Comparison of CAPM and Fama-French Three Factor Model in the Auto-mobile Industry

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Abstract—CAPM and the Fama French 3 Factor model (FFM3) are often used to calculate the rate of return. This paper attempts to verify that the Fama French 3 Factor model has better accuracy than the CAPM model in explaining the impact of the pandemic on American automobile companies. Specifically, the data from 5 companies are analyzed based on the CAPM model and the Fama French 3 Factor Model and calculating the coefficient value of the two models. The results show that after calculating the coefficient value of the data obtained in two ways, the coefficient value of the FFM3 is lower. Meanwhile, the prediction calculated by Fama French 3 Factor Model has a higher adjusted R square value than the prediction calculated by CAPM. It means that the FFM3 can more accurately predict the return of American automobile companies during the epidemic than the CAPM model. Therefore, this paper concludes that due to the impact and impact of COVID-19 on the market, in order to predict the return rate of automobile companies more accurately, in order to reduce or predict the impact of COVID-19, Fama French 3 Factor Mode would be a better choice than the CAPM model. These results shed light on guiding further exploration of the future investment and the prediction of the rate of return of American automobile companies during the epidemic in recent years.

Keywords-CAPM; Fama-French three-factor models; COVID-19.

1 INTRODUCTION

Investors are constantly finding a method that can achieve a more convenient and accurate result. This claim is true for all areas including the finance field. The comparison between different models is an essential process for developing financial anticipation [1]. In general, Capital Assets Pricing Model (CAPM) is one of most significant milestones among the development of contemporary asset pricing models based on the concepts of the Portfolio Theory of Markowitz [2, 3]. According to the analysis of well-known scholars (e.g., Sharpe, Litner et al.), it shows that the increase of risk for the underlying assets in the portfolio will affect its expected return [4-6].

Nevertheless, the CAPM model faces challenges in some markets due to the bias of the explanation with poor regression performances in terms of the statistical concepts. To enhance

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the accuracy and explanation ability of the asset pricing models, Fama and French investigated other extra factors that affect the expected returns in 1992, which is later known as Fama French 3 Factor model (FFM3) [7]. According to the empirical analysis, the beta value of the stock market cannot explain the difference in stock returns, while the book market ratio and P / E ratio of listed companies can explain the difference in stock returns, which was considered as an impact on β in CAPM. Compensation for risk factors is not reflected [7, 8].

Contemporarily, a large amount of empirical studies have been carried out to test the effectiveness of the CAPM and FFM3, but the results vary a lot. According to previous literature, the CAPM does well in Chinese market, generating non-biased risk-adjusted alpha in most fund types [9]. This conclusion might not be successful for other markets, including the market we want to analyze, the American car market [10]. With this in mind, we will compare the accuracy of CAPM and FFM3 with their advantages and disadvantages using the method of doing regression analysis of different car companies and comparison to check the accuracy of different models. We collected daily stock data of five motor companies from 2021/1/1 to 2021/12/31 as well as the Fama French Factors from Kenneth's Website from the period. Then we did a regression analysis of those data. It is found that FFM overall has better prediction accuracy against CAPM.

The rest part of this article will be organized as follows. Sec II will introduce the data origination and analysis method. Sec. III will demonstrate the results and give explanations. Eventually, a summary will be given in Sec. IV.

2 DATA & METHOD

We used two different models for predicting rate of return, i.e., the FFM3 and the CAPM. CAPM only has a single factor in the calculation model formula, while FFM3 has three factors. The CAPM formula is as follows:

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

where R_i is the expected return of the investment; R_f is the risk-free rate that is treated as a constant term and added to the value. βi is the single factor of the formula which represents the relationship between investments and markets; R_m is the expected market return; the term (Rm-Rf) represents the market risk premium. The FFM3 is quite different from the CAPM. In the FFM3 model, there are three factors that affect the value of the expected investment. The FFM3 formula is:

$$R_i = R_f + \beta_i(R_m - R_f) + \beta_S SMB + \beta_H HML \tag{2}$$

Compare with the CAPM formula, FFM3 formula has two more factors β_S and β_H with variables SMB and HML. R_i and $\beta_i(R_m\text{-}R_f)$ are the same factor that appears in the CAPM formula. The factor β_S represents the coefficients of the underlying assets; SMB is the size premium; β_H represents the coefficients of security i to movements in value stocks; HML means the value premium.

