Covid-19's Impact on the U.S. Stock Market based on Fama-Frech Multi-factors Model

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Abstract. Since COVID-19 outbreak in 2019 has hugely impacted the global economy, influencing the U.S. stock market. Many industries went through the shutdown, heavy loss, and bankruptcy. During this challenging period, investors suffered from tremendous stresses of financial risk and sought to use the capital asset pricing model to evaluate different stock portfolios. This article is designed to help them find an effective investment method to gain more return in the U.S. stock market. The daily 49 Industry Portfolios datasets used in this research are from Kenneth R. French Data Library and were selected the date from 2000, January 1st to 2021, December 31st, and equally divided into three periods, before the COVID-19 period, during the COVID-19 period, and after the first Pfizer vaccine authorized. Based on the CAPM model, the Fama-French Five-Factor model can better explain the excess return in the U.S. stock market. This article uses the method of multiple linear regression to process the dataset and adopt the Fama-French Five-Factor model to analyze the change in significance and coefficient of five factors. By analyzing the number of anomalies in 49 industries, the result shows that anomalies decreased from 26 to 6 industries, indicating that the Fama-French Five-Factor model has a good explanation for excess return. As for the coefficient change of five factors, the coefficient of market portfolio return (MKT) is close to 1, which means the power of explanation becomes stronger. The coefficient of Small Minus Big Size (SMB) slightly changed but is larger than 0, indicating small-cap firms have better performance than large-cap ones. High Minus Low B/M (HML), Robust Minus Weak Operating Profitability (RMW), and Conservative Minus Aggressive investment (CMA)becomes an insignificant factor. Therefore, the factors HML, RMW, and CMA would not be appropriate to consider as practical investment methods for investors.

Keywords: Covid-19; Fama-French Five-Factor Model; U.S. Stock market.

1. Introduction

1.1 Background

The outbreak of COVID-19 in early 2020 has led to an unprecedented disruption to the global economy, and The U.S. stock market was unparalleled slumped. As COVID-19 rapidly spread worldwide, the United States was severely influenced by the pandemic, with numerous companies going bankrupt, many workers losing their work, and investors inevitably suffering heavy losses from plunging stock prices. Furthermore, one of the most dramatic stock markets falling through the floor has been triggered four times in sequence, and crashes happened in March 2020 [1]. In our research, we try to analyze the effect of this black swan effect (i.e., Covid) on the entire U.S stock market.

1.2 Related research

Most previous studies have focused on the effects of COVID-19 on single industries. Liu has conducted a study on the stock market in the service industry in the United States by applying the Fama-French Five-Factor model to examine the performance of the service industry before and after the outbreak of the COVID-19 [2]. In Liu's research, he aimed to analyze the estimated coefficients and t-statistics of the five-factor factors to evaluate the service industry's performance using the Kenneth R. French Data Library dataset. After analyzing the dataset, Liu concluded that all five factors were statistically significant during the COVID-19 period with a substantial change in factors. The result shows that COVID-19 hurts the service industries. According to a recent study, Bartik et al. claimed that in-person industries like personal services or retail reported were in a worse situation for dealing with the pandemic outbreak than other sectors or professional services with minimal need

for face-to-face contact. That indicates the service and retail industry was greatly shocked by the pandemic [3]. Moreover, Xia and Hu selected 223 pharmaceutical stocks from the CSI 300 index [4]. To investigate the impact of investors' attention on the pharmaceutical stock market, they applied the Fama-French Three-Factor model and panel regression analysis. The epidemic significantly positively impacted the return rate, trading volume, and amplitude during COVID-19, which shows that the pharmaceutical sector was greatly affected by the pandemic. Furthermore, Hou and Chen analyzed the U.S. stock market changes in the steel industry during the COVID-19 period by using Fama-French Five-Factor model and the dataset from Kenneth French-Data Library [5]. According to the result, the five-factor coefficient changed, and the epidemic dramatically declined in the steel industry.

