		CAPM	
MKT	0.9664***	0.9513***	1.1227***
	0.0024	0.0039	0.0081
Constant	0.0032	0.0045	0.0039
	0.0031	0.0050	0.0103
R-squared	0.9647	0.9092	0.7669
Var.		FFTFM	
MKT	0.9799***	0.9503***	1.1051***
	0.0013	0.0030	0.0031
SMB	-0.1170***	-0.0808***	-0.0281***
	0.0025	0.0059	0.0062
HML	-0.2479***	0.3058***	0.9136***
	0.0020	0.0047	0.0050
Constant	0.0064***	0.0019	-0.0052
	0.0016	0.0037	0.0039
R-squared	0.9905	0.9494	0.9661
Var.		FFFFM	
MKT	0.9931***	0.9860***	1.0502***
	0.0013	0.0031	0.0030
SMB	-0.1006***	-0.0233***	-0.0574***
	0.0024	0.0059	0.0058
HML	-0.2342***	0.2475***	1.0001***
	0.0022	0.0054	0.0052
RMW	0.0967***	0.1317***	-0.2591***
	0.0030	0.0074	0.0072
CMA	-0.0129***	0.1764***	-0.1478***
	0.0040	0.0098	0.0096
Constant	0.0042***	-0.0042	0.0035
	0.0014	0.0035	0.0034
R-squared	0.9922	0.9544	0.9739
Observations		5849	

In summary, for different portfolios, the effects of MKT, SMB, HML, RMW, and CMA on stock returns are complex and diverse, influenced by the interaction of firm size and book value. However, in general, CAPM, FFTFM, and FFFFM are effective in explaining stock returns, with FFFFM performing the best and helping investors manage risk and develop strategies.

3.3. Robustness Analysis

To test the robustness of the model, this paper runs a separate regression using data from 2020-2023 based on the best-performing FFFFM from the previous section to test whether FFFFM remains valid during the special period of COVID-19.

In Table 5 and Table 6, the R-squared after the regression of all six portfolios is above 96%, indicating that the FFFFM model still has strong explanatory pow-er overall during the novel coronavirus epidemic period, but the significance of each factor, and the degree and direction of the effect on stock returns, produces some differences from the previous paper.

Table 5: Regression results of 3 small-size portfolios based on FF5 during COVID-19.

	SMALLLoBM	ME1BM2	SMALLHiBM
MKT	1.0248***	0.9957***	0.9922***
	0.0053	0.0048	0.0042
SMB	0.9964***	0.9390***	0.9139***
	0.0113	0.0101	0.0090
HML	-0.2647***	0.1639***	0.5479***
	0.0096	0.0085	0.0076
RMW	-0.3847***	0.0786***	-0.0317***
	0.0138	0.0123	0.0109
CMA	-0.1156***	-0.0492***	0.0960***
	0.0181	0.0161	0.0143
Constant	0.0144*	-0.0056	0.0066
	0.0079	0.0070	0.0062
R-squared	0.989	0.9897	0.9929
Observations		818	

Table 6: Regression results of 3 big-size portfolios based on FF5 during COVID-19.

	BIGLoBM	ME2BM2	BIGHiBM
MKT	1.0192***	0.9490***	1.0520***
	0.0028	0.0069	0.0065
SMB	-0.0975***	0.0208	-0.0143
	0.0061	0.0146	0.0139
HML	-0.2353***	0.3885***	0.9516***
	0.0051	0.0123	0.0117
RMW	0.0980***	-0.0417**	-0.2544***
	0.0074	0.0178	0.0169
CMA	-0.0073	0.0075	-0.2184***
	0.0097	0.0233	0.0221
Constant	0.0089**	-0.0175*	0.0167*
	0.0042	0.0102	0.0096
R-squared	0.9948	0.9679	0.9819
Observations		818	

In small-sized companies, all variables remain significant at the 99% confidence level, and stock returns are more influenced by MKT and SMB, and less influenced by HML, RMW, and CMA, and are negatively correlated when book value is low, and the model findings are consistent with the previous paper. Only with the increase of book value, RMW and CMA still exist to show a negative correlation, which is different from the previous conclusion.

