The Analysis of CAPM and Fama French Model Based On The US Stock Market Under Coronavirus*

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Abstract

This paper mainly investigates the explanatory power of the Capital Asset Pricing Model, the Fama-French Three-Factor Model and the Fama-Fench Five-Factor Model in the US stock market under the Covid-19 pandemic.This paper employs six types of groupings based on different sets of variables and for each type, we constructs nine portfolios and conducted regressions. Both the time series regression and the OLS regression are conducted. According to the statistical results, this paper concludes that CAPM fails under the complex economic environment but the Fama French Three Factor Model and Five Factor Model are still suitable and efficient asset pricing models for the US stock market.

1 Introduction

The outbreak of Coronavirus has become a worldwide pandemic and has drawn the attention of every world citizen. While raising the health and safety concerns, it also affects tourism, schools, factories and the whole supply chain, thus imposing a negative impact on the economy. According to Bloomberg statistics, the FTSE 100 Index, Dow Jones index and S&P 500 index all dropped drastically around 30% from Feb 2020 to Apr 2020 and the U.S. stock market triggered the circuit breaker four times in March. These facts motivate the study of the market performance under the Covid-19 pandemic.

Gormsen and Koijen(2020) used aggregate stock and dividend futures to predict the performance of the whole economy and Tashanova(2020) conducted the industry sector analysis to show companies that might have stock price gain during the pandemic. But few papers released focused on the capital asset pricing of the whole stock market. One key issue might be that the stock price dataset is too small in 2020, which is just after the breakout of coronavirus, so the bias is high and no convincing results could be made on any model. But now, we have been fighting the virus for more than a year so we believe the price history dataset of the US stock market is enough for analyzing. The previous pricing models like CAPM and Fama French model have been proved to be efficient for analysing stock prices during economic booming. But is it still the case under Covid-19? So we conducted our analysis of various pricing models on the US stock market from Mar 2020.

2 Literature Review

The main focus of financial analysis on the modern stock market is to forecast the future price trend, thus recommending different investing strategies to common investors.

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*You could directly download all the relevant files from *our GitHub repository*

Markowitz (1952) first proposed the modern portfolio theory which creates a "mean-variance model", which assumes investors only focus on the mean and variance. Sharpe (1964) and Lintner (1965) further developed the theory by adding two key assumptions on the market and constructed the Capital Asset Pricing Model(CAPM). It offers a fairly simple intuition on how to evaluate the stock by utilizing its expected return and its covariance with the market portfolio. The theory is still widely used nowadays and acts as a base of many subsequent pricing models.

While the results of empirical tests on the CAPM model vary greatly among papers, Fama and French (1993) noticed the phenomenon that small stocks and high book-to-market stocks always indicate a higher expected return. This empirical finding shows that there could be other variables not captured by the CAPM model that affect the expected return of portfolios. So they proposed a Fama French three factor model which takes the size effect and value effect into consideration.

But in the 21st century, Novy-Marx (2012), Titman, Wei, and Xie (2004) pointed out that the three factor model is still not a comprehensive descriptor since it ignores company profitability and investment, which they believe will greatly affect the stock price. So Fama and French (2015) further added these two factors accordingly to the three-factor model, forming a final Fama French five-factor model.

All of the above mentioned models are still widely in use nowadays and in our work, we will examine the performance of US stock after the breakout of Covid-19 using the CAPM, Fama French three-factor model and Fama French five-factor model. We will see how well and accurately those models perform under this big economy recession.

3 Experiment

3.1 List Forming

Since we are studying the explanatory power of CAPM and Fama-French's 3 and 5-factors model for the US stock market during the pandemic era, it is best that we choose the target companies that can represent the overall market performance. According to efficient market theory, the S&P 500 seems to be a good stock pool, considering that the index accounts for 80% of the market value of the U.S. equities market (S&P Dow Jones Indices. "S&P 500," Accessed April 23, 2020). However, we used screener from Reuters Eikon to select the Top 50 US stocks in terms of market cap. This is due to our limited time and computing power. Still, we consider our choice reasonable because S&P 500 is a market-capitalization-weighted index of 505 large-cap U.S. stocks. Moreover, the 10 biggest stocks make up 26% of the index's market value, indicating that the top tier companies largely influence the performance of the index. Therefore, we believe the top 50 companies that we selected serve as a fair proxy for index performance.

