

Improvements the Performances of the Fama-French Model with New Factors: Evidence from US Technology Industry

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Abstract: Fama-French 3-factor (FF3F) and 5-factor (FF5F) model is one of the most used asset pricing models after CAPM. However, there are still scopes to improve the efficiency of this model by adding further factors. This research aims to conduct research on such asset pricing models and identify whether the accuracy of the FF model increases with the inclusion of new factors or not. Therefore, this study chooses technical indicators including MACD and CCI to add to the Fama French multifactor model (FFNF) to show whether this factor can improve the performance and robustness of the model. It will also compare the result with other popular asset pricing models like CAPM, FF3F and FF5F models to get a comprehensive result. This report will use weekly trading data of 10 US technology firms and will conduct regression analysis to evaluate the models. From the regression result it can be seen that the multifactor model with technical indicators shows much more precision in predicting asset price changes. All the parameters like R square value, Standard error value, and P-value proved that the multifactor is more efficient compared to the other three models.

Keywords: Fama-French models, CAPM, new factor, US technology industry.

1. Introduction

Asset pricing models are fundamental tools to evaluate the relationship between the risk and return of the assets. These models explain important factors that influence asset return as well as the degree of influence that helps investors identify over or undervalued assets. With time there are several asset pricing models emerge intending to increase the accuracy of the result. The Capital Asset Pricing Model (CAPM) was introduced in 1960 by William Sharpe and is regarded as the first significant asset pricing model. According to this model, the return on any asset directly correlates with its systematic risk according to its correlation coefficient beta. Although it is still relevant to many cases due to unrealistic assumptions and lower accuracy, researchers developed several advanced models like CCAPM, FF3F model, FF5F model etc. Fama-French models were first published in 1992 by Eugene Fama and Kenneth French, in the FF3F model, they introduce two more factors, namely size (small minus big, SMB) and Value (High minus low, HML). This model became more statistically significant with higher explanatory power and explained anomalies like why small and value stocks mostly outperform the market [1]. In Fama-French factors, two more factors namely investment (robust minus weak RMW) and profitability (Conservative minus aggressive CMA) were introduced [2]. Several research has proved that this FF5F model can explain more market anomalies than the

FF3F and CAPM models [3]. However, some researchers claim that FF5F is not statistically better than the FF3F model under every circumstance [4]. After the success of the FF5F model, researchers started exploring other factors like momentum factors, profitability quality factors, technical indicators etc. added to the model to further increase the explanatory power which are known as the FFNF model.

However, the FF model also failed to explain some of the market anomalies like the momentum effect in Germany, profitability for Italy, Investment rate anomaly in France etc. [5, 6]. In order to increase its accuracy further, several researchers started adding new factors. For example, Fama & French, also added the momentum factor and used a six-factor model to maximize asset ranking. The research found that although Mkt and SMB factors play the highest role in maximizing model output, the integration of the momentum factor (UMD) does increase the effectiveness of the model [7].

Recently, some researchers also integrated technical indicators like MACD, CCI, PSAR, SMA etc. factors into the FF model to increase the accuracy of asset price and market movement predictions [8]. According to Zhao, after the FF5F model, the number of such factors keeps increasing rapidly and reaches several dozen to a hundred factors. In most cases, researchers experience an increase in explanatory power with increasing factors [9]. These multifactor models are therefore the most popular asset pricing model worldwide. According to the other study [10], the multifactor FF model can make portfolios with an astonishing Sharpe ratio of up to 4.49. Another research by Fadlalla, & Amani added technical factors like MACD, and CCI and analysed the Qatar exchange index. The results found that this model has a higher explanatory power in predicting next-day prices compared to the FF3F model.

This report therefore aims to check whether adding additional factors like moving MACD and CCI does increase the accuracy of the model and be able to explain some anomalies in the stock market. This paper hypothesized that technical factors can be more useful in explaining anomalies like moving average outperformance, winner's curse etc. The next chapter will discuss the data and model this report is going to use. It will highlight the data sources and rationale behind the use of that particular data. after that, this report will build the desired model with the French N factor model followed by a detailed explanation of the factors used in the model. After model building and testing the result and discussion part will discuss the findings and discuss its implications on real-life markets like how the findings can help investors in pricing assets.

