Analysis on the US Food and Semiconductors Industry Tests of Fama-French Models

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Abstract: Asset pricing models are usually used to determine a theoretically rate of return of a particular asset, in order to make decisions about the investments in diversified portfolio. This study focuses on testing the Fama French 3-factor (FF3) and 5-factor (FF5) models in the US food product industry and semiconductor industry by applying multiple linear regression analysis on daily excess return of the industry stock portfolios from July 2005 to June 2020. Each models' goodness of fit in these industries are demonstrated by the results. By comparing the coefficients of each factor in the FF models, this paper has focused on five essential factors with respect to industrial sensitivity: market, size, book-to-market ratio, profitability and investment style. In general, the food product industry appears to be more inclined to the large size and robust profitability of companies, whereas the chips industry is more dependent on good economy condition and aggressive investment style. Also, the profitability factor in chips industry is worth noticing since it is a redundant factor, suggesting the return of this industry portfolio is unrelated to firms' profitability. Accordingly, the investment advice is proposed based on the analysis: large-size food products firms with strong profitability and conservative investment style are more preferrable, whereas semiconductors companies with low book-to-market ratio and relatively aggressive investment style are recommended to the investors.

1. Introduction

Asset pricing model plays an important role of helping investors to predict the returns of investment portfolios and to make decisions of asset allocation, it has gone over several times of evolution. The Capital Asset Pricing Model (CAPM), which is developed by Sharpe [1] and Lintner [2], is used to calculate the cost of capital and measure portfolio performance. The model states a linear relationship between the expected risk premium on individual assets and their market beta, which can be interpreted as "systematic risk". However, there remained some limitations about the validity of CAPM regarding the insufficiency of market beta to explain the stock returns. Decades after the introduction of CAPM model, Fama and French [3, 4] proposed a three-factor, characteristic-based model for the expected return of stocks without assuming linearity, including factors of the return on the stock index, the sizes (SML) and book-to-market value ratios (HML) of particular firms. The Fama-French 3 Factors Model (FF3) successfully reconciled some of the anomalies in the stock market in 1980s. Stimulated by the validity of valuation model and the recent empirical findings regarding the correlation between firms' profitability, investment style and the assets return, Fama and French [5] developed a new 5-factor asset pricing model (FF5) based on the previous 3-factor one, incorporating two new factors (i.e. RMW and CMA) which respectively demonstrates the profitability and investment style of firms.

Ever since the Fama French model first come out, researchers around the world have been testing the model to evaluate its practicability and reliability in different market circumstances, and most of the researchers confirmed its significance in aspects of asset pricing as results. Connor and Sehgal [6] used the FF3 model to study India market and empirically examined the stock returns in Indian market; the results are reasonably consistent with the 3-factor model. Gregory, Tharyan and Christidis [7] found that the Fama-French model are, in general, capable of explaining the return in large firms particularly, by constructing the 3-factor model in the UK market and conducting analysis. The US stock market has also been studied by Li, Rao, Zhou and Mizrach [8], who confirmed the FF5 model's validity in the US stock market by analyzing data from 48 industries portfolio. Another major equity market in the world, the Chinese stock market, has also been tested with both 3-factor and 5-factor Fama French model by Lin [9], who confirmed the applicability of Fama-French model in China and later realized the 5-factor model consistently outperform 3-factor model in the Chinese equity market. Moreover, Chiah, Chai, Zhong and Li [10] have tested the Fama-French model in Australian stock market and discovered that the FF5 model can explain the pricing anomalies better than other models in Australia by comparing it with other pricing models. Petkova [11] investigated the 3-factor FF model and reached a result that the factors of size and book-to-market value, promoted by Fama and French, are significantly correlated with the innovations in state variables that can be used to predict excess market return.

Supported by numerous findings, it appears that FF model is reliable and practical in pricing assets and forecasting returns of firms and portfolio in all circumstances. However, although many researches have conducted experiments to attest to the validity of FF model, very few examined the FF model in specific industries, comparing the dependence of factors on portfolio returns for different industries. We believe that analyzing and comparing portfolios from different industries would help us further explore the applicability of FF model in reality and give meaningful portfolios suggestion for financial investors at the same time.

