A Comparison of Three Asset-pricing Models During COVID-19

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Abstract. With the shock of COVID-19 pandemic bringing changes to world economy, it is necessary to reexamine the efficiency of models for asset pricing. In this paper, three different financial assets models, namely the CAPM as well as Fama-French (FF) three factor and five factor model, have been applied to provide explanation for the return of pharmaceutical industry of the US during the COVID-19 pandemic. According to the analysis, it is congruent with existing theories suggesting greater explanation capacity of the FF models over the CAPM and in this case, the FF five factor model is superior to the three factor one. However, the FF models are more complex than the CAPM and it takes more time and effort to conduct the calculations. It provides evidence that despite the restructuring of world economy the three models still stand and the FF5 model has the best explanatory power out of the three. These results shed light on guiding further exploration of financial asset-pricing models application in specific times.

Keywords: COVID-19, CAPM, Fama-French three-factor Model, Fama-French five-factor Model.

1. Introduction

The past few decades have witnessed numerous unexpected changes, and many have brought severe damage to world economy as well as human well-being. Among them, one of the most widespread and destructive crises globally would be the COVID-19 pandemic, causing irreversible and long-lasting recession in nearly every country on earth. In 2020, the WHO referred to the illness as a pandemic. This kind of huge shock to economy may bring along problems to existing financial theories and models and thus require a further and more thorough inspection. This paper aims to evaluate the effectiveness of several currently existing asset-pricing models during the pandemic and provide insight on future applications of asset-pricing models.

Evaluating expected portfolio returns and cost of equity for stocks has been one of the most central questions in the field of financial economics constantly. Three main models were developed and are frequently utilized for this purpose. The first one would be Capital Asset Pricing Model (CAPM), constructed on the Markowitz model for portfolio selection [1]. It was then extended by many scholars including Sharpe [2], Lintner [3], Mossin [4], Fama [5], Jensen and Scholes [6]. The CAPM overall is employed in the pricing of risky assets which provides a linear framework for the connection between risk and expected return. It is widely used ever since. Research shows that 73.5% in 392 CFOs in America [7] and approximately 45% of 313 European companies rely on this theory for analysis and find the cost of equity [8]. As a classical approach, many scholars have challenged this model and tested its drawbacks, for example, empirical evidence has shown that poor quality of market portfolio proxy can weaken the performance of CAPM model [9] and lots of researchers have made extended versions of this model trying to overcome the original model's limitations.

FF three-factor Model proposed in 1993 has been recognized as a better explanation for expected returns. Based on CAPM, the model added two more factors to explain market value effect. According on the empirical findings, this three-factor model has a good explanatory power for effectively analyzing cross-section stock portfolios rate of return. However, this model has its limitations as well. In 2015, a five-factor model was constructed by Fama and French directed at giving more comprehensive description, including size, investment patterns, value, and profitability, in average stock returns [10]. Many have applied these asset-pricing models into analyses for different countries and industries. Guo et al. tested the five-factor asset pricing model in the Chinese stock market [11]. They found that the profitability factor is significantly better when describing average return, but the investment factor makes rather small contributions. Many other scholars have empirically applied the

five-factor model as well. Ozkan evaluated the model based on ISE [12] while Chiah applied the model on Australian stock market [13]. Lin further approved that on Chinese equity market [14]. For the Indonesian Stock Exchange Hapsari and Wasistha conducted similar research [15]. Research on comparison between these models is also conducted to find out which has better performance under different circumstances. Drew and Veerarghavan compare the first two models' performance for Hong Kong, Korea, Malaysia and Philippines [16] and found that the FF3 model is better than the CAPM in terms of explaining the variation of stock returns. Trimech et al. tested the ability of FF3 model of prediction of stock return in the French stock market at multiple time scales [17]. Shaker and Elgiziry compared the three models along with their two counterparties for Egyptian stock market and showed evidence that the Fama-French model is the best [18].