There were still several, not many, economists concentrating on the influence of Covid-19 on entire industries. Baek et al.'s study focus on investigating the impact on U.S. stock market volatility and understanding the regime change from lower to higher volatility using a Markov Switching AR model [6]. The empirical results revealed the U.S. stock market had a significant increase in total risk, and all industries suffered from a consistent increase in total and idiosyncratic risk with exanimating changes across 30 industries. In addition, Zhang conducted research to evaluate the influence of pandemics on the U.S. stock market by using the Fama-French Five-Factor model to analyze 49 industries collected from the Kenneth R. French-Data library from May 1, 2019, to December 21, 2020 [7]. According to the results, industries significantly change positive and negative changes in five factors during the pandemic. Zhang analyzed the changes in five factors (market, scale, value, profitability, and investment) to explain anomalies in the investment field.

1.3 Objective

Although the previous study, either from a single industry or from an entire industry, discover the impact of COVID-19 on the U.S. stock market, these studies have some limitations in collecting a comprehensive dataset and investigating the influence of the development of the first Pfizer's vaccine on the U.S. stock market. This paper aims to equally divide the time frame into three periods to conduct our statistical analysis and investigate epidemic’s impact on the entire industry, 49 industries, under the U.S. stock market. The study focuses on filling the gap of the limitation and shortcomings of the previous research and further enhancing previous research achievements.

2. Methods

2.1 Model

In 1964, William Sharpe proposed the capital asset pricing model (CAPM) that establishes a linear relationship between return and risk. CAPM formula calculates the expected return of an asset and accounts for the expected return is equal to a risk-free interest rate plus the expected return of the market based on a beta factor. The beta factor measures the volatility of returns depending on the general stock market. Betas more significant than one result in stock is riskier than the market, and vice versa. However, the CAPM model has its limitation: market risk is not the only risk that can bring an excess return to stocks.

In 1993, Fama and French developed a three-factor model to capture the relation between average return and Size (market capitalization, price times shares outstanding) and the relation between average return and price ratios like B/M [8]. The Fama-French model includes three factors: the size of firms, book-to-market values, and excess return on the market. The size factor, SMB (Small minus Big), is the return on a diversified portfolio of small stocks minus the return on a diversified portfolio of big stocks. The value factor, HML (High minus Low), is the difference between the returns on diversified portfolios of high and low book-to-market stocks. Although the three-factor model has an excellent explanation for analyzing the return rate of cross-section stock portfolios, Novy-Marx, Titman, Wei, and Xie, and others think that it is an incomplete model for expected return because its three factors lack the variation in average return that related to profitability and investment [9][10].

In 2015, Fama and French proposed a five-factor model by adding profitability and investment factors [11] [12]. In Fama-French Five-Factor model, RMW (Robust Minus Weak) is the average return on the two robust operating profitability portfolios minus the average return on the two weak operating profitability portfolios, and CMA (Conservative Minus Aggressive) is the average return on the two conservative investment portfolios minus the average return on the two aggressive investment portfolios. Compared with the Three-Factor model, the Five-Factor model can better explain the excess return rate.

Fama-French Three-Factor model:

$$R_{it} - R_{Ft} = a_i + b_i(R_{Mt} - R_{Ft}) + s_i SMB_t + h_i HML_t + e_{it} \quad (1)$$

Where R_{it} is the rate of return on portfolio i for period t; R_{Ft} is the risk-free rate; $R_{it} - R_{Ft}$ is the excess return of stock; $R_{Mt} - R_{Ft}$ is the excess return of the market; SMB (small minus big) is the return on a diversified portfolio of small stocks minus the return on a diversified portfolio of big stocks. HML (High minus Low) is the difference between the returns on diversified portfolios of high and low book-to-market stocks.

Fama-French Five-Factor model:

$$R_{it} - R_{Ft} = a_i + b_i(R_{Mt} - R_{Ft}) + s_i SMB_t + h_i HML_t + r_i RMW_t + c_i CMA_t + e_{it} \quad (2)$$

RMW (Robust Minus Weak) is the average return on the two robust operating profitability portfolios minus the average return on the two weak operating profitability portfolios; CMA (Conservative Minus Aggressive) is the average return on the two conservative investment portfolios minus the average return on the two aggressive investment portfolios.

