The Impact of COVID-19 on Airline Industry Based on Improved Fama-French 5 Factors Model

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Abstract. Since the COVID-19 has broken out, most governments have put traffic restriction policies, which affect the airline industry heavily. This paper selected companies in the S&P 500 index to calculate the original Fama-French 5 factors value as the whole market value, and compare the traditional five factors model with a new model which added a new factor, RSI, relative strength index. To collect the features and information, the data is retrieved from information system. According to the big data analysis in terms of different metrics, the new model has an improvement in R-square, and the new factor is independent of others. After implementation of the new models in airline industry, it is found that the big and expensive companies are more stable. To be specific, the company holds a more conservative investment strategy or have higher profitability take higher exceed return. Besides, the investors tend to play a short position in the market. Overall, these results shed light on guiding further exploration of the application of improved Fama-French models in specific industry and big data retrieval from information system.

Keywords: Fama-French 5 factors model; COVID-19; Airline industry, big data analysis.

1. Introduction

Since the first stock exchange had been established in Armstrong, Netherlands, investors have started chasing the exceeded return in the market, which generally comes with a higher risk. In order to balance these returns and risks, scholars have proposed many theories to explain their relationship. For example, Markowitz indicated that the mean and variance of an investment portfolio could measure its return and risk, which is the original of the Modern portfolio theory [1]. On this basis, Sharpe suggested that Capital Assets Pricing Model (CAPM) could find the expected return by evaluating assets' system risk [2]. In the opposite, Fama and French (1993) observed that CAPM could not explain the United State market return between 1963 and 1990, and supposed that a developed model which is a multi-factor model including market portfolio $(R_m - R_f)$, market value factor (SMB) and book-market value ratio (HML) [3]. Apart from this, the complexity of the financial market is more than they expected, thus why Fama and French add two more factors into their model, which are the profitability factor (RMW) and invest factor (CMA) to describe the market better, the paper also mentioned the redundant of HML and the momentum factors might be relevant to all factors in the model [4]. Furthermore, Ehsani tested the lack of necessity of putting momentum factors into the Fama-French five factors model [5]. However, Drosos believed that the mixture factor of technical indicators, which contain the momentum index could improve the accuracy of the Fama-French three factors model [6]. Besides, Drikx thought that profitability and investment factors are useless compared with momentum factors in the application of the German market [7]. Therefore, adding a suitable momentum factor to Fama-French five-factor model might improve the accuracy of the model.

From the market perspective, due to the breakout of COVID-19, the government introduce some policies regarding travel restrictions and lock-down, which caused a huge negative impact on the airline industry. Atems stated that the epidemic significantly affects the air industry's revenue and

profitability, which leads to the stock price of this industry's sharp decline [8]. In addition, Fontanet-Pérez selected 10 airline companies as representatives to analyze the influence of COVID-19 and draw some results that the whole industry has sustained heavy losses, but lower expense companies perform better than higher one in finance [9]. Owing to the wild fluctuations in the airline industry, investors would reconsider whether this industry is worth investing, in and how much excess return they can get. There is no doubt that an analysis of the impact of COVID-19 in such a turbulent market through a financial model (e.g., the Fama-French five factors or an improved model), which could fit the market more appropriately is meaningful. With this in mind, this paper will consider the application of improved Fama-French five factors model in airline industry to analysis the COVID-19 influence. The rest part of the paper is organized as follows. The Sec. II will introduce the background information of models and the calculation of index. The Sec. III will compare original and improved Fama-French model and explore the impact of COVID-19 in air industry through new model. Eventually, a brief summary will be given in Sec. IV.

2. Methodology

2.1. Fama-French five-factor Model

CAPM is a financial pricing model on which the Fama-French model is based, it depicts the relationship between the market risk and the portfolio's expected return. It has the following equation to describe the relation

$$E(R_i) = R_f + \beta\big(E(R_M) - R_f\big) \tag{1}$$

where $E(R_i)$ is the return of the asset, $E(R_M) - R_f$is the market risk premium, and β is the coefficient between the return of the asset and the market risk premium. While CAPM is suggesting that the market risk premium is the only factor affecting an asset's return, the Fama-French model significantly improved it by introducing more factors, which provides a better estimation on an asset's return. To be specific, the Fama-French five-factor model is adopted to calculate the expected excess return by considering four more factors, i.e., size, value, profitability and investment patterns, which can be describe as:

$$\begin{aligned} R_i - R_f = \beta_1\big(R_M - R_f\big) + \beta_2 SMB + \beta_3 HML + \\ \beta_4 RMW + \beta_5 CMA \end{aligned} \tag{2}$$

Here, SMB is the difference in return between firms with small market capitalization and with big market capitalization. HML is the difference in return between firms with high book-to-market ratios and with low book-to-market ratios. RMW is the difference in return between firms with high profitability and with low profitability. CMA is the difference in return between firms with high investment value and with low investment value. Each beta is the coefficient between the excess return and each corresponding factor.

