# Portfolio Construction in Terms of APPL Based on Fama and French Five-factor Model

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**Abstract.** In the contemporary world, research has been working towards creating a model that can better explain the relationship between financial investment and risk. Iterative financial models such as CAPM, Fama French three factor model (FF3F) are strengthening the explanatory power of the extra investment risk of portfolio investments. Nevertheless, due to the global pandemic, the variability of the explanatory power of financial analysis models in the stock market has become more fickle. The objective of this paper is to analyze the portfolio investment data of Apple, one of the world's largest high technology companies, from 2017 to 2022 using the Fama French five factor model (FF5F) to determine whether the model still has strong explanatory power on the stock market during the pandemic. According to the analysis, the FF5F model coefficients still robust in explaining Apple's stock markets over five-year global pandemic period. It seems as if the epidemic and similar force majeure factors do not affect the explanatory efficiency of the model, but it is unknown that whether the actual impact is not captured by the FF5F model. The results of this study based on the FF5F model shed lights for reducing portfolio investment risks.

**Keywords:** Fama French five factor; Stock market; Portfolio investment; β coefficient.

## 1. Introduction

Stock portfolio returns are an enduring research topic in the stock market. The CAPM model proposed by Sharp and Lintner laid down the basic idea that asset returns are derived from asset risk [1, 2]. CAPM model is based on portfolio investment selection theory which was proposed by Markowitz in 1952 [3]. CAPM model can be described as:

$$r_a = r_f + \beta(r_m - r_f) \tag{1}$$

$$\beta = \frac{Cov(r_a, r_m)}{\sigma_m^2} \tag{2}$$

The definition of the variables are given in Table. 1. Asset pricing models have improved with the development of computing efficiency. The CAPM model proposed by Sharp et al. contained a single Beta coefficient, but the information it provided was very finite and unstable. Carhart et al. published the Carhart four factor model in 1997, which further enhanced the explanatory power of FF3F in the field of asset pricing [4, 5]. FF3F model included the size effect and value effect issues that could not be explained by the CAPM model, and were considered to enhance the explanatory power of cross-sectional variation in stock returns on a global scale. FF5F model adds the profitability factor (RMW) and the investment factor (CMA) to the FF3F model model to capture the size, value, profitability and investment pattern of average stock returns [6]. The outstanding performance of FF5F model had been verified by the stock market in the United States for nearly half a century.

In the past study, Huang tried to verify whether the FF5F model is valid in analyzing stock market of Chinese companies during the decade of 1996-2016 [7]. Although different stock exchanges in China have different market mechanisms that may lead to a decrease in the explanatory power of the FF5F model. The conclusions drawn confirm that the FF5F model outperforms all other models in explaining individual stock returns. Nevertheless, the profitability and investment factors does not significantly improve the performance of the model.

Mardy et al. verified the validity of the FF5F model in the Australian stock market, concluding that the FF5F could enhances the explanatory power of the FF3F model, and explains more asset pricing anomalies than other asset pricing models. However, the result does not robust enough to explain the time-series variations in portfolio returns which corroborate with the conclusion drawn

from the FF5F model [6]. FF5F model gives an incomplete explanation of average stock returns. Analysis of US Sector of Services with a New FF5F model suggests that in the US services stock market, the FF5F model with EGARCH-typed volatilities and non-normal errors is still applicable. However, the model considering GARCH-typed is a little bit more efficient than the FF5F model considering EGARCH-typed volatilities.

Hou et al. used the FF5F model to examine the variation in the steel industry's five factors: earnings, industry size, profitability, and investment before and after the pandemic [8]. The study shows that the model is suitable for analyzing the downward performance of the U.S. steel industry during the COVID-19, where persistently low individual stock profits lead to stock price insensitivity to the market, which in turn makes the RMW coefficient ineffective. James finds that the FF5F model has explanatory power in the stock markets of Eastern Europe and Latin America, but does not improve on the traditional FF3F model when explaining Asian stock markets [9]. This finding also supports that the two additional introduced variables in the FF5F model is invalid in explaining the Chinese stock market [7]. James' conclusion is congruent with Lin that the investment style factor is redundant in the Chinese stock market, and its explanatory power seems to be null and void [10]. With the continued impact of the epidemic, the development of high-tech industries around the world has stalled to varying degrees. Introducing stock datasets of Apple Inc. from Kaggle library, this research tried to use FF5F model in performing multiple linear regression to get the five coefficients. As a result, this study analyzed the coefficients and provided corresponding investment recommendations.