2.2 DATA

This paper aims to use the Fama-French Five-Factor model in our analysis. The data used in this research are the daily 49 Industry Portfolios datasets from Kenneth R. French Data Library [13]. The daily 49 Industry Portfolios datasets include the daily average value-weighted return and daily average equal-weighted return. In this research, we only use the equal-weighted return as the daily return. The date of this dataset is from July 1926 to March 2022. Since we investigated the period before COVID-19 happened, after the outbreak of COVID-19, and the development of the first Pfizer vaccine, this dataset was divided into three time periods with equal time duration. The first period is defined as before COVID-19 happened and was selected from 2000, January 1st to 2020, February 28th. The second period is defined as during COVID-19 and was selected from 2020, March 1st to 2020, December 11th. The third period is defined as after the development of the first Pfizer vaccine and was selected from 2020, December 11th to 2021, December 31st [14].

3. Results and Discussion

3.1 Anomaly

Previous work shows that average returns stock market is related to market, scale, value, profitability, and investment. Anomalies often occur in the capital asset pricing model (CAPM) because CAPM cannot explain the excess gain or loss in the stock market as Alpha is not equal to 0.

As shown in Table 1, by comparing the number of anomalies from three periods, before COVID-19, During COVID-19, and after the Pfizer vaccine was authorized, the result shows that anomalies decreased from 26 industries to 6 industries. The result also means that the Fama-French Five-Factor model has better explanations of the excess return in the stock market.

Table 1. The number of anomalies

Stage	The number of anomalies	Percentage
Before pandemic	26	53.06%
During pandemic	10	20.41%

3.2 Coefficient bi

bi is an important factor in measuring a stock's risk in CAMP and relates to measuring a stock's relative volatility. The stock market's volatility shows how much the price of stock changes in an industry compared to how much the price changes in the whole stock market. If a share price moves faster than the market, the stock's Beta is greater than 1. If a share price moves more slowly than the market, the stock's Beta is less than 1. (See Table 2)

Table 2. The sign definition of coefficient bi

Negative sign (-)	The price of a stock change in an industry changes lower than the price of a stock change in the whole stock market, which means stock beta less than 1.
Positive sign (+)	The price of a stock change in an industry changes more quickly than the price of a stock change in the whole stock market, which means stock beta is greater than 1.

To deeply investigate the change in stock's Beta, we decided to divide the change of stock's Beta into three different types, significant change, normal change, and unchanged in the three periods. According to Table3, the stock's Beta of 9 industries normally changed from a share price moving slower than the market to quickly, and 2 industries changed oppositely. In other words, this change represents the sensitivity of those 9 industries' stock prices to market change to sensitive because of the impact of the epidemic. Although the stock Beta of some industries did not change before COVID-19 and after the Pfizer vaccination authorized period, it significantly changed during the COVID-19 period. This significant change occurred in 6 industries. Moreover, 27 industries' stock Beta do not change as stock beta less than 1, and 5 industries' stock Beta does not change as stock beta greater than 1 during three time periods.

Table 3. The volatility of bi (comparing with 1)

Change	State	The number of changes	Industries
Significant changed	-+-	2	Fun, Hlth
	+-+	4	Chems, Steel, Autos, Ships
Normal changed	--+	9	Clths, FabPr, ElcEq, Aero, BusSv, Chips,Trans, Whlsl, Fin
	-++	2	BldMt, Hardw
Unchanged	---	27	Agric, Food, Soda, Beer, Smoke, Toys, Books, Hshld, MedEq, Drugs, Rubbr, Txtls, Guns, Gold, Util, Telcm, PerSv, Softw, LabEq, Paper, Boxes, Rtail, Meals, Banks, Insur, RlEst, Other
	+++	5	Cnstr, Mach, Mines, Coal, Oil