In contrast, the variable significance varies more among large-scale companies. In the low to medium book value portfolio, CMA becomes insignificant with t-values as high as 0.448 and 0.747. In the medium to high book value portfolio, SMB becomes insignificant with t-values of 0.155 and 0.304, respectively. in the medium book value portfolio, the confidence level that RMW is significant also decreases from 99% to 95%. For the remaining variables that remain significant at the 99% confidence level, the model gives essentially the consistent conclusions as in the previous section.

In summary, the FFFFM performs better in forecasting the earnings of smaller companies, while there is room for adjustment and improvement based on the book value of the company when forecasting the stock earnings of larger companies, but it still explains most of the stock price movements. Overall, the FFFFM remains valid even when financial markets are in an anomalous period of receiving shocks from COVID-19.

4. Conclusion

With data from six portfolios over the past few years, this research compares and validates the CAPM, FFTFM, and FFFFM models' performance, concluding that the traditional asset pricing models are still valid, with FFFFM performing best and being equally applicable in special market environments such as epidemics. However, the FFFFM still has some limitations. Although the model has added four additional factors to the CAPM, it still cannot include all sources of risk and is lacking in the consideration of nonlinear risk. In addition, the effectiveness of the FFFFM is to some extent affected by portfolio selection, e.g., for some stocks with low trading volume, biased coefficients may be obtained. The FFFFM's explanatory power also varies with the market and over time, necessitating ongoing validation.

Future research can continue to refine and expand the five-factor model using new data sources and technical tools to improve its explanatory and predictive power and further adapt it to different asset classes and market environments. Researchers may consider introducing new factors or improving existing factors, such as incorporating market sentiment, financial indicators, macroeconomic factors, etc., to capture more return variance. Considering that factor loadings may change over time, future research can focus on time-varying factor models so that the models can adaptively adjust factor loadings over different time periods to more accurately reflect asset return relationships in different market environments. Considering the different asset return characteristics in different countries and regions, models that are more suitable for different market characteristics can also be developed. The five-factor model can be applied to other asset classes to support the advancement of factor models in the fields of asset pricing and portfolio management. At the moment, the five-factor model is mostly used in the stock market.

References

[1] *Sharpe, W. F.: Capital asset prices: A theory of market equilibrium under conditions of risk. The Journal of Finance 19(3), 425-442 (1964).*
[2] *Ross, S. A.: The arbitrage theory of capital asset pricing. Journal of Economic Theory 13(3), 341-360 (1976).*
[3] *Fama, E. F., & French, K. R.: Common risk factors in the returns on stocks and bonds. Journal of Financial Economics 33(1), 3-56 (1993).*
[4] *Carhart, M. M.: On persistence in mutual fund performance. The Journal of Finance 52(1), 57-82 (1997).*
[5] *Fama, E. F., & French, K. R.: A five-factor asset pricing model. Journal of Financial Economics 116(1), 1-22 (2015).*
[6] *Nsibande, L. M., & Sebastian, A.: Is the environmental, social and corporate governance score the missing factor in the Fama-French five-factor model? South African Journal of Economic and Management Sciences 26(1) (2023).*
[7] *Fama, E. F., & French, K. R.: International tests of a five-factor asset pricing model. Journal of Financial Economics 123(3), 441-463 (2017).*
[8] *Huang, T.: Is the Fama and French five-factor model robust in the Chinese stock market? Asia-Pacific Management Review 24(3), 278–289 (2019).*

DOI: 10.54254/2754-1169/37/20231845

[9] Lewellen, J., Nagel, S., & Shanken, J.: A skeptical appraisal of asset pricing Tests. Journal of Financial Economics 96(2), 175-194 (2010).
[10] Racicot, F. E., & Rentz, W. F.: A panel data robust instrumental variable approach: A test of the new Fama-French five-factor model. applied Economics Letters 24(6), 410-416 (2017).