Proceedings of the 2023 International Conference on Management Research and Economic Development
DOI: 10.54254/2754-1169/24/20230433

An Empirical Investigation of the Fama-French Five-factor Model in North America Before and During COVID-19

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Abstract: This study takes an investigation in the North American financial market before and during the epidemic using a five-factor model to compare the performance of the regression models and the significance of the factors before and during the epidemic and to analyze the changes in the North American financial market before and after the epidemic. The study selects representative companies in each sector from the top ten companies in the North American financial market. It performs regressions on each company before and after the epidemic to compare the differences in the significance of the factors and the reasons for the differences between the companies in different sectors.

Keywords: Fama-French five-factor model, CAPM, COVID-19, stock market

1. Introduction

The capital asset pricing model (CAPM) illustrates the relationship between the return and risk of a security based on the investment's beta. During the past thirty years, the literature has developed from the CAPM to applying multi-factor models of pricing securities [1]. Fama and French's study in 2015 introduced the five-factor asset pricing model with the factors of the size of firms, excess return on the market, book-to-market values, profitability, and investment. This five-factor model performs better than the three-factor model of Fama and French, which was introduced in 1993 [2]. This article will test its performance in the North American financial market, especially when the market faced an unexpected crisis – COVID-19 on the Fama-French Five-factor Model.

In late 2019, COVID-19 started to spread, and soon, it became a pandemic, causing a global crisis. The pandemic has brought enormous economic impact, including an effect on the financial market. Many constituents faced much loss and even shut down, while some industries still survived and grew. These can be reflected in their stock returns, considering the sectors these constituents are in [3]. When writing this article, the pandemic is winding down, and people's lives are getting back on track. I want to investigate how the Fama-French Five-factor Model performed in North America before and during the pandemic, and I will attempt to explain the results of the performance of the five-factor model generated based on pre-and post-pandemic data from macro and micro perspectives. I chose the stock returns of the constituents from the top 10 members based on the MSCI North America index as a sample, and these constituents come from different sectors, being well representative of their sectors. From the macro perspective, this paper will test the mod-

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DOI: 10.54254/2754-1169/24/20230433

el's performance before and during the pandemic based on the overall financial market of North America and analyze the effect of COVID-19 on the market. From the micro perspective, the performance of the five-factor model for each constituent will be analyzed to see the influence in each sector due to the pandemic.

This article is conducted as follows. Section 2 introduces the literature review of this study. Section 3 will discuss the selected data of this study and methodology. Section 4 discusses the results and the analysis based on the results. The general aim of this article is to compare the performance of the Fama-French Five-factor Model before and during COVID-19 and use the results to analyze whether there is any change in the North American financial market before and during COVID-19, and the impact of the pandemic, taking a future insight of North America financial market in the post-pandemic period.

2. Literature Review

After the pandemic broke out, the literature on the impacts of COVID-19 on economics emerged quickly. For instance, Basuony et al. [4] talk about the effects of the pandemic on global stock markets, focusing on return, volatility, and destructive state probability dynamics. Their article finds unprecedented increases in risk and wrong state probabilities across all the needs, although the impact is unsymmetric across the markets. Just and Echaust investigate the relationship between S&P 500 and the volatility, correlation, and liquidity during the COVID-19 crisis [5]. Moreover, there is also much literature on the impacts of COVID-19 focused on the financial markets and institutions. For example, Goodwell briefly investigates the effects of COVID-19 on banking and insurance, government, and the financial markets according to past epidemics and the facts during the pandemic [3].

In Fama and French's study in 2015, the five-factor asset pricing model is introduced, which performs much better than the three-factor model introduced in 1993 [2]. Therefore, much literature on the multi-factor model of pricing assets in different markets emerges. Chiah et al. [1] investigate the five-factor model empirically in Australia. Jain investigates the effect of COVID-19 on the Indian financial market and takes insight into tracking firm betas [6].

This article will investigate the performances of the Fama-French Five-factor Model on the North American financial markets and find the impacts of the pandemic on the model performances based on the precious literature.

3. Data and Methodology

3.1. Data

This study selects the sample data from January 2017 to January 2023 to cover both the pre-pandemic period and during the pandemic. The pre-pandemic data is from January 2017 to December 2019, and the period during the pandemic starts from January 2020 to January 2023. This aims to ensure the two periods have almost a symmetric sample size. The investigation takes the monthly stock return data of the constituents from the Investing website [7] and monthly research and returns of North American 5 factors from Kenneth R. French's website [8]. The stocks are selected from the Top 10 constituents of North America ranked by the weight of the MSCI North America index. This index is designed to measure the performance of the large and mid-cap segments of the US and Canada markets, covering around 85% of the free float-adjusted market capitalization in North America with 714 constituents [9]. The constituents are from six sectors and are shown in Table 1.