2. Data and Method

This study will use firms from the US tech industry due to their high volatility in returns. It will take historical weekly trading data from 10 companies over the last 10 years to conduct the research. Data related to historical prices is taken from investing.com while data related to the Fama French model is taken from Dartmouth's data library. Technical factors like MACD and CCI are calculated using the historical return data. MACD shows a stock price's strength, direction, momentum, and duration. It is calculated by subtracting a 26-period exponential moving average (EMA) to 12 days EMA:

$$\text{EMAToday} = (\text{Stock price today} * (2/(\text{period}+1))) + \text{EMAYesterday} * (1 - (2/(\text{period}+1))) \quad (1)$$

Here 2 is the smoothing factor.

$$\text{MACD} = 12 - \text{day EMA} - 26 - \text{day EMA} \quad (2)$$

CCI on the other hand is a momentum-based indicator that shows overbought and underbought regions. CCI mostly ranges between +100 and -100 however, it can exceed these values. A CCI higher than +100 or lower than -100 shows overbought and oversold region respectively. This report calculates CCI using the following formulae:

$$\text{CCI} = (\text{Typical price} - \text{SMA}) / (0.015 * \text{mean deviation}) \quad (3)$$

where,

$$\text{Typical price} = (\text{High} + \text{Low} + \text{close}) / 3 \quad (4)$$

$$SMA = 10\text{-day moving average} \quad (5)$$

This research will conduct extensive research on the effectiveness of the asset pricing models using four of the most popular models which are as follows. For CAPM models, dependent variable would be the excess return of the firms and the independent variable is the market excess returns:

$$R_i - R_f = \alpha_{i,t} + \beta * (R_m - R_f) + \varepsilon_{i,t} \quad (6)$$

From the above discussion, one knows that there are three independent variables, market risk premium (MKT), and size factor (SMB) which is the difference between small firms' and big firms' returns. and value factor (HML) which is the difference in return of high-value stocks and low-value or growth stocks:

$$R_i - R_f = \alpha_{i,t} + \beta_1 * (MRP) + \beta_2 * (SMB) + \beta_3 * (HML) + \varepsilon_{i,t} \quad (7)$$

Compared to the FF 3 model, this model has two additional factors, The profitability factor (RMW) represents the nature of profit for the firm and the investment factor (CMA) represents the investment strategies of investors.

$$R_i - R_f = \alpha_{i,t} + \beta_1 * (MRP) + \beta_2 * (SMB) + \beta_3 * (HML) + \beta_4 * (RMW) + \beta_5 * (CMA) + \varepsilon_{i,t} \quad (8)$$

Under the Fama-French multifactor model, one incorporates three technical indicators, which are MACD, which is a momentum indicator and shows the relationship between 12-day and 26-day exponential moving averages. CCI is also a momentum-based indicator that helps identify overbought and underbought zones. This is the difference between the typical price and the moving average. Therefore, the model is as follows.

$$R_i - R_f = \alpha_{i,t} + \beta_1 * (MRP) + \beta_2 * (SMB) + \beta_3 * (HML) + \beta_4 * (RMW) + \beta_5 * (CMA) + \beta_6 * (MACD) + \beta_7 * (CCI) + \varepsilon_{i,t} \quad (9)$$

R square is a statistical measure that shows the proportion of the changes in the dependent variable can be explained by the independent variable. it typically ranges from 0 to 1 and the higher the R-value the better the model is at predicting the behaviour of the dependent variable. Standard error measure shows the average distance of the observed value from the regression line. the higher the standard error the less effective the model is to predict a relationship. Beta coefficient shows the correlation of the dependent variable with the factors and shows how much the dependent variable will change with a single unit change in the independent value. magnitude of the beta shows the strength of the relationship while the sign shows the direction of change. The P-value shows whether the relationship occurred by chance with an assumption that the null hypothesis is true. Simply it shows whether the results are statistically significant or not. Typically, a P-value less than 0.05 indicates a statistical significance under 5% significance level.

3. Results and Discussion

This study uses weekly data to perform four multiple linear regressions per stock to find the explanatory power of these variables used. Regression analysis can show how much the independent variables can predict the behaviour of the dependent variable and how they are related. Here, this study uses 10 different stocks and run regression analysis to confirm the explanation power of these models. The results from the regression analysis are as follows,

3.1. Model Performance

The R-square value in Table 1 shows the explanatory power of any model, the higher the R-square value, the higher the model can explain changes. A low R-square value indicates that other factors play a significant role in changing the dependent variable. This table presents the R-square values of the CAPM, Fama-French 3-factor, Fama-French 5-factor, and Fama-French multifactor models. This

table shows that CAPM has much less explanatory power with almost all the stocks, which means investors can't rely much on the CAPM model to predict price changes. The Fama-French 3-factor model shows a significant increase in explanatory power compared to CAPM but it is still much lower. Apart from APH and ORCL stock, the Fama-French 3-factor model fails to predict price changes. The R-square value for the Fama-French 5-factor model is mostly similar to the FF3F. Although the value is slightly higher, it does not provide any statistically significant result, which is in line with the findings of Kubota & Takehara [6]. Multifactor model with technical indicators like MACD and CCI on the other hand shows a very high R-square value mostly over 90% which shows that this model has a very high explanatory power over stock prices which satisfies the findings of previous study [8]. This high R square value also suggests that the most important determining factors of asset price changes are captured in this model.