3.2 Data Description

Our main variables are the market excess return, market value, book to market ratio, investment and profit. The book to market ratio is computed as net assets per share divided by stock price. Investment is measured as the total asset yearly growth rate and profit is evaluated as net income divided by net asset value.

All the relevant data together with the market value used for computing are directly extracted from the Reuters Eikon website. The daily returns of each stock are downloaded from Yahoo finance. For the Fama French factors and risk-free rate, we obtain from the *Fama French Official Website*.

3.3 CAPM Analysis

Noted that the US stock market triggered the circuit breaker four times in March 2020, we want to analyze how this will affect our model capability during the pandemic as a sub topic of research. So for each model, we did two sets of analysis. One with stock prices starting from March 02, 2020 till February 26, 2021 and the other with stock prices starting from April 01 2020, this is to do a comparison experiment to show the effect of circuit breakers on financial data.

To evaluate the performance of top twenty-six US stocks after the outbreak of covid-19, we first accessed their daily stock prices from March 2020 to February 2021 as mentioned above from Yahoo Finance. Then we calculated the daily return of each stock, and computed the excess return by subtracting the risk free rate. After that, we did time series regression to the data and obtained the beta value for all the twenty-six stocks. The next step we took was to calculate the average return of each stock and use the pre-computed beta values to do the OLS regression, so that we could evaluate the performance of the CAPM model. We then repeated this process to these twenty-six stocks with a changing period from April 2020 to February 2021.

3.4 Fama French Model Analysis

Grouping: For the verification of the Fama French model, we need to first group our stocks into portfolios based on the Fama French factors. We follow the factor-construction method stated in the official website, which is to use 0.3 and 0.7 as two quantiles to separate the stock pool into three categories(small, middle, large) based on each factor value mentioned above(market value, book to market ratio, investment and profit).

Then for each two factors, we create portfolios by combining these factor separated groupings into a 3*3 matrix. For example, we need to group stocks based on size and book to market ratio, then for each row in the resulting matrix, it indicates the portfolios formed within the same size categories with B/M value ranging from low to high. For each column in the matrix, it shows the portfolios located in the same B/M value range but with size ranging from small to large. In this way we formed 9 portfolios, all with different values in at least one dimension we are interested in experiment. Moreover, we also computed the weights of each stock for every portfolio using the market-cap weighted approach. This grouping and our following analysis strategies are all adopted from Wenjian(2017).

For the actual grouping work, we utilize python to implement the logic, and the key code snippets are attached below for reference:

```python
factors = [["size", 2], ["B/M", 6], ["inv", 7], ["OP", 8]]
d = {}
for factor in factors:
    name, i = factor
    group = df.iloc[:, [0, i]]
    group = group.to_numpy(copy=True)
    group = list(group)
    group.sort(key=lambda x: x[1])
    small_group = np.array(group[:quantile_index1])[:, 0]
    middle_group = np.array(group[quantile_index1:
        quantile_index2])[:, 0]
    large_group = np.array(group[quantile_index2:])[:, 0]
    d[name] = np.array([small_group, middle_group,
        large_group])
```

For more details, please refer to the complete python code.

Analysis: We have four factors other than the beta for the Fama French model, namely, market value, book to market ratio, investment and profit. By selecting two factors as the standard for separation of stocks and construction of portfolios, a total of 6*9 = 54 sets of portfolios are created.

After constructing the above portfolios, we conducted time series regression for each portfolio's 3 factors and 5 factors model respectively, with a time window of Mar 2020 -Feb 2021 and Apr 2020 - Feb 2021 each according to the reason stated above.