To compare which of the two models is more accurate on predicting the expect return of American automobile companies during the epidemic time, we need to use the linear regression

model to calculate the adjusted R square value and coefficient value. Due to the different number of factors appear in the two models, we need to apply both Multiple Linear Regression and Single Linear Regression model to calculate.

Multiple Linear Regression can be described as

$$Y_i = \beta_0 + \beta_1 x_1 + \cdots + \beta_p x_p + \epsilon \tag{3}$$

where Single Linear Regression is:

$$Y_i = \beta_0 + \beta_1 X + \epsilon \tag{4}$$

Here Y_i is the dependent variable that is the expected return; $\beta 0$ is the y- intercept; β_p is the slope; X is the independent variable, ϵ is the model's error term, which is residuals. In order to get the factors and the variables that appear in the formulas, we need to use the data from the website named Kenneth R. French who once came up with the Fama French Model with Eugene F. Fama. The website provides the factors needed to calculate the Fama French Model. In addition, it is also necessary to use the data of companies to calculate the models that is provided by Yahoo Finance.

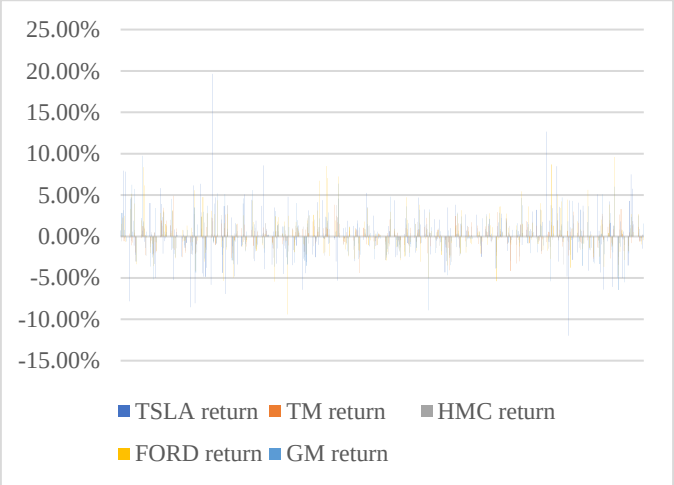

Figure 1. Expect Return of companies.

3 RESULTS & DISCUSSION

3.1 CAPM Regression Results and Analysis

1250 observations were collected in total from five US motor companies (Ford Motor, Tesla, General Motor, Honda Motor Co., and Toyota Motor) from January 1st, 2021 to December 31st, 2021. For each of the company chosen, data of 250 days was collected, calculated, and interpreted. Owing to the impact of COVID-19 pandemic, 2021 was a tumultuous and turbulent year for the whole world's economy, and the US market was impacted as well. Table 1 represents the regression results of the five different companies during the year of 2021 using the CAPM as the prediction tool, which means only use the market premium as a sole risk factor.

The table indicates that this model did not do a great job in predicting the stock return, and the adjusted R^2 ranges from 0.146 to 0.267. The standard error is generally small, ranging from 0.012 to 0.030. In the 1250 total observations, the average R^2 is 0.195, suggesting that the CAPM correctly predicted about 20% of the stock return of the five different US motor companies in the year of 2021.

