

The Comparison between CAPM and FF3 Model: Evidence from America

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Abstract. As the most developed financial market in the world, liquidity in the market remains in a very strong position despite the recent rise in long-end US bond rates. This paper compares the usefulness and characteristics of Capital Asset Pricing Model and Three Factor Model by using the regression model to carry out bigdata analysis from the US market between 2021 and 2022. Based on the analysis, Three Factor Model is better suited to today's market with the characteristic of variability and uncertainty. However, the concerns raised by previous studies regarding the momentum effect still remain unresolved. In order to enhance the reliability and precision, data spanning a longer period of time should be selected. This paper can be of great help to investors who need to make financial decisions, as it compares the beta of each stock with the beta calculated from two models to find out which model gives a more accurate forecast. Overall, these results shed light on beta evaluation model selection for the state-of-art approaches.

Keywords: Bigdata analysis; CAPM model; Fama-French model; Regression analysis.

1. Introduction

The way to estimate the return on assets has always been one of the main concerns for investors, which largely affects different kinds of financial decisions. As a result, many different models have been developed to estimate cost of equity for assets. Two of the most representative models among them are the Capital Asset Pricing Model (CAPM) developed by Sharpe in 1964 [1], which is also called single factor model, and the Three Factor Model introduced by Fama and French in 1992 [2]. CAPM is a financial model that establishes a linear relationship between the return on an asset and risk, it suggests that beta is the only factor that affect the risk on asset. Beta represents the amount of the movement of price of an individual asset per unit of price movement of the market. For example, if the beta for a stock is 1.3, it means that if the price for the market goes up for 10%, the increase in price for this stock should be 13%. The CAPM model has been well received since its introduction for a number of reasons. Firstly, Beta is considered as a very useful measure for the return on asset. Other scholars suggest that the definition for beta is very understandable and beta offers investors a quantifiable metric that makes the model very easy to compute [3]. In addition, Olweny explains that CAPM takes into account the beta, which is the systematic risk [4]. However, models such as the dividend discount model does not consider it. The systematic risk is crucial for financial decisions as it is unpredictable and cannot be mitigated by diversification. The assumptions of the CAPM model are crucial for evaluating the beta value of the underlying assets. Sharpe argues that CAPM should be based on several assumptions: all investors in the market are risk-averse; all investors have similar expectations on risk and return on their chosen assets; all investors have free access to all available information in the market, which means there is no cost for gathering information, etc. [1]. Nevertheless, the real world will not always be as expected. Because the assumptions of the CAPM model are so perfect, plenty of researchers believe that the model is not applicable to markets that are full of uncertainty. As a result, many studies on the flaws of the CAPM model have gradually emerged. When running the empirical test on CAPM, Basu finds that the model fails to show that stocks with higher earnings/price ratios have higher returns than stocks with lower earnings/price ration, and vice versa [5]. Jaffe et al. further confirm the study of Basu [6]. In addition, Banz indicates that the average

return for stocks of firms with low level of market capitalizations is higher than average return for stocks with high level of market capitalizations [7].

Most studies agree that the contradictions in the CAPM model are due to the fact that beta is not the only factor that affects the return on assets. Consequently, the Three Factor Model has been introduced. In addition to the original beta in CAPM, Fama and French has included size risk and Book-to-market Equity Ratio (BE/ME) factors into the model. Under this situation, compared with CAPM, two more inputs are needed when computing the Three Factor Model. Arshanapalli states that the Three Factor Model is not only works in the U.S. Market, but also applicable for most international markets around the world [8]. Whereas the most serious problem for the Three Factor Model should be the momentum effect. Other scholars claim that the momentum effect is different from the effect reflected by the BE/ME carried by Fama and French [9]. Furthermore, Fama and French find that both CAPM and Three Factor Model cannot explain the momentum effect [10].

Both pricing models have their own distinctive features as well as strengths and weaknesses, and the testing of both models by scholars and the controversy over them has continued to the present day. These two models have been developed over a long period of time, so the main motivation for this paper is to test whether they are still appropriate for a market that is completely different from that of the 1990s, i.e., give more insights to investors when deciding which asset to invest in. In addition, the paper also focuses on running tests to discover the main differences between the two models in order to find out under what circumstances each model can help investors to predict more accurate results. This paper focuses on the U.S. market because the chosen data and results can be more representative due to the more complete and mature financial system of the U.S. market. The rest parts of the paper are organized as follows. The Sec. II is the methodology for the testing which includes the data chosen from the U.S. market and the testing for CAPM and Three Factor Model. The Sec. III will explain and compare the result from testing of two models and then discuss the limitation of the method used for testing. The Sec. IV is the conclusion that concludes all the findings for the whole paper and also discuss the future prospects in related field.