**Table 1.** Definition and practical construction of parameters.

| Parameter | Definition | Practical Construction |
|---|---|---|
| $R_{it}$ | Portfolio return rate for a particular industry at time t | Portfolio investment returns in the t-statistical interval |
| $Rf_t$ | Risk-free portfolio return rate for a particular industry at time t | Risk-free portfolio investment returns in the t-statistical interval |
| $\alpha_i$ | Excess return of the portfolio investment (Intercept) | Stock selection ability of investors |
| $\beta_i$ | Market risk exposure | Portfolio investment sensitivity to market risk |
| $Rm_t$ | Market portfolio average return rate | |
| $SMB_t$ | Industry size factor average return rate | |
| $HML_t$ | Industry Book-to-Market ratio return rate | Changes in book-to-market ratio of listed companies as judged by return rate differences |
| RMW | Profit factor | |
| CMA | Investment style factor | |
| $\beta_{i,\,RMW}$ | Coefficient of profit factor | |
| $\beta_{i,\,CMA}$ | Coefficient of investment style factor | |
| $\varepsilon_{it}$ | Regression error term | |

## 2. Models

### 2.1 Introduction to FF5F Model

The CAPM model has a potential economic market threat: mispricing of assets could lead the economy to a bubble and thus cause immeasurable hazards. At the same time Frankel et al. found that the two phenomena of higher book-to-market with higher average stock returns (referred as size effect) and higher average stock returns with lower market capitalization outstanding (referred as value effect) in the portfolio formed by the stock market are not captured by the CAPM model [11]. Although the FF3F model fully explained size effect and value effect which evoked attention from the scientific community all over the world, it caused variation in average returns related to profitability and investment. The FF3F model can be decribed as [4]:

$$R_{if} = R_{ft} + \beta_i\left(R_{mt} - R_{ft}\right) + s_i SMB_t + h_i HML_t + \epsilon_{it} \quad (3)$$

Robert et al. found that the FF3F model[4] could not explain the variation relationship between profitability and profitability growth [12]. In addition to that, technically, the intercept variable $\alpha$ in the model should tend to zero if the three factors: the market factor (Rmt), the market capitalization factor (Rft), and the Book-to-Market ratio factor (HMLt), are valid enough to fully explain the excess returns of the asset. However, Novy-Marx et al. indicate that the intercept $\alpha$ is not approaching to 0 in some stock markets [13]. In 2015, Fama and French introduced two new factors: profitability (RMW) and investment style (CMA) try to offset the shortcomings of the FF3F model [4, 14-16]. The FF5F model can be described as [6]:

$$R_{it} - R_{ft} = \alpha_i + \beta_i(R_{mt} - R_{ft}) + \beta_{i,SMB}SMB + \beta_{i,HML}HML + \beta_{i,RMW}RMW + \beta_{i,CMA}CMA + \varepsilon_{it} \quad (4)$$

## 2.2 Portfolio Design

After selecting Apple as the data sample, the python code performed some filtering operations on the dataset using python. In order to obtain valid values, the code initially performed data cleaning process, then introduced the training model to re-iterate each individual stock, and finally visualized the loss between the filtered result data and the original data. As shown in Fig. 1, the data loss decreases drastically from the beginning, then stays within a small fluctuation and finally becomes stable, which means that the training model was improves the validity of the dataset throughout the training process and the data is trained to discard the meaningless garbage data, leaving the usable and stable part. Meanwhile, the code visualized the results as following illustrated in Fig. 2.