Table1 CAPM Regression Results

Regression Statistics					
Company	Ford	Tesla	GM	HMC	TM
Multiple R	0.413	0.520	0.456	0.438	0.386
R^2	0.171	0.270	0.208	0.192	0.149
Adjusted R^2	0.168	0.267	0.205	0.188	0.146
Standard Error	0.024	0.030	0.022	0.012	0.013
Observations	250	250	250	250	250

Table 2 ANOVA of CAPM Regression Results

	df	*SS*	*MS*	*F*	*Significance*
Ford					
Regression	1	0.029	0.029	51.101	9.785E-12
Residual	248	0.142	0.001		
Total	249	0.172			
Tesla					
Regression	1	0.080	0.080	91.747	1.078E-18
Residual	248	0.217	0.001		
Total	249	0.297			
GM					
Regression	1	0.031	0.031	65.094	3.071E-14
Residual	248	0.117	0.000		
Total	249	0.147			
HMC					
Regression	1	0.009	0.009	58.821	3.928E-13
Residual	248	0.037	0.000		
Total	249	0.046			
TM					
Regression	1	0.007	0.007	43.551	2.484E-10
Residual	248	0.040	0.000		
Total	249	0.046			

Table 3 Coefficients of CAPM Regression Results

	Coefficients(β)	*Std*	*t*	*P-value*
Ford				
Intercept	2.702E-03	1.525E-03	1.773E+00	7.752E-02
Mkt-RF	1.231E-02	1.721E-03	7.148E+00	9.785E-12
Tesla				
Intercept	1.845E-04	1.882E-03	9.804E-02	9.220E-01
Mkt-RF	2.036E-02	2.125E-03	9.578E+00	1.078E-18
GM				
Intercept	5.434E-04	1.381E-03	3.936E-01	6.942E-01
Mkt-RF	1.258E-02	1.559E-03	8.068E+00	3.071E-14
HMC				

Intercept	-4.823E-04	7.816E-04	-6.171E-01	5.377E-01
Mkt-RF	6.768E-03	8.825E-04	7.669E+00	3.928E-13
TM				
Intercept	2.565E-04	8.031E-04	3.193E-01	7.497E-01
Mkt-RF	5.985E-03	9.069E-04	6.599E+00	2.484E-10

Table 2 is the ANOVA of the CAPM regression results. The significance F in the table is the p-value for the F test of overall significance. Among all the five companies, the significance F are ranged from 1.078E-18 to 2.484E-10, and all of them are significantly small enough. Those values are much smaller than the significance level of 0.05, consequently, we can conclude that our regression model is statistically significant.

The Table 3 is the coefficient analysis table for CAPM regression result. Since CAPM is a single factor model, the result only shows the data of market risk premium. The p-values are generally very small, ranged from 1.078E-18 to 2.484E-10. The betas of market risk premium are all positive ranging from 6.768E-03 to 2.036E-02.

Table 4 FF3FM Regression Results

Regression Statistics					
Company	Ford	Tesla	GM	HMC	TM
Multiple R	0.572	0.633	0.622	0.514	0.429
R^2	0.328	0.400	0.387	0.265	0.184
Adjusted R^2	0.319	0.393	0.379	0.256	0.174
Standard Error	0.022	0.027	0.019	0.012	0.012
Observations	250	250	250	250	250

Table 5 ANOVA of FF3FM Regression Results

	df	*SS*	*MS*	*F*	*Significance*
Ford					
Regression	3	0.056	0.019	39.955	4.536E-21
Residual	246	0.116	0.000		
Total	249	0.172			
Tesla					
Regression	3	0.119	0.040	54.709	3.969E-27
Residual	246	0.178	0.001		
Total	249	0.297			
GM					
Regression	3	0.057	0.019	51.700	6.027E-26
Residual	246	0.090	0.000		
Total	249	0.147			
HMC					
Regression	3	0.012	0.004	29.495	2.519E-16
Residual	246	0.034	0.000		
Total	249	0.046			
TM					
Regression	3	0.009	0.003	18.489	7.537E-11