3.3 Coefficient si

The SMB data result shows that the coefficient of SMB was greater than 0 in all statistically significant industries like agriculture, food, soda, beer, toys, etc. The coefficient of SMB became large after the impact of COVID-19, indicating higher returns in small-cap stocks. This finding coincides with conclusions from Cao et al. [15]. They found that the SMB coefficients of consumption-related industries increase significantly after the global pandemic, indicating that small market value companies have strong growth potential. After vaccination, the SMB coefficient of most industries became lower than after the covid period, reflecting a weaker intention of high returns in small-cap industries.

Table 4. The significant changes of fives factors

Factor	The number of industries				
	MKT	SMB	HML	RMW	CMA
Before pandemic	49	49	43	47	29
During pandemic	49	47	36	16	13
After Pfizer vaccine authorized	49	44	38	29	16

To the impact of the pandemic, both small-cap firms and large-cap firms had high market expectations, so their stock return was similar. In this case, small-cap firms had an advantage over large ones. Small-cap stocks would offer the greatest return even if they had more volatility than large-cap stocks. Compared with large-cap companies, the small-cap companies had little productivity loss because their scale of production processes is much smaller. Furthermore, small-cap stocks tend to have lower stock prices, meaning their price appreciations had more room to grow than large ones. Therefore, for the above reasons, Investors tend to invest in small-cap firms for excess return when their price stocks are undervalued.

In Table4, the number of significant changes in the SMB factor has decreased since the onset of the pandemic. In other words, some industries were not significant after the outbreak of Covid-19.

3.4 Coefficient hi

HML factor represents the spread in returns between firms with a high market value and firms with a low market value.

Coefficient hi has positive and negative values. A positive hi means that the portfolio behaves like a value stock portfolio. A negative hi means that the portfolio behaves like a growth stock portfolio. (See Table 5)

Table 5. The sign definition of coefficient hi

Negative sign (-)	Portfolio behaves like a growth stock portfolio
Positive sign (+)	Portfolio behaves like a value stock portfolio

Table 6. The volatility of hi (comparing with 0)

Change	State	The number of changes	Industries
Normal changed	++-	1	Other
Unchanged	---	3	Drugs, Softw, Chips
	+++	24	Agric, Books, Clths, Chems, Txtls, Steel, FabPr, Mach, Autos, Aero, Ships, Mines, Coal, Oil, Util, BusSv, Paper, Boxes, Trans, Whlsl, Meals, Banks, Insur, Fin

HML factor is vital in distinguishing portfolio behaviors: value stocks or growth stocks. As a result of the pandemic, investor investment methods have changed to conservative because they are willing to invest in value stocks with a stable return. Table 6 shows that investors who would like to invest in value stock did not change their investment method as they wanted a steady return during the pandemic.

According to Table 4, the factor has significant changes in 7 industries from significant to non-significant after the pandemic, indicating that investors would not consider the HML factor as an investment method. To investigate evidence of investors' unchanged investment methods, we analyzed HML data and created Table 6. Table 6 shows investors' investment methods are unchanged in 27 industries, except 'Other' industries changing from value stock to growth stock after the Pfizer vaccine was authorized. Investors who prefer investing in value stocks did not turn their investment methods in 24 industries, and others who tend to invest in value stocks did not turn their investment methods in 3 industries. Hence, there is a weak relationship between portfolio and value premium, and the investor will not consider the HML factor as an essential factor for their investment methods.

3.5 Coefficient ri

The RMW factor indicates the relative movement of the stock in response to the profitability premium and has consistently provided excess returns.

A negative ri represents a negative size-premium, which means profitability behaves like weak companies. A positive ri represents a positive size-premium, which means profitability behaves like robust companies. (See Table 6)

Table 6. The sign definition of coefficient ri

Negative sign (-)	Profitability behaves like weak companies
Positive sign (+)	Profitability behaves like robust companies.