2.2. Improved new model

Based on the Fama-French model, we introduce a new model by taking one more factor: LMS, LMS stands for long minus short, and it takes into account on the overbought or oversold situation. The indicator chosen for LMS is RSI (relative strength index), which is a momentum measure that tells the magnitude of the recent price changes. In general, it can have a reading between 0 to 100. The higher the value means the more people are taking a long position, and the lower the value means the more people are taking a short position. Therefore, the equation for our new model is

$$R_i - R_f = \beta_1(R_M - R_f) + \beta_2 SMB + \beta_3 HML + \beta_4 RMW + \beta_5 CMA + \beta_6 LMS \quad (3)$$

The six factors are calculated as follows. Size categorizes shares with market capitalization at 50 percentiles, firms higher than 50 percentiles are classified as B(big), and firms lower than 50 percentiles are classified are S(small).

$$SMB = \frac{SH + SM + SL}{3} - \frac{BH + BM + BL}{3} \quad (4)$$

where SH is the portfolio with small market capitalization and high profitability, other terminologies are with the same pattern. Value is calculated by classifying shares with book-to-market at 30 percentiles and 70 percentiles, firms higher than 70 percentiles are classified as H(high), firms between 30 percentiles and 70 percentiles are classified are M(median), and firms lower than 30 percentiles are classified as L(low).

$$HML = \frac{SH + BH}{2} - \frac{SL + BL}{2} \quad (5)$$

Profitability classifies shares with operating profitability at 50 percentiles, the indicator used for operating profitability is EBIT/total equity, firms higher than 50 percentiles are classified as R(robust), and firms lower than 50 percentiles are classified are W(weak).

$$RMW = \frac{SR + BR}{2} - \frac{SW + BW}{2} \quad (6)$$

Investment patterns categorizes shares with investment at 50 percentiles, the indicator used for investment is

$$\frac{[(total\ assets\ in\ time\ t) - (total\ assets\ in\ time\ t-1)]}{total\ asset\ in\ time\ t-1} \quad (7)$$

Firms with value that higher than 70 percentiles are classified as A(aggressive), firms lower than 30 percentiles are classified are C(conservative).

$$CMA = \frac{SC + BC}{2} - \frac{SA + BA}{2} \quad (8)$$

Momentum factor is calculated by categorizing shares with RSI at four levels, firms with RSI between 0 and 20 are classified as VS (very short), firms with RSI between 20 and 50 are classified as SH (short), and firms with RSI between 50 and 70 are classified as L(long), firms with RSI between 80 and 100 are classified as VL (very long),

$$LMS = \frac{BVL + BL + SVL + SL}{4} - \frac{BVS + BS + SVS + SH}{4} \quad (9)$$

2.3. Data and evalution for the impact of COVID-19

All calculations in this study are based on quarterly data for both periods 2017-2019 and the period 2020-2021. Specifically, the data time ranges are 31/03/2017 to 31/12/2019 and 31/03/2020 to 31/12/2021. The data source for factors' values (i.e., SMB, HML, RMW, CMA) is from the Ken French data library, using F-F research data 5 factors 2X3 monthly and taking the three months average to be the quarterly data. RSI, the indicator for LMS is calculated by averaging the 14-days based RSI each day quarterly and using the close price each day for the S&P500 stock index. The formula for RSI each day is

$$RSI_{each\ day} = 100 - \frac{100}{1 + \frac{avgerage\ gain}{average\ loss}} \quad (10)$$

Where the average gain is the total increase in stock price divides by 14, and the average loss is the total decrease in stock price divides by 14. Table. I lists all the research sample.

Table. 1 Research sample

Stock Code	Company Name
DAL	Delta Air Lines, Inc.
LUV	Southwest Airlines Co.
AAL	American Airlines, Inc.
HA	Hawaiian Airlines
UAL	United Airlines, Inc.
JBLU	JetBlue Airways
ALK	Air Lubo
ALGT	Allegiant Travel Company
CPA	Copa Airlines
ZNH	China Southern *Airlines* Company Limited
CEA	China Eastern Airlines Corporation Limited
PYAAY	Fly Play hf.
GOL	Gol Linhas Aéreas Inteligentes S.A

The population in this study is all airline companies with valid data listed on Wind Information Technology Co. LTD in the period 2017 to 2021, the time period has been separated into two parts, 2017-2019 (before the COVID-19 pandemic) and 2020-2021 (during the COVID-19 pandemic) as our hypothesis tells that COVID-19 brings a huge impact on the airline industry.