Residual	246	0.038	0.000		
Total	249	0.046			

3.2 FF3FM Regression Results and Analysis

The table 4 is the regression results of predicting the stock return of the five motor companies in 2021 using Fama-French 3 factor model (FF3FM). Different from CAPM, FF3FM has three factors that contribute to the return rate calculation. By applying the three different factors, the adjusted R^2 ranges from 0.174 to 0.393 across different companies. The range is acceptable in the light of the turbulent market due to pandemic. The average R^2 of FF3FM from the regression result is 0.304, indicating that that the FF3FM correctly predicted about 30% of the stock return of the five different US motor companies in the year of 2021.

Table 5 is the ANOVA of the FF3FM regression results. Similar to the CAPM ANOVA results, the significance F are significantly small, ranged from 3.969E-27 to 7.537E-11. Consequently, we can conclude that our regression model is accurate to some extent according to the criterion of statistics. In addition, the overall average significance F value is smaller than that of CAPM, indicating that FF3FM has better predicting accuracy against CAPM.

Table 6 Coefficients of FF3FM Regression Results

	Coefficients(β)	*Std*	*t*	*P-value*
Ford				
Intercept	2.271E-03	1.388E-03	1.637E+00	1.030E-01
Mkt-RF	1.162E-02	1.726E-03	6.734E+00	1.161E-10
SMB	7.380E-03	1.774E-03	4.160E+00	4.393E-05
HML	7.271E-03	1.236E-03	5.882E+00	1.316E-08
Tesla				
Intercept	1.640E-03	1.725E-03	9.507E-01	3.427E-01
Mkt-RF	1.445E-02	2.145E-03	6.734E+00	1.160E-10
SMB	9.071E-03	2.204E-03	4.115E+00	5.292E-05
HML	-9.858E-03	1.536E-03	-6.417E+00	7.090E-10
GM				
Intercept	-7.116E-05	1.228E-03	-5.795E-02	9.538E-01
Mkt-RF	1.287E-02	1.528E-03	8.428E+00	2.987E-15
SMB	5.270E-03	1.570E-03	3.358E+00	9.110E-04
HML	8.095E-03	1.094E-03	7.401E+00	2.141E-12
HMC				
Intercept	-7.996E-04	7.536E-04	-1.061E+00	2.897E-01
Mkt-RF	7.448E-03	9.374E-04	7.945E+00	6.961E-14
SMB	5.415E-04	9.633E-04	5.622E-01	5.745E-01
HML	3.238E-03	6.713E-04	4.823E+00	2.479E-06
TM				
Intercept	3.495E-06	7.951E-04	4.395E-03	9.965E-01
Mkt-RF	6.691E-03	9.892E-04	6.765E+00	9.674E-11
SMB	-2.492E-04	1.016E-03	-2.452E-01	8.065E-01
HML	2.287E-03	7.083E-04	3.229E+00	1.409E-03

The Table 6 is the coefficient analysis table for FF3FM regression result. FF3FM is a three-factor model, hence the analysis includes the three different factors. The p-values for market risk premium and HML are all very small, from 2.987E-15 to 1.409E-03. However, for SMB,

the p-value is notably higher than the other two factors, from 4.393E-05 to 8.065E-01, especially for HMC and TM. This may be because the TM (Toyota Motor) and HMC (Honda Motor Co.) are Japan companies, and market turbulence due to the COVID-19 situation influenced the small business corporations in Japan, causing the p-value to change. The betas for all three factors are all positive except HML of Tesla and SMB of TM. It is unsurprising that the βs is negative, given that plenty of the member companies are diversified and transnational, making them susceptible to foreign market fluctuations [1]. Besides, the Covid-19 pandemic also affected many companies' portfolios and the market.