Table 8. The volatility of ri (comparing with 0)

Change	State	The number of changes	Industries
Significant changed	+-+	2	Smoke, Util
Normal changed	+--	2	Mines, Oil
Unchanged	---	4	MedEq, Drugs, Softw, Other
	+++	2	Clths, BldMt

After analyzing the coefficient of the RMW factor, we found that almost all statistically significant industries have a negative coefficient ri, which means investors prefer investing in weak companies to robust companies during the pandemic. Indeed, Table 8 shows that investors have significantly turned to invest in weak companies in the Smoke and Util industry and normally turned to invest in weak companies in Mines and Oil industry. These signs reveal that small-medium size firms perform better than large size firms for profitability during the crisis. However, others did not change their investment methods. The financially capable and strong firm has better profitability than the fragile firm in medical equipment, drugs, computer software, and other industries. On the contrary, the fragile firm performed better than the strong firm for profitability in Apparel and Construction materials industry. These two forms of unchanged investment methods show that investors might not consider RMW as an important factor for their investment. Moreover, another piece of evidence was found in Table 4, and the RMW factor has significant changes in 31 industries from significant to non-significant after the pandemic. Therefore, investors are not confident in ensuring the importance of profitability premium when they invest in.

3.6 Coefficient ci

The CMA factor indicates the yield spread due to different investment styles which are conservative and aggressive investments. A negative coefficient ci represents the greatest return derives from firms' aggressive investment method. A positive coefficient ci represents the greatest return due to firms' conservative investment method. (See Table7)

Table 7. The sign definition of coefficient ri

Negative sign (-)	The investment style is aggressive
Positive sign (+)	The investment style is conservative

Table 10. The volatility of ci (comparing with 0)

Change	State	The number of changes	Industries
Significant changed	+-+	1	Retail
Unchanged	+++	1	Food

As a result of the pandemic, the significance of the CMA factor became non-significance in 16 industries (See Table 4), indicating the CMA factor was not better to explain the excess return than before. This phenomenon explains that the impact of pandemics caused changing investment styles. Conservative investors believe that most conservative firms have stable returns and reliable decisions. On the contrary, aggressive investors tend to invest more funds in radical firms which has quality assets at a low price for more benefits.

To investigate the investment style change, we analyzed the CMA data and found that investors who persistently invested in conservative firms in the food industry did not change their investment style. Moreover, the retail industry has changed significantly from investing in conservative firms to aggressive ones. (See Table 10) This finding in the retail industry coincides with Hou's studies [16].

According to Hou's research, the coefficient of CMA became insignificant after the outbreak of the pandemic, and the CMA factor has little impact on the return rate. Cao et al. researched the consumption-related industry, and they found the coefficient of the CMA factor was positive in the consumption industry because investors took a dim view of it [15]. Although investors would like to get the greatest profits, most of them keep a conservative approach to pursue a stable return with getting a lower return.

4. Conclusion

This article uses the Fama-French Five-Factor model to investigate the influence of COVID-19 in 49 industries on the U.S. stock market from 2000, January 1st to 2021, December 31st. Based on the Fama-French Five-Factor model, we analyze the difference among the coefficient of five factors (market, scale, value, profitability, and investment) in three periods, before the COVID-19 period, during the COVID-19 period, and after the Pfizer vaccine authorized. With presenting anomalies decreased from 26 industries to 6 industries, we found that the Fama-French Five-Factor model performs the excess return in the U.S. stock market well. To study the changing investment style, we focus on comparing the coefficient of five factors in three periods. Before the pandemic, SMB and HML are relatively significant, and investors invest most found in small-size firms and high-value stocks to gain tremendous profits. After the COVID-19 outbreak and the Pfizer vaccine authorized, SMB and HML indicators became insignificant in some industries. In the same period, the significance of RMW and CMA indicators dramatically changed to insignificant in most industries. We found that HML, RMW, and CMA do not better explain the excess return than before. To provide investors with practical investment analysis and help them to decide, we strongly suggest investing in stocks of small-cap firms.

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