View the whole airline industry as a portfolio, and the dependent variable for both models is the excess return, the independent variables for Fama-French five-factor model are (R_M-R_f), SMB, HML, RMW and CMA, the independent. variables for the new model are (R_M-R_f), SMB, HML, RMW, CMA, and LMS.

The first step is to compare the improved model with the original Fama-French five-factor model. The indicator we choose for comparing is R-square. R-squared tells how the dependent variable is explained by the independent variables, so the model with a larger R-squared indicates a stronger relationship between the model and the dependent variable.

The second step is to compare the data before the COVID pandemic and during the COVID pandemic using the new model. To be specific, find out each coefficient(s) in both periods, then compare each corresponding coefficient and analyze changes, and find out the factors' values for the airline industry, then compare the corresponding factors' values to analyze how return varies with the different characteristic firm.

3. Results & Discussion

3.1. Comparisons of the models

Table II shows that the introduction of the new momentum factor LMS gives a rise to R square in both periods, which means that factors in the new model can have a stronger relationship than the factors in the original Fama-French five-factor model. Yet the rise is not obvious before the COVID pandemic, since the original Fama-French model has already included most possibilities affecting returns, the improvement may not look significant.

Table. 2 Comparing the R square between original model and new model

	Before COVID-19		**During COVID-19**	
	Original FF5 model	New model	Original FF5 model	New model
R square	0.951	0.960	0.959	0.977

However, it is clear that the new model offers a very high correlation between independent variables and dependent variables. 96% and 98% of the dependent variable can be explained by the

six independent variables for the two periods respectively. Generally, an R square above 0.7 would normally be seen as a signal of a high level of correlation in finance.

Table. 3 Orrelation between each factor before COVID crises

	Mkt-RF	SMB	HML	RMW	CMA	LMS
Mkt-RF	1	0.612	-0.731	-0.062	-0.754	0.266
SMB	0.612	1	-0.664	-0.783	-0.604	-0.227
HML	-0.731	-0.663	1	0.386	0.799	0.362
RMW	-0.062	-0.783	0.386	1	0.191	0.443
CMA	-0.754	-0.604	0.799	0.191	1	0.228
LMS	0.266	-0.227	0.362	0.443	0.228	1

According to Table III and Table IV, the correlation between each factor in the two periods, the correlation between LMS and other factors before COVID-19 performed well, has the lowest correlation with other factors among all factors. The correlations during COVID-19 are not high, meaning that LMS does not have a very strong relationship to any other factors. Therefore, we are able to conclude that the original five factors do not incorporate this new factor and confirm its effectiveness of it.

Table. 4 Correlation between each factor AFTER COVID crises

	Mkt-RF	SMB	HML	RMW	CMA	LMS
Mkt-RF	1	0.690	0.490	0.310	0.136	0.166
SMB	0.690	1	0.652	-0.233	0.335	0.010
HML	0.490	0.652	1	0.304	0.838	0.638
RMW	0.310	-0.233	0.304	1	0.465	0.586
CMA	0.136	0.335	0.838	0.465	1	0.629
LMS	0.166	0.010	0.638	0.586	0.629	1

Table. 5 factors' coefficients for each period in airline industry

	BEFORE COVID-19	**DURING COVID-19**
INTERCEPT	0.016	0.038
$\beta(R_M-R_F)$	-0.066	0.118
β(SMB)	0.032	-0.154
β(HML)	0.100	-0.028
β(RMW)	-0.030	-0.238
β(CMA)	-0.332	0.403
β(LMS)	0.535	-0.275

3.2. The impact of COVID-19

3.2.1. R_M-R_f

According to TABLE V. R_M-R_f represents the risk premium. Comparing the two periods, $\beta(R_M-R_f)$ changes from -0.066 to 0.12. Before the pandemic, the coefficient of -0.066, a small negative number, means that the airline industry does not move much with the market, or even moves to oppose the market change. The interpretation is that for most investors, the airline industry has been viewed as a stable industry, i.e., there are not many things that can change it except large crises (e.g., war, diseases). On this basis, it does not move with the market. During the pandemic, the increase in coefficient (to 0.12) offers the perspective that the COVID pandemic incurs the airline industry into a less stable position, it may be attributed to the change in policy, e.g., locking down, and travel restrictions. Hence it suffers crises with the market. Yet the coefficient is still much less than 1, which means that the market move would not generate much change in the airline industry.