Table 1: R square values of the firms

	CAPM	FF3F	FF5F	FFNF
ACN	0.00134	0.00937	0.01133	0.95950
ADBE	0.00040	0.00429	0.00513	0.97368
AKAM	0.00011	0.00104	0.00379	0.75366
APH	0.00340	0.01270	0.00560	0.95443
ADI	0.00321	0.00883	0.01417	0.96057
MSFT	0.00162	0.00855	0.01230	0.98568
NVDA	0.00345	0.01478	0.01851	0.98649
AVGO	0.00134	0.00937	0.01133	0.73029
ORCL	0.00264	0.01363	0.01748	0.90460
CSCO	0.00087	0.00771	0.00816	0.87666
QCOM	0.00222	0.00971	0.01488	0.89311

Table 2: Standard error of the firms under CAPM, FF3F, FF5F and FFNF

	CAPM	FF3F	FF5F	FFNF
ACN	91.09658	90.90384	90.98897	18.50034
ADBE	178.67826	178.67371	178.94270	29.16064
AKAM	21.54016	21.57154	21.58333	10.75361
APH	13.41901	13.38187	13.45582	2.88613
ADI	52.02648	51.97931	51.93904	10.40780
MSFT	118.40179	118.21739	118.22076	14.26330
NVDA	24.92949	24.83502	24.83578	2.91984
AVGO	91.09658	90.90384	90.98897	47.61608
ORCL	27.87029	27.76948	27.76869	8.66982
CSCO	11.17843	11.16146	11.18046	3.95036
QCOM	43.86346	43.78244	43.75224	14.44015

The Table 2 shows the standard error by all four models per stock. From this table, it can be seen that the CAPM, FF3F and FF5F have a very high standard error which indicates that the models are incomplete and several important factors are not added. On the contrary, Fama-French multifactor model shows much less standard error compared to the other 3 models which clearly indicates that the multifactor model is more robust and provides a more precise estimation.

Beta value corresponds to any independent factor and shows how the independent factor is related to the dependent factor. Table 3 shows the beta values for the multifactor model along with the intercept value. From the Table 3, it can be seen that technical indicators like MACD and CCI have a higher beta compared to Fama French factors. While beta related to MACD is more stable for most firms, Beta related to CCI is volatile and often shows a high negative or positive coefficient. Market risk premium mostly has a negative beta for most stocks which is different from the CAPM model as for this model, the beta value for market risk premium is positive for most stocks. Fama-French factors especially HML and RMW have a much lower beta which shows they have a low correlation with stock prices. Conversely, one can't predict asset price changes with HML and RMW factors. AVGO stock has an unusually high intercept of 152.05 which shows that the model is not very suitable for the firm and also does not have a high explanatory power. Overall, it can be concluded that technical indicators, MACD and CCI show the highest correlation with price changes in this model. Market risk premium and CMA also have a significantly high beta. However, factors like RMW and HML show extremely low coefficients which shows these factors cannot explain price changes

Table 3: Coefficient values

	ACN	ADBE	AKAM	APH	ADI	MSFT	NVIDIA	AVGO	ORCL	CSCO	QCOM
Intercept	-5.14	5.24	26.61	-1.26	-0.73	-11.71	-2.57	152.05	6.53	8.44	5.53
Mkt-RF	-0.16	-0.05	-0.11	-0.04	0.49	0.26	-0.10	1.14	0.36	0.17	0.33
SMB	0.23	-0.02	0.20	0.02	0.14	-0.01	-0.07	1.83	-0.26	-0.12	0.06
HML	0.09	-0.63	0.18	0.05	-0.15	-0.62	-0.09	0.60	-0.17	0.02	-0.16
RMW	0.00	0.47	0.07	0.03	0.24	0.05	0.03	-0.31	-0.14	0.02	0.14
CMA	0.29	0.87	-0.24	-0.06	-0.04	0.25	0.04	0.86	-0.02	0.10	0.23
MACD	1.01	1.00	0.70	1.05	1.01	1.07	1.25	2.14	0.95	0.80	0.96
CCI	2.19	7.17	1.21	0.34	0.78	2.14	0.35	-3.07	0.00	0.01	0.13