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Table 1: Information of selected constituents according to MSCI Index.

Constituent	Sector	Index Wt. (%)
Apple (AAPL)	Information Technology	6.40
Amazon.com (AMZN)	Consumer Discretionary	2.34
Alphabet A (GOOGL)	Communication services	1.46
ExxonMobil Corp (XOM)	Energy	1.24
UnitedHealth Group (UNH)	Health Care	1.20
JPMorgan Chase & Co (JPM)	Financials	1.14

Table 2:Descriptive statistics.

Panel A: Numerical summary of the selected constituents						
	AAPL	AMZN	GOOGL	XOM	UNH	JPM
Minimum	-0.1840	-0.2375	-0.1795	-0.2619	-0.1146	-0.2246
Median	-0.0409	0.0261	0.0193	0.0042	0.0159	0.0104
Maximum	0.2144	0.2706	0.1590	0.2692	0.1785	0.2046
Mean	0.0261	0.0184	0.0151	0.0076	0.0176	0.0094
Std. Dev.	0.0884	0.0957	0.0703	0.0924	0.0632	0.0744
Kurtosis	2.3277	3.8139	2.8440	4.2083	2.8979	4.0748
Skewness	-0.1265	0.2836	-0.3696	0.2924	0.4065	-0.0847
Panel B: Numerical summary of the return spread of five factors and risk-free rate						
	$R_{Mt} - R_{Ft}$	SMB	HML	RMW	CMA	RF
Minimum	-0.1409	-0.0981	-0.1040	-0.0294	-0.0647	0
Median	0.0162	-0.0016	-0.0104	0.0024	-0.0039	0.0009
Maximum	0.1333	0.0564	0.1214	0.0622	0.0968	0.0035
Mean	0.0096	-0.0020	-0.0034	0.0044	0.0016	0.0009
Std. Dev.	0.0514	0.0257	0.0404	0.0184	0.0282	0.0009
Kurtosis	3.5625	4.5264	3.8299	3.6570	4.6590	2.8415
Skewness	-0.4551	-0.2780	0.6703	0.5590	0.9976	0.6799

3.2. Methodology

3.2.1. The Fama-French Five-factor Model

The Fama-French five-factor model evolves from its three-factor model, designed to capture the relation between average return and size and the connection between average return and price ratios based on the CAPM of Sharpe [10].

The five-factor model is shown below.

$$R_{it} - R_{Ft} = \alpha_i + b_i(R_{Mt} - R_{Ft}) + h_i HML_t + s_i SMB_t + r_i RMW_t + c_i CMA_t + e_{it} \quad (1)$$

Where R_{it} is the return for the security i at time t; R_{Ft} is the risk-free monthly rate at time t; R_{Mt} is the return of the value-weighted market portfolio at time t; SMB_t is the difference between the return on a diversified portfolio of small stocks and of extensive stocks, HML_t is the return spread of diversified portfolios of high book-to-market ratio stocks minus diversified portfolios of low book-to-market ratio stocks; RMW_t is the difference between the returns on the most profita-

DOI: 10.54254/2754-1169/24/20230433

ble firms and the least profitable firms, CMA_t is the difference between the returns of firms that invest conservatively minus aggressively; e_{it} is the residual [2]. If the factors b_i, s_i, h_i, c_i capture all the variation in expected returns when treating the parameters as actual values, then a_i equals zero for any security i. Using the sample data mentioned in Section 3.1, the regressions of each security before and during the pandemic are generated. Then I am interested in the model's performance, including testing significant factors and variability.

3.2.2. The Coefficient of Determination

The coefficient of determination, denoted as R^2, is a measure to assess whether the regression line explains enough of the variability. This summary gives the total sample variability in response that the regression model explained.

The formula for the coefficient of determination is as follow:

$$R^2 = \frac{SS_{reg}}{SST} \tag{2}$$

Where SS_{reg} is the regression sum of squares and SST is the total sum of squares. Let $y_{it} = R_{it} - R_{Ft}$, $\widehat{y_{it}}$ be the estimated value from the regression, then SS_{reg}, SST can be written as the formulas below.

$$SS_{reg} = \sum_{i=1}^{n}(\widehat{y_{it}} - \overline{y})^2 \tag{3}$$

$$SST = \sum_{i=1}^{n}(y_{it} - \overline{y})^2 \tag{4}$$

In this study, the adjusted coefficient of determination is used and conducted by R program to avoid overfitting because of the multi factors in the model. The adjusted R^2 is given as below:

$$R^2_{adjusted} = 1 - \frac{RSS/(n-p-1)}{SST/n-1} \tag{5}$$

where RSS is the residual sum squared,$RSS = SST - SS_{reg}$ with the degree of freedom of $n - p - 1$, we can find how much variation the five-factor model can explain by computing the adjusted coefficient of determination.