2. Methodology

2.1 Data

The area of the focus of this paper is the U.S. Market. The Standard & Poor 500 Index and 13 Week Treasury Bill are chosen as market and risk-free rate. Six most representative organizations listed in same stock exchange (Nasdaq) were selected from six different industries, including Apple, Tesla, Netflix, Amazon, Microsoft and Marriot, and their daily stock close prices were obtained from Yahoo Finance from February 16, 2021 to February 11, 2022. In addition, these six stocks are all included in the Standard & Poor 500 Index.

2.2 CAMP model

CAPM is a useful financial model introduced by Sharpe in 1964, which indicates a linear mapping between the risk and return on investment. The daily stock prices for all the underlying assets are firstly used to test the CAPM model, which follows can be described as:

$$E(R_i) - R_{rf} = \alpha + \beta_i [E(R_{mkt}) - R_{rf}] \quad (1)$$

Where $E(R_i)$ is the expected return of the stock, R_{rf} is the risk-free rate, α is the abnormal rate of return on security, β_i stands for the coefficient beta, which is the measure of systematic risk and R_{mkt} is the expected rate of return on the market. Besides, the daily return on the stock of Apple, the standard deviation and beta for Apple and the correlation coefficient between market (S&P 500) and Apple are calculated by using Excel.

In particular, the HPR (holding period return) formula was used to calculate daily return as

$$HPR_n = \frac{P_{n+1} - P_n}{P_n} \quad (2)$$

Where the HPR is the holding period return, P_n is the value of stock at period n and P_{n+1} is the value of stock at period $n+1$. Subsequently, the following equation is used to calculate beta:

$$\beta = \frac{\text{Corr}(S, \sigma_s)}{\sigma_m} \quad (3)$$

Where σ_s is the standard deviation of security S and σ_m stands for the standard deviation of the market. Afterwards, the regression analysis will be carried out based on these calculated data to get the beta of apple and other 5 companies to know and compare their sensitivity to the movement of market.

2.3 Fama-French three-factor model

Now that the CAPM model is mentioned, another well-known model must be discussed, which is Fama French three factors model proposed by Fama and French in 1992 [11]. They discovered that the stock market's beta value could not explain the differences in stock returns, but that market capitalization, book-to-market ratio, and P/E ratio of publicly traded companies did. As a result, they come to the conclusion that the aforementioned extra returns are compensation for risk variables that are not captured by CAPM. Second, the three-factor model will be introduced and showed how to explain the return rate of stocks [12].

$$E(R_i) - R_{rf} = \beta_i [E(R_{mt} - R_{ft})] + s_i(SMB_t) + h_i(HML_t) + \alpha \quad (4)$$

Here, R_{ft} represents the risk-free rate, R_{mt} represents the market rate of return and $E(R_{mt}) - R_{ft}$ denotes the market risk premium. As for another 2 factors, SMB_t is the simulated portfolio return rate of the market value factor of time t (Small minus Big) and HML_t is the modelled portfolio return rate of the book-to-market factor of time t (High minus Low). Subsequently, the regression model of the three factors model will be talked about and R_{it} is the rate of return of asset I at time t .

$$R_{it} - R_{rf} = \alpha_i + \beta_i [E(R_{mkt}) - R_{rf}] + s_i(SMB_t) + h_i(HML_t) + \varepsilon_i \quad (5)$$

3. Results & Discussion

3.1 CAPM model

After calculating all fundamental values, the regression analysis should be carried out to get the value of beta in Eq. (1). The regression function of Excel was applied by using the excess stock return of Apple (stock price of Apple-risk-free rate) as the Y-axis and the excess market return (market-risk-free rate) as the X-axis to derive the final result as shown in Table 1.

According to the results, the value for intercept, which is α , is -0.00556. The confidence level for the regression analysis is 95%, the p-value is 0.03422, which is less than 5%. This shows that the value of α is statistically significant and Apple does not have an excess return compared with the market. In addition, the value of beta is about 0.76, which means that the market can explain 76% of the movement of Apple. However, the 5-year monthly beta for Apple in Yahoo Finance is 1.19, which is different from the beta calculated by CAPM. This is because the time period for chosen data is only one year, which is not long enough to get a representative result. Apart from the data, stock prices of organizations are affected by multiple factors and participants in financial market are not all rational and have the same level of risk preference. However, CAPM model itself just take one factor into account and also have assumptions that do not really correspond to the reality, this may contribute to

the difference between calculated value and the value observed from Yahoo Finance. The same method was applied to other 5 companies and results for the 6 companies are shown in Table 2. One sees that Microsoft reacts the most to the market as it has the highest value of beta, which is 0.83, and Marriot reacts the least to the market with the beta of 0.29.