For regression results and analysis, please see the next section "Results" and "Conclusion".

4 Results

We are now going to give analysis to our regression results. For simplicity, we will only show the results for CAPM using the top 26 stocks. For Fama French results, we will only show portfolios grouped by size and B/M ratio, size and investment, size and profit. We will analyze the regression function intercept for both the Fama French three-factor-model and the Fama French five-factor-model to show the explanatory power under the Covid-19 pandemic.

4.1 CAPM Results

The regression function is:

$$R(t) - R_f(t) = a + b[R_M(t) - R_f(t)] + e(t)$$

OLS regression result for data from March

	Coefficients	Standard Error	t Stat	P-value
Intercept	-0.1774435	0.075757399	-2.3422596	0.02779478
Slope	0.31593304	0.073743235	4.28423079	0.00025637

OLS regression result for data from April

	Coefficients	Standard Error	t Stat	P-value
Intercept	-0.0833333	0.090173848	-0.9241406	0.36461206
Slope	0.3376828	0.091591418	3.68683884	0.00115776

Figure 1: Regression results for CAPM

Twenty six stocks are picked in this case, time series regression for each one is done followed by the OLS regression as a whole. We could easily see from the above chart that for the data extracted from March 2020, CAPM is not working since its intercept alpha has an absolute t-value greater than 2, which means it could not reject the null hypothesis. But for the data extracted since April 2020, the t-value is smaller than 2 and CAPM generally works well. Since in March 2020 the S&P index dropped significantly and starting from April 2020, it gradually picked up again. So we could conclude that CAPM has a systematic error when evaluating recession periods but generally performs good when dealing with bull market cases.

4.2 Fama French Results

Nine portfolios formed by Size and B/M: Use the market value and book to market ratio of each company to divide the stocks into three portfolios, cross them to get $3*3 = 9$ portfolios as we mentioned in the grouping part. We apply the Fama French model (both three factor and five fator) regressions on these nine portfolios and get the intercepts shown below.

The regression functions are:

$$R(t) - R_f(t) = a + b[R_M(t) - R_f(t)] + sSMB(t) + hHML(t) + e(t)$$

and

$$R(t) - R_f(t) = a + b[R_M(t) - R_f(t)] + sSMB(t) + hHML(t) + rRMW(t) + cCMA(t) + e(t)$$

Panel A: Three-factor intercepts: Rm - Rf, SMB, and HML						
B:M	Low	Medium	High	Low	Medium	High
		a			t(a)	
Small	0.01848	-0.0472	-0.0163	0.36597	-1.1731	-0.3528
Medium	-0.0354	-0.0227	-0.0482	-0.7303	-0.5957	-1.1539
Big	0.07123	-0.018	-0.0201	1.00041	-0.4011	-0.5474
Panel B: Five-factor intercepts: Rm - Rf, SMB, HMLO, RMW and CMA						
		a			t(a)	
Small	0.01342	-0.0442	-0.0075	0.269	-1.11	-0.1673
Medium	-0.0322	-0.0217	-0.0475	-0.6899	-0.5744	-1.1335
Big	0.05924	-0.0223	-0.0175	0.85436	-0.5279	-0.48

Figure 2: Regression results on Size and B/M from March

Panel A: Three-factor intercepts: Rm - Rf, SMB, and HML						
B:M	Low	Medium	High	Low	Medium	High
		a			t(a)	
Small	0.04327	0.00306	0.01203	0.87384	0.08111	0.25175
Medium	0.02973	0.01856	-0.0201	0.7345	0.50662	-0.5474
Big	0.13037	0.03303	0.02667	1.90041	0.76133	0.45429
Panel B: Five-factor intercepts: Rm - Rf, SMB, HMLO, RMW and CMA						
		a			t(a)	
Small	0.04315	0.00613	0.01946	0.88066	0.16352	0.42505
Medium	0.02676	0.02087	-0.0175	0.67149	0.5706	-0.48
Big	0.1248	0.02543	0.02968	1.90174	0.61311	0.50501