Hypothesis Test.

The hypothesis test for multiple linear regression will be conducted to test the significance of the factors. Based on the assumption that the estimated factors follow the normal distribution, then we can test the hypotheses,

$$H_0: \beta_j = 0$$

$$H_1: \beta_j \neq 0$$

Use test statistics, performing a t-test:

$$T = \frac{\widehat{\beta_j} - 0}{S\sqrt{C_{jj}}} \sim t_{n-p-1} \tag{6}$$

The p-value is the probability of obtaining a sample that provides evidence against the hypothesized value of the factors and can be calculated as

$$p = P(T > |t|) \tag{7}$$

In this study, the p-value is compared with a level of significance value of 0.05. If the p-value is smaller than 0.05, then we have evidence to reject the null hypothesis, which implies that the factor is significant for the model.

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In this study, β_j can be s_i, b_i, h_i, c_i, r_i.

4. Results and Analysis

After generating the regressive five-factor model for each security, we can get the estimations of the five factors and their significance at 5% significant level, which can be seen in Table 3. For AAPL, before COVID-19, the factor for $\boldsymbol{R_{Mt} - R_{Ft}(b_i)}$ is substantial with the p-value of 0.0113, which is smaller than 0.05. Thus, we have evidence against the null hypothesis. We can also conclude by comparing the p-value with the significant level of 0.05. The results are given in Table 4, which lists the essential factors for all the firms before and during the COVID-19. Table 4 shows that before the pandemic, the element of $\boldsymbol{R_{Mt} - R_{Ft}}$ is the only significant one among the five factors for AAPL, AMZN, GOOGL, and UNH, while $\boldsymbol{R_{Mt} - R_{Ft}}$, HML, and CMA are important for JPM; $\boldsymbol{R_{Mt} - R_{Ft}}$, and CMA are significant for XOM. During the pandemic, the significant factors are likely more than the pre-pandemic. $\boldsymbol{R_{Mt} - R_{Ft}}$ is the only significant factor for AMZN, UNH, and XOM. The other firms' many characteristics have changed. For GOOGL, its important factors are added up with HML and CMA, and AAPL adds one significant element of HML. However, some firms experience a decrease in the number of essential factors. During COVID-19, both JPM and XOM lose the significance of CMA. By comparing the result above, it seems that during the pandemic, more factors are involved in the regression, and the five-factor model might have a better performance.

We then compare the adjusted coefficient of determination to compare the model performance better. Table 5 shows the results of the adjusted R^2 before and during the pandemic. From Table 5, the overall adjusted R^2 during the pandemic is higher than before. Thus, the five-factor model during the pandemic explains much more variation on average than the model before the pandemic.

Before the pandemic, these six firms' asset prices are all related to the excess return on the market. Although CMA is significant for XOM and JPM, it plays a small role in the model's performance. Compared with the model during the pandemic, both CMA for XOM and JPM is insignificant, while the model during the pandemic can explain much more variation. For XOM, the adjusted R^2 only be improved by 0.079; for JPM, the adjusted R^2 increases by 0.1203. However, it is interesting to find HML becomes significant for AAPL and GOOGL during the pandemic, and with the factor of HML, the models have a higher adjusted R^2, which is almost twice that before the adjusted R^2 for AAPL increases from 0.3784 to 0.7581; the adjusted R^2 for GOOGL increases from 0.4389 to 0.7257.

The insignificant CMA might be related to the negative impacts of the COVID-19 pandemic on the North American financial market. In the study of Chaudhary et al., COVID-19 increased market volatility in all these indices [11], which might lead firms to invest less aggressively. The significance of HML might imply the security's returns are attributable to the value premium.

Table 3: The Regression result of the fama-French five-factor model for each firm.

AAPL						
	Before COVID-19			During COVID-19		
Coefficients	Estimated Value	Std. Error	p-value	Estimated Value	Std. Error	p-value
(Intercept)	0.0058	0.0122	0.6390	0.0056	0.0086	0.5166
$R_{Mt} - R_{Ft}$	0.8895	0.3295	0.0113	1.2928	0.1510	0.0000

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Table 3:(continued).