Overall, it seems that model effectiveness can vary when analyzing different economy or in different periods of time. Hence the main concern of this essay is to test which of the three models work most effectively in the post-pandemic era especially in American pharmaceutical industry when it is strongly affected by the pandemic. The following of the essay is structured as below. The data and techniques utilized in this passage would be briefly described in the second section. Section 3 provides details of empirical analysis and result. Section 4 talks about limitations and future outlooks and after that section 5 is where conclusions are drawn.

2. Methodology

2.1. Data and evaluations

Data and returns of listed firms in the US stock market is obtained from Yahoo Finance and the data library of Kenneth R. French (collection from CRSP and Bloomberg database) and is examined based on the Microsoft Excel program. Beta is estimated using the Scholes-Williams method. Portfolios are constructed with the closing price of each time period selected. All models (the CAPM, Fama-French three factor and five factor model) were used to determine the effectiveness of the models by regression. comparing with each other. Five companies are randomly picked from the industry namely Biogen Inc. (BIIB), Bristol-Myers Squibb Company (BMY), Johnson & Johnson (JNJ), Merck & Co., Inc. (MRK), Pfizer Inc. (PFE), owing to the timing and availability of trade data. Total 3890 daily observations were taken into consideration from October 2019 to October 2022, covering the time of pandemic, which is enough to make the research reliable. For the computation, only the capital gain was taken into account. Cash or stock dividends are not factored into the pricing, and excess return was computed by deducting the risk-free rate from the return on each individual stock. Figure 1 plots the five companies' daily rate of return over the three years.

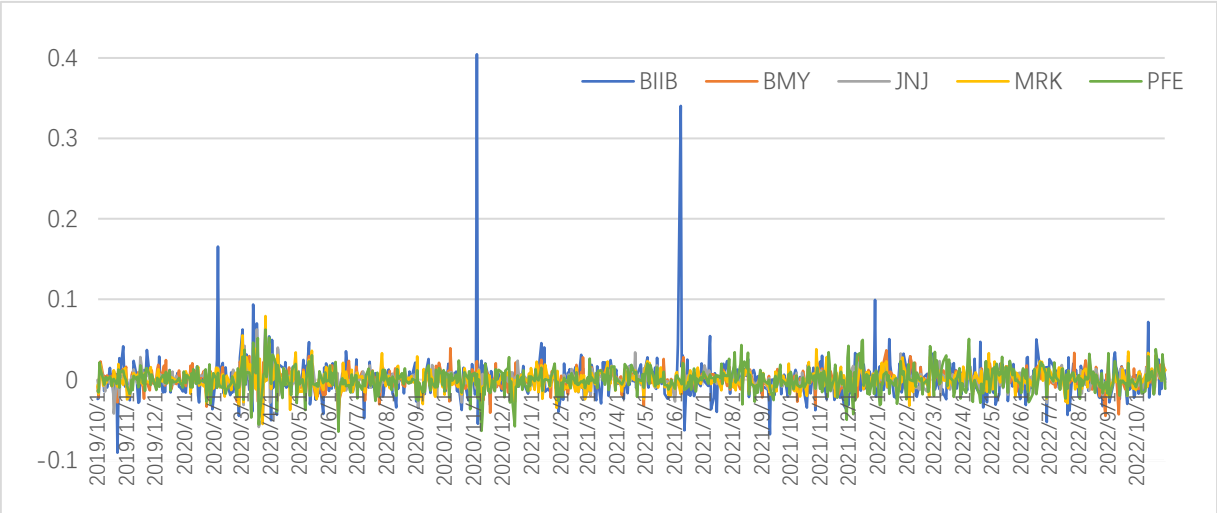

Figure 1. Five companies' daily return (Oct. 2019 – Oct. 2022)

This paper is quantitative and uses traditional statistics methods like simple or multiple linear regression analysis. In order to make a comparison between the three asset-pricing models, a performance is required for each. For CAPM, simple linear regression is used and for Fama-French models, multiple variable regression is used. For the CAPM and the FF three-factor model, regression was done using the excess return of each of the five stocks versus market excess return as well as against market risk premium, size premium, and value premium. Regression analysis was done with 95% confidence level, which means α, the level of significance, was 5%. Adjusted R^2 is used for examining the accuracy of the regression's results. A relatively low p-value stands for a statistically significant study.