3.3 Comparison

Figure 2 is a plot comparing the R^2 of the five different motor companies using two different return prediction models (CAPM and FF3FM). From figure 2, it is obvious that the FF3FM (orange line) is overall higher than the CAPM (blue line) across the companies. The average R^2 of FF3FM from the regression result is 0.304, which is higher than the CAPM average R^2 (0.195). Indicating that FF3FM has a better accuracy against CAPM overall in the stock return prediction of the five companies.

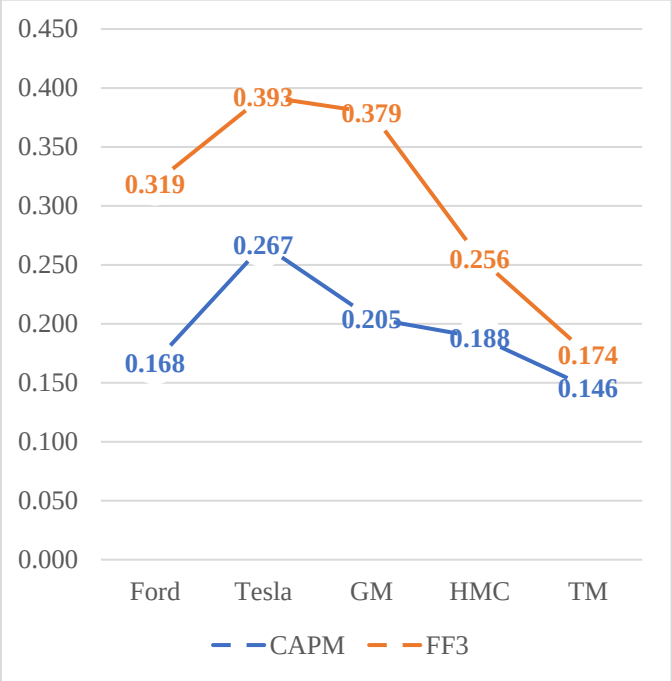

Figure 2. Adjusted R Square comparison between CAPM and FF3.

3.4 Limitation

Nevertheless, this research has some shortcomings and limitations. Adjusted R square is used in the research to determine whether the data fits the CAPM and FF3FM or not. Normally, a higher R square indicates that the model has better prediction accuracy, however, R square is not always the most precise method. In some situation, a biased model can have a high R square while an

accurate model can also result in a low R square. Although adjusted R square can provide better insights of a model's predication ability than the R square, it is not a guaranteed method as well. There exists some room for potential errors in the comparison of the accuracy between CAPM and FF3FM, yet in a general sense, all data presents FF3FM has better accuracy over CAPM.

4 CONCLUSION

In summary, this paper investigates the accuracy of using CAPM and FFM3 models to predict the rate of return of the US automobile industry during the COVID-19 outbreak based on the data from 5 US automobile companies during the year 2021. The adjusted R^2 of the FFM3 model is larger than CAPM, while the coefficient value predicted by the FFM3 model is smaller than that predicted by the CAPM model. By comparing the adjusted R square value and the coefficient value of FFM3 and CAPM that are calculated by the linear regression model, the result shows that FFM3 is more accurate than CAPM in predicting the rate of return of American automobile companies during the COVID-19 epidemic. At present, whether it is FFM3 or CAPM, the adjusted R-square of the predicted values of these two models is not high. In this case, the returns obtained by these two models are not very accurate, and there may be errors. As a consequence, if similar comparison that compares CAPM and FFM3 on the accuracy of their predictions on rate of return based on the data about US automobile companies during the COVID-19 epidemic will be make in the future, the size of companies and the data must be increased in order to reduce the error. The results of this paper allow people to choose a more accurate model FFM3 to predict the rate of return of American automobile companies during the epidemic in recent years, so as to selectively invest in these companies. Meanwhile, when encountering similar epidemics in the future, investors can also choose to use FFM3 instead of CAPM to predict the rate of return of American automobile companies. Overall, these results offer a guideline for investing America automobile companies during similar epidemic like COVID-19 in the future to choose proper and accurate model to predict the expect return of the company.

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