SMB	0.1869	0.7100	0.7942	-0.2990	0.3509	0.4007
HML	0.3015	0.8102	0.7124	-1.0434	0.3152	0.0024
RMW	1.7226	1.0464	0.1102	0.3482	0.4202	0.4136
CMA	-2.3111	1.2326	0.0706	0.8657	0.4404	0.0584
AMZN						
	Before COVID-19			During COVID-19		
Coefficients	Estimated Value	Std. Error	p-value	Estimated Value	Std. Error	p-value
(Intercept)	-0.0014	0.0096	0.8845	0.0102	0.0117	0.3910
$R_{Mt} - R_{Ft}$	1.5075	0.2583	0.0000	1.1882	0.2071	0.0000
SMB	-0.8251	0.5567	0.1487	-0.7425	0.4813	0.1330
HML	0.0346	0.6352	0.9570	-0.4325	0.4323	0.3250
RMW	0.2350	0.8204	0.7765	-0.6389	0.5763	0.2760
CMA	-1.7946	0.9664	0.0732	-0.9407	0.6040	0.1290
GOOGL						
	Before COVID-19			During COVID-19		
Coefficients	Estimated Value	Std. Error	p-value	Estimated Value	Std. Error	p-value
(Intercept)	-0.0029	0.0077	0.7140	0.0134	0.0080	0.1030
$R_{Mt} - R_{Ft}$	1.0733	0.2084	0.0000	1.0527	0.1403	0.0000
SMB	-0.6445	0.4492	0.1620	-0.4448	0.3261	0.1825
HML	-0.4095	0.5126	0.4310	0.6390	0.2929	0.0368
RMW	0.3515	0.6620	0.5990	-0.0791	0.3905	0.8409
CMA	0.3362	0.7799	0.6690	-1.3740	0.4093	0.0021
UHN						
	Before COVID-19			During COVID-19		
Coefficients	Estimated Value	Std. Error	p-value	Estimated Value	Std. Error	p-value
(Intercept)	0.0075	0.0112	0.5106	0.0041	0.0094	0.6627
$R_{Mt} - R_{Ft}$	0.7553	0.3032	0.0185	0.6679	0.1651	0.0003
SMB	-0.6554	0.6533	0.3238	-0.1676	0.3839	0.6654
HML	-0.2760	0.7455	0.7138	-0.0293	0.3448	0.9327
RMW	-1.2539	0.9629	0.2027	0.5551	0.4597	0.2363

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Table 3:(continued).

CMA	-0.0981	1.1343	0.9317	0.3440	0.4818	0.4806
JPM						
	Before COVID-19			During COVID-19		
Coefficients	Estimated Value	Std. Error	p-value	Estimated Value	Std. Error	p-value
(Intercept)	0.0111	0.0060	0.0760	-0.0028	0.0067	0.6822
$R_{Mt} - R_{Ft}$	1.2180	0.1631	0.0000	1.0946	0.1181	0.0000
SMB	-0.5365	0.3515	0.1370	0.1064	0.2746	0.7010
HML	1.9678	0.4011	0.0000	0.9392	0.2466	0.0006
RMW	-0.0985	0.5181	0.8500	-0.6336	0.3288	0.0632
CMA	-1.7341	0.6103	0.0080	-0.4085	0.3446	0.2448
XOM						
	Before COVID-19			During COVID-19		
Coefficients	Estimated Value	Std. Error	p-value	Estimated Value	Std. Error	p-value
(Intercept)	-0.0127	0.0064	0.0573	0.0074	0.0124	0.5548
$R_{Mt} - R_{Ft}$	1.1881	0.1738	1,39e-07	1.1169	0.2195	0.0000
SMB	0.5166	0.3746	0.1781	0.3895	0.5102	0.4510
HML	-0.3864	0.4274	0.3732	0.8606	0.4582	0.0698
RMW	-0.1887	0.5521	0.7348	-0.9165	0.6109	0.1437
CMA	1.5444	0.6503	0.0242	0.5916	0.6403	0.3626

Table 4: Significant factors of the five-factor model for firms before and during COVID-19.

	Significant Factors	
Firms	Before COVID-19	During COVID-19
AAPL	$\boldsymbol{R_{Mt} - R_{Ft}}$	$\boldsymbol{R_{Mt} - R_{Ft}, HML}$
AMZN	$\boldsymbol{R_{Mt} - R_{Ft}}$	$\boldsymbol{R_{Mt} - R_{Ft}}$
GOOGL	$\boldsymbol{R_{Mt} - R_{Ft}}$	$\boldsymbol{R_{Mt} - R_{Ft}, HML, CMA}$
UNH	$\boldsymbol{R_{Mt} - R_{Ft}}$	$\boldsymbol{R_{Mt} - R_{Ft}}$
JPM	$\boldsymbol{R_{Mt} - R_{Ft}, HML, CMA}$	$\boldsymbol{R_{Mt} - R_{Ft}, HML}$
XOM	$\boldsymbol{R_{Mt} - R_{Ft}, CMA}$	$\boldsymbol{R_{Mt} - R_{Ft}}$

DOI: 10.54254/2754-1169/24/20230433

Table 5: The adjusted coefficient of determinations for each firm before and during COVID-19.