Table 4: P- values of the regression

	ACN	ADBE	AKAM	APH	ADI	MSFT	NVIDIA	AVGO	Oracle	CSCO	QCOM
Intercept	0.1043	0.0422 4515	1.2113E -55	0.00072 968	0.69464 913	5.9858E- 09	1.5912E- 41	8.3623E- 84	2.415E -13	4.4463 E-51	0.000162 05
Mkt-RF	0.4205	0.8784 0517	0.33163 169	0.15848 344	0.01305 099	0.331379 14	0.085591 59	0.203521 66	0.0243 9357	0.0224 1933	0.225126 42
SMB	0.4531 1	0.9622 0118	0.27275 354	0.60833 204	0.66485 145	0.984962 2	0.472481 55	0.226177 68	0.3453 8604	0.3256 2298	0.901613 58
HML	0.8078	0.2646 2684	0.38750 404	0.37466 248	0.49752 199	0.043948 47	0.142854 71	0.561113 19	0.3750 3138	0.8280 1937	0.601403 02
RMW	0.9944	0.4448 7219	0.75394 671	0.67822 684	0.20705 373	0.848111 06	0.579846 2	0.727589 46	0.3892 7426	0.8086 3647	0.602374 59
CMA	0.5939 3	0.3166 6303	0.45316 582	0.50486 827	0.84373 044	0.402053 5	0.549747 71	0.388793 92	0.9062 4691	0.2124 3114	0.439536 6
MACD	0	0	4.168E- 156	0	0	0	0	1.6471E- 91	3.11E- 263	2.629E -235	5.629E- 251
CCI	1.5726 E-19	1.722E -77	8.8612E -21	9.4364E -19	6.7049E -11	1.8795E- 24	1.4632E- 64	1.6327E- 15	0.2570 8121	0.1911 218	2.5224E- 15

The Table 4 shows the P values for the factors under the Fama-French multifactor model. From this table, it can be seen that the intercept value is significant in most analyses like in ADBE, APH, MSFT, NVIDIA, AVGO, ORCL, CSCO. However, other stocks like ACN and ADI show an insignificant intercept value. From the table, it can also be seen that Fama-French factors, SMB, HML, RMW and CMA show an insignificant p-value in all the stocks. On the contrary, the technical

indicators, MACD and CCI show a very high significance over the asset price movement. Market risk premium shows significance for some assets like ADI, Oracle and CSCO.

3.2. Comparisons and Implications

From the above results, it can be concluded that the Fama-French multifactor model with technical indicators like MACD and CCI possesses a much higher explanatory power compared to the other three models as the FFNF model has constant high R-square and low standard error compared to these factors. CAPM, the French factor model as well as the French five-factor model showed much less R square value while very high standard error which shows that these models are incomplete and one needs to add other significant factors to get a statistically significant model. From beta and P-value analysis, it can also be concluded that technical indicators are much more statistically significant in predicting price changes compared to other factors.

3.3. Limitations

Although the study provides useful insights by comparing asset pricing models for investors, it does have several limitations that may decrease the credibility of this study. This study is exclusively based on the US tech industry which means it is highly country and industry-specific data. Moreover, the US tech industry is known for a much more volatile nature which makes the result irrelevant for sectors like utility or other low-volatile industries. Similarly, as the US is an established equity market, the models may not be as useful in emerging equity markets like Indian markets or Brazilian markets. Similarly, the frequency of the data also plays an important role. This study took weekly trading data for 10 years, instead of daily trading data which may decrease the accuracy of the models. Moreover, this potentially ignored the effect of short-term fluctuation in the market. Another big limitation is the model's reliance on historical data. Historical data can be a good indicator of what could happen, but it cannot predict the future. Therefore, the relationships derived from historical data may not hold in future. Market disruptions like COVID-19, technological advancement and changing investor behaviour can significantly impact price changes that may not follow the same model. The inclusion of only two technical indicators may show an incomplete picture. MACD and CCI both are momentum-based indicators and although these factors show a high significance in this model, they can be incomplete as several other technical indicators analyze stock prices using different parameters. Including those factors can provide the full extent of significance. Another important limitation of this model is it fails to analyze the potential multicollinearity among the factors used. Correlation factors between the factors used like SMB, HML, CMA, MACD, and CCI may increase the robustness of the model.

Overall, the model and data used in this study are highly limited and therefore there are several scopes to improve the study. Investors can expand the data to various industries or various regions. Researchers should keep adding different factors to the multifactor model as the data here shows there should be other important factors as well.

4. Conclusion

To sum up, this research aimed to find out the significance level of different asset pricing models like CAPM, the Fama FF3F model, the FF5F model and the multifactor model with 2 technical indicators. From the above discussion, it is clear that the multifactor model with technical indicators is more effective in predicting the changes in asset price compared to the other 3 models. The multifactor model produces a much higher R square value for almost all the observations. Similarly, standard error in the multifactor model is also significantly lower than the other 3 factors. These data indicate that the multifactor model is more robust and precise compared to the other three models. However,

the data taken is limited to only the US technology industry which is a mature and volatile industry and therefore the result from this report may be less useful for investors. Moreover, all the data taken here are historical data which means it can never predict future price changes effectively as several market-level factors can impact the result. therefore, researchers should continue to find more robust data and factor that can have an even higher explanation power.

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