2.2. Models

The capital asset pricing model (CAPM), a financial model that is frequently used in the pricing of risky securities, describes the relation of return and systematic risk [19]. The CAPM states that there is a linear relationship between a stock's necessary return and its beta, which stands for systematic risk. The core of the model would be this single factor systematic risk. The equation of the CAPM is here below,

$$E(R_i) = R_f + \beta_i\big(E(R_m) - R_f\big) \tag{1}$$

In which $E(R_i)$ is the expected return from risky asset i, R_f is the risk-free rate, R_m is average market return, usually taken as market proxies, β is the systematic risk calculated with the equation of $\beta = Cov(R_i, R_m)/\partial m^2$.

Fama and French further added another two variables to CAPM equation:

$$E(R_i) = R_f + \beta_i\big(E(R_m) - R_f\big) + s_i SMB + h_i HML \tag{2}$$

Here, $E(R_i)$, R_f, and R_m, same as CAPM, stand for portfolio's expected return, risk-free return rate and the market return respectively. SMB is the value of small market cap minus big market cap and HML is the gap between high and low book-to-market ratio. Coefficients β_i, s_i, h_i follow the regression model as below.

$$R_i - R_f = a_i + \beta_i\big(R_m - R_f\big) + s_i SMB + h_i HML + \varepsilon_i \tag{3}$$

Novy-Marx found that the FF3 Model was unable to account for variations in profitability and average return on investments [20]. Fama and French then introduced two elements (i.e., profitability and investment factors) to correct these flaws.

$$E(R_i) = R_f + \beta_i\big(E(R_m) - R_f\big) + s_i SMB + h_i HML + r_i RMW + c_i CMA \tag{4}$$

Here, $E(R_i)$, R_f, R_m, SMB and HML are the same as the first two models. RMW and CMA are the two newly added factors where RMW denotes robust minus weak. On the other hand, conservative minus aggressive is what CMA stands for.

3. Results & Discussion

A simple linear regression of daily excess return over the period of three years of each of the five companies' stock against market premium is run for CAPM. Daily data is used instead of weekly or monthly data because it has better performance for all five companies. Daily excess return is used to perform multiple linear regressions against the market risk premium, size premium, and value premium in the Fama-French three component model (Small minus Big and High minus Low respectively). For the FF5 model a similar regression to the three factor one is conducted with two more factors RMW and CMA. Table.1. shows the result of the CAPM regression. P value is zero for all five companies and average adjusted R^2 is 6.94%. Table. 1. summarizes the findings of the FF3 model regressions. P value is also zero for all five companies and average adjusted R^2 is 11.82%.

Table.3. lists the result of the FF5 model regression. P value is again zero for all five companies and average adjusted R^2 is 14.38%.

The FF5 model has the highest explanation power, followed by the three-factor model and finally the CAPM, according to the regression findings from the three tables above. Based on comparisons of adjusted R^2 values, which considerably increase for each organization as the model transitions from CAPM to Fama-French three factor to five factor. A low p value for all three regressions denotes statistical significance for the study. In the three-factor model, changes in beta shows that there are many other variables to explain the variability than just market portfolio as captured by CAPM. The SMB column's total negative coefficients show that large businesses often have larger returns in this period in the US pharmaceutical industry, which is congruent to the fact that they are more stable and have more capital in development during this recession time in general than their smaller counterparts. Similarly, all five coefficients in the HML column are negative indicating lower return for high book to market value firms. In the five-factor model, the overall non-positive coefficients of the SMB column suggest a similar conclusion that big firms tend to have higher return. Additionally, the HML column's five coefficients are all negative, indicating inferior return for companies with larger book-to-market values.