	Adjusted R^2	
Firms	Before COVID-19	During COVID-19
AAPL	0.3784	0.7581
AMZN	0.6089	0.6447
GOOGL	0.4389	0.7257
UNH	0.0988	0.3799
JPM	0.7017	0.822
XOM	0.6421	0.65

5. Conclusion

COVID-19 has negatively affected North American financial markets, causing people to shift their investment attitudes. By regressing the stock prices of the top-ranked North American companies before and during the pandemic on the Fama-French Five-factor model, we can find that HML starts to become significant during the epidemic. However, CMA loses significance for some companies. The HML becomes substantial during the pandemic, reflecting a greater tendency for firms to invest in value during the pandemic. Companies' stock prices in each sector before the epidemic was mainly related to market returns. After experiencing the epidemic crisis, more detailed factors were considered for pricing stocks.

After the pandemic, I think the pricing of the stock will be influenced by the firm's more cautious and conservative investment attitude and will last for a while. However, whether it will return to the same level as before the pandemic is still unknown.

This study has many shortcomings as well. First, the sample size is small, with only monthly data from 2017 to 2023. Second, the number of companies is relatively small, just a representative selection of large companies in the North American financial market. Third, there is no way for the sample to fully fit the conjecture of the five-factor model, and the fact that the five factors do not fully explain stock prices. Stock prices are not related to only five elements.

References

[1] *M. Chiah, D. Chai, A. Zhong, and S. Li, "A Better Model? An Empirical Investigation of the Fama-French Five-factor Model in Australia: Empirical Tests on the Five-factor Model," International Review of Finance, vol. 16, no. 4, pp. 595–638, Dec. 2016, doi: 10.1111/irfi.12099.*

[2] *E. F. Fama and K. R. French, "A five-factor asset pricing model," Journal of Financial Economics, vol. 116, no. 1, pp. 1–22, Apr. 2015, doi: 10.1016/j.jfineco.2014.10.010.*

[3] *J. W. Goodell, "COVID-19 and finance: Agendas for future research," Finance Research Letters, vol. 35, p. 101512, Jul. 2020, doi: 10.1016/j.frl.2020.101512.*

[4] *M. A. K. Basuony, M. Bouaddi, H. Ali, and R. EmadEldeen, "The effect of COVID -19 pandemic on global stock markets: Return, volatility, and bad state probability dynamics," Journal of Public Affairs, vol. 22, no. S1, Dec. 2022, doi: 10.1002/pa.2761.*

[5] *M. Just and K. Echaust, "Stock market returns, volatility, correlation and liquidity during the COVID-19 crisis: Evidence from the Markov switching approach," Finance Research Letters, vol. 37, p. 101775, Nov. 2020, doi: 10.1016/j.frl.2020.101775.*

[6] *S. Jain, "Betas in the time of corona: a conditional CAPM approach using multivariate GARCH model for India," MF, vol. 48, no. 2, pp. 243–257, Feb. 2022, doi: 10.1108/MF-05-2021-0226.*

[7] *Stock market quotes & financial news, Investing.com, 2023 [Online]. Available: http://www.investing.com/.*

[8] *Current Research Returns of Developed Market Factors and Returns, Kenneth. R. French, 2023. [Online]. Avaliable: http://mba.tuck.dartmouth.edu/pages/faculty/ken.french/data_library.html.*

[9] *MSCI North America Index, MSCI. [Online]. Available: https://www.msci.com/.*

DOI: 10.54254/2754-1169/24/20230433

[10] W. F. Sharpe, "CAPITAL ASSET PRICES: A THEORY OF MARKET EQUILIBRIUM UNDER CONDITIONS OF RISK," The Journal of Finance, vol. 19, no. 3, pp. 425–442, Sep. 1964, doi: 10.1111/j.1540-6261.1964.tb02865.x.*

[11] R. Chaudhary, P. Bakhshi, and H. Gupta, "Volatility in International Stock Markets: An Empirical Study during COVID-19," JRFM, vol. 13, no. 9, p. 208, Sep. 2020, doi: 10.3390/jrfm13090208