3.2.2. SMB

Table VI clearly shows that before the COVID crisis, the small-capitalization firms offer a higher return than the large-capitalization firms since SMB is always positive. Whereas during the COVID pandemic, especially from the beginning of 2020 to September 2020, large-capitalization firms perform better. This can be explained as the investors believe that the larger firms would have a stronger ability to get over the crises since once the amount of total flight is reduced, the larger firms would obtain a larger competitive capacity Furthermore, the coefficient beta tells the same thing, as shown in Table V, positive beta (0.032) for the period before the pandemic, and negative beta (-0.15) for the period during the pandemic.

Table. 6 SMB value for each period in airline industry

Date (before COVID)	SMB	Date (during COVID)	SMB
29/3/2018	0.003	**31/3/2020**	-0.042
29/6/2018	0.095	**30/6/2020**	-0.047
28/9/2018	0.065	**30/9/2020**	-0.032
31/12/2018	0.057	**31/12/2020**	0.112
29/3/2019	0.057	**31/3/2021**	0.172
28/6/2019	0.088	**30/6/2021**	0.129
30/9/2019	0.125	**30/9/2021**	0.097
31/12/2019	0.125	**31/12/2021**	0.097

3.2.3. HML

HML is also known as the value premium. According to TABLE V, the change in beta from 0.10 to -0.028. After COVID took place, the beta for HML becomes negative and insignificant, this is because the transportation decreased dramatically during the epidemic, which leads to a decrease in the stock price. Hence HML becomes insignificant due to COVID-19. Table VII demonstrates the HML value for the airline industry, the concept that has been held up in Table VII is that before the COVID crisis, companies with high book-to-market ratios returned more than companies with low book-to-market ratios, yet it is reversed during the COVID crises. The book-to-market ratio is always an indicator of whether the stock is overvalued or undervalued, or briefly how cheap the stock is. The reason for the positive HML before COVID took place is that the stocks with a high book-to-market ratio are undervalued. Therefore, it has a higher return compared to the amount they cost. However, the overvalued stocks must have some attractive characteristics. In this case, the investors are willing to buy at the overvalued price, and those attractive characteristics are the reason for the better performance during the pandemic.

Table .7 HML value for each period in airline industry

Date (before COVID)	HML	Date (during COVID)	HML
29/3/2018	0.032	**31/3/2020**	-0.146
29/6/2018	0.137	**30/6/2020**	-0.120
28/9/2018	0.133	**30/9/2020**	-0.094
31/12/2018	0.103	**31/12/2020**	-0.053
29/3/2019	0.113	**31/3/2021**	-0.082
28/6/2019	0.241	**30/6/2021**	-0.031
30/9/2019	0.292	**30/9/2021**	-0.032
31/12/2019	0.292	**31/12/2021**	-0.032

3.2.4. Mains RMW

By comparing the two betas of RMW shown in TBALE V (i.e., -0.03 and -0.24), it is demonstrated that before the epidemic, the return in the airline industry is not affected much by the change in return of different levels of operating profitability in the market. Yet the epidemic incurred a stronger negative coefficient, meaning that for each unit increase in the market RMW, the excess return on the

airline industry decreased by 0.24 units. According to Table VIII, robust companies perform better both before and during COVID-19, and the difference between the two periods is insignificant. Therefore, we are able to draw the conclusion that for the airline industry, firms with higher operating profitability will always generate a higher return compared with lower operating profitability firms.

Table. 8 RMW value for each period in airline industry

Date (before COVID)	RMW	Date (during COVID)	RMW
29/3/2018	0.085	**31/3/2020**	0.118
29/6/2018	0.126	**30/6/2020**	0.119
28/9/2018	0.106	**30/9/2020**	0.110
31/12/2018	0.051	**31/12/2020**	0.080
29/3/2019	0.042	**31/3/2021**	0.113
28/6/2019	0.111	**30/6/2021**	0.147
30/9/2019	0.132	**30/9/2021**	0.100
31/12/2019	0.132	**31/12/2021**	0.100

3.2.5. CMA

In accordance with Table IX, the CMA before the COVID crisis is almost all negative whereas the CMA during the crisis is almost all positive. The restatement is that before the crises, firms with higher investment perform better, whereas, during the crises, firms with lower investment perform better. The reason is that the airline industry is an industry that required a large number of assets, especially PPE, before COVID-19, the larger investment which means that having more assets would be a positive sign for the development of an airline company. Nevertheless, during COVID-19, the whole market is experiencing crises and so does the airline industry. The demand for traveling decreases, which leads to a decrease in earnings. Hence, having more investment would not offer the company a higher earning, instead, it can bring negative effects on the book value of equity. Based on Table V, the show of betas, illuminates that there is a significant increase in beta CMA, from -0.33 to 0.42. It also shows the same idea as above, about how the crises bring impact return on investment point of view.