This article aims to explore the application of FF3 and FF5 on food products industry and semiconductors (or chips) industry classified by FF 48-Industry Classification. Food product industry is usually robust and healthy with a stable excess return in stock portfolio and hardly impacted by the economic fluctuation since food is a necessity good. In contrast, the semiconductors industry depends largely on the technology development and has a high turnover rate in the technology due to Moore's law, making this industry less stable and more sensitive to the economy cycle as well. This study will analyze those two industries using Fama-French model and offer investment advice to investors.

2. Method

2.1 Fama-French 3-Factor Model (FF3) Theory

Fama found that β could not completely explain the cross-sectional excess return of portfolio in CAPM model. Therefore, Fama and French made a more comprehensive analysis on the factors that can better explain the excess return of portfolio and put forward FF3 model. The FF3 model holds that besides β in capital asset pricing model, market value ME (risk premium due to different company sizes) and book market value ratio BE/ME (risk premium due to different book market values) also have significant explanatory power to excess returns, which are known as small-scale market value stock anomaly and high book market value ratio stock anomaly. The basic form of this model is:

$$E(R_i)-R_f = \beta_{Mkt} (E(R_M)-R_F) + \beta_{SMB}SMB + \beta_{HML}HML \qquad (1)$$

where R_f is risk-free rate of return, Rm denotes market rate of return, R_i represents the yield of asset i; $E(R_m) - R_f$ is the market risk premium, SMB is the simulated portfolio return of the market value (Size) factor, and HML is the simulated portfolio return of the book to market factor.

Mkt represents the return of market portfolio with randomly dispersed risks minus the return of risk-free assets. SMB represents the premium of the market value of an enterprise, which is the income of a small-cap company minus the income of a large-cap company. HML represents the development opportunity premium of an enterprise, which means that the income of a company with high BM value (book-to-market ratio) minus the income of a company with low BM value.

2.2 Fama-French 5-Factor Model (FF5) Theory

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In 2015, Eugene F. Fama and Kenneth R. French introduced a five-factor model and added profitability and investment style factors to the three-factor model to better describe the expected return rate of stock portfolio in cross section. The five-factor model is as follows:

$$R_{it} - R_{Ft} = a_i + b_i(R_{Mt} - R_{Ft}) + s_i SMB_t + h_i HML_t + r_i RMW_t + c_i CMA_t + e_{it} \quad (2)$$

The two additional factors are RMW and CMA. RMW_t is a profitability factor, and the difference between the return rate of stock portfolio with high operating profit rate and low operating profit rate reflects the premium of high-profit stock investment relative to low-profit stock portfolio. CMA_t is an investment style factor, and the difference between the return rate of stock portfolio with conservative investment style and aggressive investment style reflects that the high investment ratio model is relatively higher than the low investment ratio model.

2.3 Data Selection & Processing and Calculation Formula

The data is collected from Kenneth R. French's data library in the Dartmouth College, derived from the Fama and French 49 Industry Portfolios, which contains daily returns from July 1st, 2005 to June 30th, 2020. The daily portfolio return of the food products and chips industry were selected, and the daily excess return was calculated by deducting R_f. For the Fama-French 3-factor model, we performed the multivariable linear regression analysis on the excess return for both industries with factors: β_{Mkt}, β_{SMB} and β_{HML}. The same steps were also done for 5-factor model, except the additional β_{CMA} and β_{RMW}.

3. Results

The regression results of the FF3 model and FF5 were discussed separately. For foods product industry, the multivariable linear regression was applied on the daily food industry portfolio data selected from French's data library.