Table 1. CAPM Linear Regression Results

Company	R^2	Adjusted R^2	beta	t-value
BIIB	8.58%	8.46%	0.0050	8.53
BMY	3.62%	3.49%	0.0014	5.40
JNJ	9.07%	8.95%	0.0021	8.80
MRK	7.49%	7.37%	0.0021	7.93
PFE	6.55%	6.43%	0.0024	7.38

Note: the regression is conducted at 95% confidence level

Table 2. FF3 Model Regression Results

Company	R^2	Adjusted R^2	Rm-Rf	SMB	HML	F
BIIB	11.43%	11.09%	0.0051	-0.0009	-0.0034	33.3
BMY	4.68%	4.31%	0.0016	-0.0016	-0.0001	12.68
JNJ	19.42%	19.11%	0.0026	-0.0046	-0.0001	62.18
MRK	12.34%	12.00%	0.0024	-0.0034	0.0000	36.31
PFE	12.93%	12.59%	0.0028	-0.0047	-0.0002	38.3

Note: the regression is conducted at 95% confidence level

Table 3. FF5 Model Regression Results

Company	R^2	Adjusted R^2	Rm-Rf	SMB	HML	RMW	CMA	F
BIIB	12.1%	11.53%	0.0067	0.0021	-0.0025	0.0026	0.0094	21.24
BMY	7.48%	6.88%	0.0020	-0.0010	-0.0012	-0.0000	0.0047	12.49
JNJ	24.76%	24.27%	0.0031	-0.0034	-0.0013	0.0015	0.0056	50.8
MRK	14.44%	13.88%	0.0028	-0.0030	-0.0005	-0.0000	0.0041	26.06
PFE	15.87%	15.33%	0.0033	-0.0034	-0.0014	0.0018	0.0054	29.13

Note: the regression is conducted at 95% confidence level.

Overall, it appears that the systematic risk factor beta alone has less ability to explain the excess return. The adjusted R^2 in the regression model of the time series data is increased by incorporating size and value beta, and this explanatory power is further increased by including the RMW and CMA factors. FF3 model is better when predicting the excess return over R_f than the CAPM for all the five companies of pharmaceutical industry over the period of 2019-2022 and FF5 model is even better than the three factor one. It is congruent with the theoretical models of Fama-French and their deduction. However, it is also worth noticing that the Fama-French models require far more data and effort than the CAPM, so the time and other cost might be higher and consequently causing an overall less effective performance.

4. Limitation & Prospects

Admittedly, the study is limited by a relatively small sample size on one hand since the pandemic has only been three years and on the other there are only five companies selected. The sample might also be biased since all five of selected firms are survivors through the pandemic, which means the performance is relatively good. There may exist a lookahead bias when apply these models in calculating, for example, expected return as well using only historical data.

In future studies, when the time span extends, there may be more data available for similar analysis and more companies can be applied to further test the three models. A robustness test may also be conducted to further verify the explanatory power of the indices. The pandemic has severely influenced the economy and pharmaceutical industry, which is difficult to explain from just one or two perspectives. Future analysis may focus on the overall effectiveness of the three or even more pricing models and find further conclusions.

5. Conclusion

In summary, CAPM, Fama-French three factor and five factor model have been applied to explain the return of pharmaceutical industry of the US during the COVID-19 pandemic. The findings are consistent with theories that claim the Fama-French models have better explanatory ability than the CAPM since beta by itself cannot forecast the variance in return. Moreover, the FF5 model is better than the three factor one in this scenario. However, the Fama-French models are a lot more complex than the CAPM and it takes more time and effort to conduct the calculations. It may not be cost effective for practitioners to use the Fama-French three and five factor models. Individual investors may lack the expertise to use the Fama-French models with comprehensive data hence reduce the effectiveness and institutional practitioners should also evaluate the cost required before replacing the CAPM with the other two models when doing stock return analysis. Only the pharmaceutical industry in America is analyzed with the CAPM, the FF3 model and the FF5 model. It is not within the scope of this work to compare the efficacy of these models in other industries, which leaves opportunity for future research on the best strategy for both individual and institutional investors and academics. These results offer a guideline for future studies of asset pricing models as well as how the COVID-19 pandemic affects the assessment efficiency of the models.

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