Figure 3: Regression results on Size and B/M from April

From the above tables, we saw that all of the absolute t-values for alpha in the three factor model and five factor model, whether for data from March or April, are smaller than 2, which indicates that none of them could reject the null hypothesis of alpha. So for portfolios created by size and B/M ratio, both the three factor model and five factor model have a good explanatory power regardless of the triggering of the circuit breaker. But we also see that for both cases, the five factor model's intercept generally shrinks towards 0 compared to the three factor model. And the intercept distribution becomes more uniform. So we say that the five factor model is a slightly better fit for the market.

Nine portfolios formed by Size and Investment: Use the market value and Investment of each company to divide the stocks into three portfolios, cross them to get 3*3 = 9 portfolios as we mentioned in the grouping part. We apply the Fama French model (both three factor and five fator) regressions on these nine portfolios and get the intercepts shown below.

The regression functions are:

$$R(t) - R_f(t) = a + b[R_M(t) - R_f(t)] + sSMB(t) + hHML(t) + e(t)$$

and

$$R(t) - R_f(t) = a + b[R_M(t) - R_f(t)] + sSMB(t) + hHML(t) + rRMW(t) + cCMA(t) + e(t)$$

Inv	Low	Medium	High		Low	Medium	High
Panel A: Three-factor intercepts: Rm - Rf, SMB, and HML							
		a				t(a)	
Small	-0.0307	-0.0226	-0.0151		-0.5413	-0.5736	-0.2892
Medium	-0.0337	-0.0544	-0.0104		-0.7503	-1.2833	-0.1808
Big	-0.007	-0.0322	0.06609		-0.1359	-0.5768	1.28076
Panel B: Five-factor intercepts: Rm - Rf, SMB, HMLO, RMW and CMA							
		a				t(a)	
Small	-0.0211	-0.025	-0.0077		-0.3797	-0.6442	-0.1516
Medium	-0.0411	-0.0496	-0.0007		-0.9684	-1.1914	-0.0133
Big	-0.0244	-0.0359	0.068		-0.5282	-0.7055	1.34108

Figure 4: Regression results on Size and Investment from March

Inv	Low	Medium	High		Low	Medium	High
Panel A: Three-factor intercepts: Rm - Rf, SMB, and HML							
		a				t(a)	
Small	-0.0073	0.01546	0.03377		-0.1289	0.41509	0.68446
Medium	-0.0072	-0.0166	0.06609		-0.197	-0.4398	1.28076
Big	0.04023	0.01631	0.15448		0.76409	0.29588	2.18444
Panel B: Five-factor intercepts: Rm - Rf, SMB, HMLO, RMW and CMA							
		a				t(a)	
Small	-0.0002	0.01671	0.03887		-0.0037	0.45778	0.79986
Medium	-0.0068	-0.0161	0.068		-0.1902	-0.4376	1.34108
Big	0.03495	0.0056	0.15429		0.78812	0.10955	2.1728

Figure 5: Regression results on Size and Investment from April

From the above tables, we saw that all of the absolute t-values for alpha for data from March are smaller than 2, and for data from April, both models have only one in nine portfolios that reject the null hypothesis. So for portfolios created by size and investment, both the three factor model and five factor model performs well. But again as mentioned above, the five factor model's intercept generally shrinks towards 0 compared to the three factor model. So the five factor model wins by a narrow margin.

Nine portfolios formed by Size and Profit: Use the market value and profit of each company to divide the stocks into three portfolios, cross them to get 3*3 = 9 portfolios as we mentioned in the grouping part. We apply the Fama French model (both three factor and five fator) regressions on these nine portfolios and get the intercepts shown below.