Table 1. Estimates for FF3-Food from July 2005 to June 2020

	Coefficients	*t Stat*	*P-Value*	*F*
Mkt-RF	0.661	76.041	0.000	2107.196
SMB	-0.149	-8.352	0.000	
HML	-0.068	-4.442	0.000	
R^2 = 0.626		Adjusted R^2 = 0.626		

Table 2. Estimates for FF5-Food from July 2005 to June 2020

	Coefficients	*t Stat*	*P-Value*	*F*
Mkt-RF	0.710	80.141	0.000	1420.508
SMB	-0.124	-7.132	0.000	
HML	-0.144	-8.956	0.000	
RMW	0.186	6.500	0.000	
CMA	0.535	15.400	0.000	
R^2 = 0.653		Adjusted R^2 = 0.653		

As shown in Table 1 and Table 2, $\beta_{Mkt-RF} < 1$ indicates that the food product industry is less sensitive to the economy fluctuation than the whole market. The results show a negative β_{SMB} and

β_{HML} in both 3-factor and 5-factor model. The results of the Fama-French 5-factor model show that the coefficients of the extra two factors, namely β_{RMW} and β_{CMA}, are all positive.

At the meantime, by employing the same analyzing strategy, we get the results below, as shown in Table 3.

Table 3. Estimates for FF3-Chips from July 2005 to June 2020

	Coefficients	*t Stat*	*P-Value*	*F*
MKT-R_F	1.139	123.835	0.000	5666.289
SMB	0.104	5.548	0.000	
HML	-0.334	-20.629	0.000	
R^2 = 0.818		Adjusted R2 = 0.818		

Table 4. Estimates for FF5-Chips from July 2005 to June 2020

	Coefficients	*t Stat*	*P-Value*	*F*
Mkt-R_F	1.128	116.155	0.000	3415.096
SMB	0.103	5.422	0.000	
HML	-0.307	-17.387	0.000	
RMW	0.007	0.217	0.000	
CMA	-0.150	-3.943	0.000	
R^2 = 0.820		Adjusted R2 = 0.820		

Table 3 and Table 4 are the results by applying FF3 and FF5 model on the US semiconductors industry through the calculation of multivariate linear regression. One thing we need to pay attention to is the factor of book-to-market ratio β_{HML} with a prominently negative coefficient. Besides, a very small coefficient of profitability factor β_{RMW} is shown in the result.

4. Discussions

In this article, the validity of the FF3 and FF5 models in the food products and semiconductors industries were analyzed. Then, each coefficient of factors in the model was further explored to explain the differences within the models and industries. For FF3 model, as shown in Table 1 and Table 3, the model fits well in both the food product industry and semiconductor industry. For FF5 model, based on Table 2 and 4, the model fits better in the food product industry than the semiconductor industry, since the RMW factor is a redundant factor with 0.217 in its t value.

4.1 Mkt-R_F Coefficients

As shown in Table 1 and Table 2, the βMkt-RF of food products is less than 1, indicating the market impact on fluctuation of the industry is relatively small. The relationship of supply and demand is inelastic, which explains why it can outperform the market during economy downturn. While, βMkt-RF in semiconductor industry is opposite, which can be considered as a cyclical industry and impacted by the innovation of technology. For example, it largely depends on the demand from its downstream industry such as electrical devices and equipment providers. Moreover, the consumption of the electrical devices largely relied on the prosperity of the economy. Besides, a semiconductor company often requires large capital, technology and labor resources. The semiconductor firms are always facing various challenges, such as failure in development and competitions, and some outer factors can also largely impact the industry such as international trade conflict. For example, the restriction of exporting chips foundry service to Huawei in US-China trade conflict has a significant influence on the industry. We can see the national restrictions on Huawei had also heavily impacted the chips suppliers in United States.

4.2 SMB Coefficients

In the result of the FF3 model, the β_{SMB} in the food products industry is negative, revealing that the industry is generally more inclined to the large-size firms than small-size firms. In early stages of the competitive market of the food product industry, several outstanding food companies complete great tasks in operational optimization and cost control and become oligarchies in the market after a series of merging and acquisition. Those large companies have reached an economy of scale and would have a large advantage comparing to the small companies, in terms of cost control and brand reputation. In the result of the FF3 model, the β_{SMB} in the chips industry is positive, meaning the industry are generally more inclined to the small-size firms. In the semiconductor industry, however, the large companies would not have any advantage in competing with the small-size one since the industry is still in the stage of rapid development with high-frequency technology iteration. Under such circumstances, small-size companies would have less burden and hesitation in adapting to new technology trends.