Table. 9 CMA value for each period in airline industry

Date (before COVID)	CMA	Date (during COVID)	CMA
29/3/2018	0.002	**31/3/2020**	-0.089
29/6/2018	-0.174	**30/6/2020**	-0.071
28/9/2018	-0.123	**30/9/2020**	0.146
31/12/2018	-0.084	**31/12/2020**	0.114
29/3/2019	-0.055	**31/3/2021**	0.152
28/6/2019	-0.076	**30/6/2021**	0.231
30/9/2019	-0.075	**30/9/2021**	0.013
31/12/2019	-0.075	**31/12/2021**	0.013

3.2.6. LMS

In Table X, LMS before COVID is almost all positive whereas it becomes all negative with the occurrence of COVID. It illustrates that before the COVID pandemic, investors in the long position gains a higher return than the investors in the short position, whereas investors in a short position gains a higher return than the investors in the long position during the pandemic. The beta table (Table V) also shows a positive beta (0.53) before the epidemic and a negative beta (-0.27) during the epidemic. This beta has the most significant change among all six betas. In a general sense, investors in short positions expect the price to fall and investors in long positions expect the price to rise. The interpretation of the above observation is that during the epidemic, bearish investors gain a higher return than bullish investors, indicating that the stock price is falling as bearish investors expected.

However, the overall stock price is on a rising trend before the pandemic. The significant change in beta also offers us the concept of how significant the price drops due to the COVID pandemic.

Table. 10 LMS value for each period in airline industry

Date (before COVID)	LMS	Date (during COVID)	LMS
29/3/2018	-0.023	**31/3/2020**	-0.059
29/6/2018	-0.024	**30/6/2020**	-0.029
28/9/2018	0.134	**30/9/2020**	-0.149
31/12/2018	0.145	**31/12/2020**	-0.016
29/3/2019	0.156	**31/3/2021**	-0.210
28/6/2019	0.134	**30/6/2021**	-0.199
30/9/2019	0.157	**30/9/2021**	-0.162
31/12/2019	0.157	**31/12/2021**	-0.162

3.2.7. Comparing returns macroscopically

From a macroscopic point of view, comparing the return for the airline industry as a whole portfolio, there is a clear decrease in return, from positive to negative. Hence, the overall COVID impact on return in the airline industry is negative.

Table. 11 Returns for each period in airline industry

Date (before COVID)	R_i	Date (during COVID)	R_i
29/3/2018	0.355	**31/3/2020**	-0.109
29/6/2018	-0.083	**30/6/2020**	-0.217
28/9/2018	-0.218	**30/9/2020**	0.120
31/12/2018	-0.061	**31/12/2020**	0.157
29/3/2019	0.107	**31/3/2021**	0.084
28/6/2019	0.028	**30/6/2021**	0.049
30/9/2019	-0.126	**30/9/2021**	-0.15
31/12/2019	0.014	**31/12/2021**	0.011
Average	0.002	**Average**	-0.007

3.3. Limitation

The limitation of this study includes the lack of sample. The small sample size in this study would restrict the ability to represent the distribution of the population. The degree of freedom is too small, so one can only obtain a small power to reject a false null hypothesis. Additionally, the small sample size leads to the failure of using indicators other than R square to judge whether the new model is better than the original Fama-French five-factor model.

4. Conclusion

In conclusion, this paper compares the Fama-French five factors model and an improved one, which adds LMS, a momentum factor that uses RSI as the indicator, into the model in the application of analyzing the airline industry. As a result, the improved one has an improvement in R-squared, yet it is insignificant. The new factor could be regarded as independent of original factors. Moreover, this paper also investigates the effect of the COVID crisis on the airline industry. By comparing the changes in betas and the differences in the airline industry factors before and during COVID-19, there is a conclusion that high profitability airline companies always generate a higher return; the big, expensive and conservative companies have a better performance during the pandemic. Furthermore, investors' attitude toward the airline industry is also shown with the introduction of the new factor. To be specific, the investors hold the tendency of a long position before the crisis whereas during the crisis they tend to play a short position in the market. In the future, the competition between big companies and small ones is still unpredictable, but there is clear that the big one, which profit more

and stabler will deal with crises better. Overall, these results offer a guideline for exploring the impact of a crisis on the industries through improved Fama-French five factors model, which including new technique indexes or other new indexes.

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