Table 1. Regression result for Apple

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	-0.00556	0.002609	-2.13172	0.03422	-0.01071	-0.00042	-0.01071	-0.00042
beta	0.756539	0.072269	10.46832	8.08E-21	0.614052	0.899026	0.614052	0.899026

Table 2. Intercept and beta for 6 organizations

	Apple	Tesla	Netflix	Amazon	Microsoft	Marriot
Intercept	-0.00556	-0.36332	-0.00072	-0.00045	0.00122	0.01312
beta	0.756539	0.772987	0.345254	0.453754	0.833867	0.289367

Table 3. Regression result for Apple by FF3F model

	Coefficients	Standard Error	t Stat	P-value	Lower 95%	Upper 95%	Lower 95.0%	Upper 95.0%
Intercept	-0.000808	0.000891	0.906629	0.365815	-0.00095	0.002566	-0.000950	0.002566
Market RF	-0.987228	0.001214	-813.035	0	-0.98962	-0.98483	-0.989624	-0.984832
SMB	-0.007597	0.002207	-3.44315	0.000715	-0.01195	-0.00324	-0.011952	-0.003243
HML	-0.008215	0.001178	-6.97663	5.58E-11	-0.01054	-0.00589	-0.010539	-0.005892

Table 4. Intercept and 3 betas for 6 organizations

	Apple	Tesla	Netflix	Amazon	Microsoft	Marriott
Intercept	-0.000808	0.000806	0.002303	-0.0003	0.000924	-1.9E-05
Market RF	-0.987228	-0.98499	-0.97998	-0.99101	-0.99044	-0.99244
SMB	-0.007598	0.003497	0.012532	-0.00531	-0.01125	-0.00809
HML	-0.008215	0.009163	-0.01335	-0.00888	-0.00784	-0.00932

3.2 FF3F model

According to the introduction of FF3F model, the Eqs. (4) and (5) can be used to conduct the regression analysis of the companies. Primarily, Apple will be analyzed as an example as given in Table 3. First, the explanation of coefficient will be given. According to Blanco, the positive value of SMB coefficient indicating that the performances (evaluated in terms of return) will be better for the small-cap underlying assets, vice cetera [13]. If the HML's coefficient is negative, indicating that the growing underlying assets (low book-to-market) will be preferred. Seen from Table 4, we can find that except Marriot, all of these companies have negative HML coefficient. From point of Basiewicz and Auret, this suggests that HML has a negative impact on these companies' excess returns. Based on the analysis, the portfolio will be favorable to allocate growth equities with a low book-to-market ratio in the selected time period. Nevertheless, on account of the lower excess returns of the underlying assets during this period, the gains of the fund are limited [14]. Except for Marriott and Tesla, all of these companies have a negative SMB coefficient, indicating that Marriot and Tesla may prefer to allocate to large-cap stocks and that their excess returns are influenced by large-cap stock returns.

3.3 Comparison

Based on the analysis, the fact of pricing model is closer to Sattar's argument, which indicates that this model has better performance than CAPM model to some extent because beta itself cannot predict most of the changes in cross-section returns [15]. However, Bhatt and Rajaram claimed that the three-factor model has more complex structures than CAPM, so it requires more time to calculate. If our portfolio variety exceeds a certain amount, practitioners may find it not worth the effort to gather the additional information they need because in this case the market may change faster than our analysis can [16]. Although both of these models can tell us a little bit more about the investment style of this

fund, Bello argued that maybe FF3F accounts for its risk properly or on a more proper manner and resulting different alphas than CAPM, which means more reliable alphas or measure of excess return or performance [17].

3.4 Limitation

As a matter fact, this paper has some defects that should be addressed, which mainly lies in the fact that the selected assets are less, i.e., there are fewer ranked combinations of assets. The sample size seems so small that more evidence is needed to support the generalization. Furthermore, the fact is, the only ranking variables available in this study rely on the same size and value characteristics used to create risk factors. Even though our investigation indicated a statistically weak association, Lam claimed that Fama and French's work has to be based on a longer sample period and a bigger cross-section of wages data. Moreover, it should have understood that the three-factor model is unable to regarded as the eventually version of pricing model [18]. According to Bilou, many aspects of the three-factor model, including as short-term reversals, medium-term momentum, volatility, skewness, gambling, and other elements, remain unexplained, which all affect the actual stock returns but the three-factor model does not predict them [19]. Overall, the limitation is lack of more long-term data evidence and analysis to prove the generality of our study.

4. Conclusion

In summary, this paper investigates the usefulness and comparison between CAPM model and Three Factor Model based on stock price data chosen from the U.S. market. The result shows that the value of beta calculated by CAPM model is slightly different from the beta given by Yahoo Finance. In contrast, the difference between the beta calculated by Three Factor Model and the beta shows on website is less. This concludes that the Three Factor Model beats over CAPM model as the former takes more factors into account such as size risk and Book-to-market Equity Ratio. However, this study still has the limitation that the asset class is homogeneous and the sample size is too small to show generality of results. Moreover, this paper still does not figure out the momentum effect that contradicts to theories of CAPM and Three Factor Model. In order to improve accuracy of results and find ways to refine these two models, more categories of assets and even portfolios with longer time period should be chosen. In addition, apart from the U.S. market, market that has rarely been studied by academics also deserves more in-depth exploration. Overall, these results offer a guideline to investors when they are choosing a model to predict the price movement of assets.

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