4.3 HML Coefficients

The results of Table 1 and Table 3 have shown negative results of βHML in both food product industry and semiconductor industry. However, the coefficient value for food product industry is very close to 0 whereas the coefficient value for semiconductor industry is -0.307, suggesting that the firms in semiconductor industry tend to have lower book-to-market ratio than the companies in the food product industry. The semiconductor companies with core technologies, on which people usually have great expectations on, always earn extremely high market value and thus relatively lower book-to-market ratio. As for the food industry, the close-to-zero value of HML could be interpreted by their insensitivity to the book-to-market ratio for portfolio return.

4.4 RMW Coefficients

In the results of FF5 model analysis, the profitability factor βRMW of firms in food product industry and semiconductor industry have shown the different inclinations on the profit choices for those two industries. The positive βRMW in the food products industry shows that the stock returns is higher for the firms with robust profitability in the recent 15 years. As an industry producing daily necessary goods for consumers, the firms in the industry usually have a robust income due to the inelastic demand for food products, and although the net margin rate for the industry might be really low, the gigantic amount of sales would bring firms relative robust profit at any time. As for the semiconductor industry, the coefficient of profitability factor is redundant, revealing the ability to earn profit is not an important factor in deciding the portfolio return in the stock market. This phenomenon probably could be explained by the hard demand for the large upfront investment in the semiconductor industry and thus semiconductors firms could rarely earn profits in the early stage. Thus, the profitability is not an important factor influencing the portfolio return of this industry.

4.5 CMA Coefficients

For Table 2 and Table 4, the coefficients of the investment style factor βCMA has shown great difference within the food product industry and semiconductor industry. The CMA coefficient is 0.535 in the food product industry, suggesting food product firms’ great inclination on conservative investment style rather than risk one. The companies in food product industry, as a traditional industry with a major role in the national economy, cannot put gargantuan amount of investment into research and development, nevertheless need to competitively control the cost and optimize the operation in order to compete with each other. Thus, the firms in the food product industry require highly conservative investment style. On the other side, the CMA coefficient for the semiconductor industry is negative, meaning companies in the industry are more tended to make risky choice when considering investment style. The semiconductor industry, as a high-tech industry, requires significant funding for the research and development of the new product, and a conservative company would not survive in this fast pace industry. Thus, a risky investment style would be more regular for the semiconductor companies.

5. Conclusion

In this paper, the FF3 and FF5 models have been empirically tested in the food product and semiconductors industry in US by applying multilinear regression analysis to the daily excess return of industry stock portfolios. The goodness of fit of each model in industries were compared, and the with the similar fitness of FF3 on both industries, FF5 model appears to fit better in food industry rather than chips industry due to the existence of one redundant RMW factor.

When we dive into the detailed comparisons of those factors in these two industries, the market coefficient has proven the food product industry as a less volatile industry during the fluctuation of whole economy. In terms of the size of companies, the size factor βSMB suggests food product industry is more preferred in terms of large size companies than chips industry is. Although both industries have same inclination on book-to-market ratio, shown by βHML, the semiconductor firms have much more tendency in having high market value but lower book value, which is a trait could be well explained by the constantly high valuation of technology companies.

When it comes to the profitability, the food product firms are more likely to pursue for consistent ability to earn profit, whereas on semiconductor side, the factor itself is redundant, showing profitability does not related to the return of chips portfolio. For the last factor of investment style, the food product enterprises have shown its strong favor in conservative investing style rather than the risky one, and the semiconductor industry is, on the contrary, prefer aggressive investments, which is an interesting contrast could be explained by the different nature of these industries.

After looking at the result of the Fama-French analysis, some investment opportunities about the two industries could be found out. It is recommended for investors to invest infood products company with large size, stable profitability and conservative investment style. As for the semiconductor company, investors should pick the companies with relatively smaller size and more aggressive investment style. An appropriate proportion of investment in these two industries can result in high return during economic upturn and defend our portfolio during economic downturn.

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