The regression functions are:

$$R(t) - R_f(t) = a + b[R_M(t) - R_f(t)] + sSMB(t) + hHML(t) + e(t)$$

and

$$R(t) - R_f(t) = a + b[R_M(t) - R_f(t)] + sSMB(t) + hHML(t) + rRMW(t) + cCMA(t) + e(t)$$

OP	Low	Medium	High		Low	Medium	High
Panel A: Three-factor intercepts: Rm - Rf, SMB, and HML							
		a				t(a)	
Small	-0.0195	-0.0126	-0.1003		-0.4917	-0.28	-0.9181
Medium	-0.0513	-0.0339	-0.0247		-0.9949	-0.9161	-0.5464
Big	-0.0215	0.08497	-0.015		-0.2859	1.23507	-0.3261
Panel B: Five-factor intercepts: Rm - Rf, SMB, HMLO, RMW and CMA							
		a				t(a)	
Small	-0.0208	-0.0085	-0.0782		-0.5309	-0.1907	-0.7408
Medium	-0.0486	-0.0347	-0.0211		-0.9646	-0.9714	-0.473
Big	-0.0226	0.07174	-0.0184		-0.3024	1.0759	-0.4245

Figure 6: Regression results on Size and Profit from March

OP	Low	Medium	High		Low	Medium	High
Panel A: Three-factor intercepts: Rm - Rf, SMB, and HML							
		a				t(a)	
Small	0.02179	0.02453	-0.0829		0.57713	0.55133	-0.7756
Medium	0.01335	0.00521	0.01011		0.29001	0.15252	0.23244
Big	-0.0056	0.15134	0.03573		-0.076	2.23686	0.82383
Panel B: Five-factor intercepts: Rm - Rf, SMB, HMLO, RMW and CMA							
		a				t(a)	
Small	0.02299	0.02811	-0.0637		0.60959	0.63683	-0.6508
Medium	0.00929	0.00929	0.01036		0.20588	0.2776	0.2407
Big	-0.0099	0.14907	0.02904		-0.1343	2.41242	0.6941

Figure 7: Regression results on Size and Profit from April

Again, we saw that both models have only one in nine portfolios that reject the null hypothesis for data from April. So for portfolios created by size and profit, both the three factor model and five factor model are good descriptors. But again as mentioned above, the five factor model's intercept generally shrinks towards 0 compared to the three factor model. So the five factor model is slightly better but the difference is not fairly significant.

4.3 Proposed Explanation for Abnormal Data

We noted that for the last two groups(Size and Investment, Size and Profit), both the three factor model and the five factor model performs well for data since March, but failed for one set of portfolios for data since April. First of all, only one in nine portfolios failed in each case, which might potentially be totally accidental. But we empirically propose an explanation for it. Since Apr 2020, the overall market sentiment is rather pro-risk. After the four trading curbs in March 2020, the Federal Reserve came out to rescue the market, interest rates were lowered, and the government bought bonds directly, which leads to a fairly

great amount of money poured into the market. Individual investors flooded into the market with hot money, driving risky assets such as small stocks with even no profit to sky high. On the other hand, traditional big companies with large market cap and high investment / profit can seem less attractive because its limited upside return. Therefore, the model may fail to explain the excess return of such companies with market data from April 2020.

5 Conclusion

After our evaluation of the models in the US stock market under coronavirus, we could draw some obvious conclusions. First of all, the CAPM is generally good in bull market but fails to explain the case in recession. This indicates that CAPM itself is not a proper evaluator, which might have divergence with the actual market when encountering the trading curbs. Secondly, we see that for both the Fama French three factor model and five factor model, it generally conforms with the market situation, no matter whether the trading curbs happen or not. We also observed that the five factor model only outperforms the three factor model slightly and there is no substantial difference. So the final conclusion is that under the coronavirus pandemic, CAPM fails to explain the US stock market, but the Fama French model keeps making sense. And for simplicity, the application of the three factor model is already suitable and efficient enough.

We mainly did our research based on CAPM and the Fama French model on the US stock market from March 2020 to Feb 2021, further research could be deepened by extending the timeline of stock price data and more work could be down in digging into the abnormal effects we pointed out in our regression results.

Acknowledgments

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