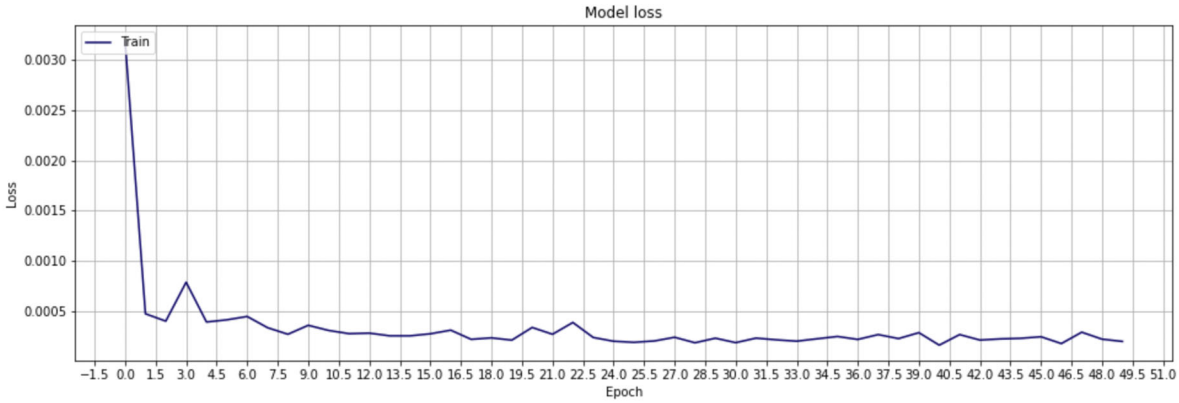


**Fig. 1** Model loss.


**Fig. 2** The predicted value and real value.

### 2.3 Applying FF5F model

Prof. French's website provides risk factors, including three factors, momentum factors, and five factors, and calculated monthly returns. Merging the datasets for the FF5F model generates the data frame. Performing multiple linear regression gives us the OLS Regression results and five FF5F model coefficients as shown in Table. 3. Finally, one exported corresponding value of five factors into Excel and generated the correlation matrix and heatmap as exhibited in Fig. 3.

**Table 2. Monthly regression results of FF5F model.**

| | mkt | smb | hml | rmw | cma | rf | rtn | excess_rtn |
|---|---|---|---|---|---|---|---|---|
| 2017-12 | 0.011 | -0.011 | 0.001 | 0.007 | 0.017 | 0.001 | -0.015 | -0.016 |
| 2018-01 | 0.056 | -0.032 | -0.013 | -0.007 | -0.010 | 0.001 | -0.011 | -0.012 |
| 2018-02 | -0.037 | 0.003 | -0.011 | 0.005 | -0.024 | 0.001 | 0.068 | 0.067 |
| 2018-03 | -0.024 | 0.036 | -0.002 | -0.005 | 0.000 | 0.001 | -0.058 | -0.059 |
| 2018-04 | 0.003 | 0.009 | 0.005 | -0.024 | 0.013 | 0.001 | -0.015 | -0.016 |

**Table 3.** OLS Regression Results.

| | coef | std err | t | P > \| t \| | [0.025 | 0.975] |
|---|---|---|---|---|---|---|
| Intercept | 0.010 | 0.008 | 1.227 | 0.225 | -0.006 | 0.027 |
| mkt | 1.23 | 0.168 | 7.337 | 0.000 | 0.897 | 1.572 |
| smb | 0.039 | 0.355 | 0.110 | 0.913 | -0.673 | 0.750 |
| hml | -0.785 | 0.275 | -2.849 | 0.006 | -1.338 | -0.232 |
| rmw | 0.764 | 0.413 | 1.847 | 0.070 | -0.066 | 1.593 |
| cma | 0.548 | 0.439 | 1.248 | 0.217 | -0.333 | 1.428 |


**Fig. 3** Heatmap of variables correlation coefficients.

## 3. Results & Discussion

### 3.1 FF5F Regression Results and Coefficients

Seen from Table. 3, the coefficient of intercept is 0.0101. The intercept converges to zero indicating that the FF5F model could sufficiently giving a reason of the excess returns that appeared in the portfolio investment. The goodness of fit of the model is also as high as 0.99999216 which also coincidentally confirms our assumption. The introduction of two new factors, profitability (RMW) and investment style (CMA), adds some explanatory power to Apple's stock.

### 3.2 The Coefficients of MKT-$Rf_t$

The coefficient of the market factor is 1.234 greater than 1, which indicates that Apple's overall stock market return for the five years spanning the epidemic is positively correlated and the fund's operating trend is consistent with the overall market operating trend. The Table. 4 shows the change in Apple's annual earnings rate from 2017 to 2022. The annual return in 2017 is 261.61 billion and the annual return in 2022 is 394.33billion. Comparing the annual return change on the graph, this is in line with the conclusion one reached. A 28.62% total revenue in 2021 somewhat pulls up the market factor threshold. By the data provided by Marketwatch, the cell phone market in 2021 shows signs of a surge in demand for the new iPhone, a sign that also directly lifts Apple stock from a single share gain of $1.68 in 2020 to a single share gain of $2.10, or 25%. This is largely consistent with the market factor of 1.2344 obtained before.

**Table 4.** Annual Revenue.

| Year | Revenue | Change |
|---|---|---|
| 2022(TTM) | $394.32 B | 4.23% |
| 2021 | $378.32 B | 28.62% |
| 2020 | $294.13 B | 9.88% |
| 2019 | $267.68 B | 2.32% |
| 2018 | $261.61 B | 9.38% |
| 2017 | $239.17 B | 9.65% |

### 3.3 The Coefficients of RMW-$Rf_t$

The outbreak of the epidemic in 2019 will only come to a close in 2021, and the impact of these three years on the electronics market will undoubtedly be huge. Potential consumption in the U.S. cell phone market in 2019 is 18% bellower than original expectations. Apple's market share in 2019 was 36%, while Samsung's was 34%. There is a 14% decline in the overall U.S. cell phone market in 2020, plus the largest exporter of Apple products were shut down: 80% of Apple's offline stores in China are closed due to the outbreak, resulting in overall stagnant sales of Apple products. These signals seem to foreshadow a recession in the U.S. chip industry and electronics industry. As it turns out, Apple's phone sales figures for the two years 2020, 2021 were slightly weaker and did not meet the optimistic expectations before the epidemic. In 2022 CBS announced a global chip shortage costing the U.S. economy $240 billion. The loss of chip shortages for electronics is reflected in Apple's earnings factor.

### 3.4 The Coefficients of CMA

The investment factor is not significant in the analysis results indicating that Apple's investors demand higher yields. The differential returns are not significant indicating that the investment factor does not provide excess returns

## 4. Limitation & Prospects

In this study, the FF5F model was used to analyze the stock data of Apple Inc. for the past five years. Although the FF5F model has been shown to be valid in previous studies [6-9], it still has some limitations, for example, this study could not verify the accuracy of the conclusion. Part of the results corroborating with the variations of cell phone industry does not provide enough information to generate an accurate statement [6]. Nonetheless, the FF5F model coefficients provide a vague and general prediction. In addition to this, the study found that some of the coefficients of FF5F model are still in the unexplained stage. The CMA coefficients did not give more meaning to the study and it is unknown whether the analyzed CMA coefficients are valid, which would bring a lot of confusion and misunderstandings. The advent of machine learning has drastically accelerated data analysis progress. Training neurons can compute millions of times faster than the human brain, but they may not be able to handle the complex situations encountered in the stock market. Humans should not rely

entirely on the computer's calculations whenever under any circumstance. Rather, they should take advantage of the computer to help them minimize portfolio investment risks.

## 5. Conclusion

In summary, this study investigates the validility of the FF5F model based on stock data from Apple Inc. Specifically, FF5F model's profit factors RMW and market factors $R_{ft}$ provide a good overview of the mobile industry trends over the past five years and explain Apple's developments. Acccording to the analysis, the downturn profit factor during the pandemic was consistent with the overall declining trend in cell phone market sales. In addition, insignificant CMA factor reveals that investment factors are not important in the overall portfolio analysis and represents that the excess returns were voided. Nevertheless, the other factors in FF5F model do not give a practical meaning and thus no conclusions can be drawn from them. In the future, as the field of machine learning continues to evolve, it has greater discernment and explanatory power for more complex asset investment models. More and more intelligent algorithms will gradually improve the explanatory power of the FF5F model, and also extend the reduction of human risk for asset allocation . Overall, these results offer a guideline for understanding reducing portfolio investment risks.

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