



Empirical Research and Regulatory Reflections on the U.S. Stocks and Pharmaceutical Industry under the COVID-19 Pandemic

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Abstract. Based on the Fama-French three-factor and five-factor models, this article empirically studies the changes in the pharmaceutical industry of the US stock market before and after the epidemic and analyzes the medical-related industry and its three sub-sectors of health care, medical equipment, and pharmaceuticals. The results show the explanatory power of the two models after the epidemic has changed. The overall change in market factors is relatively small. The epidemic has not affected the "small-scale" effect of the US stock pharmaceutical industry, and the market is more ignorant of growth stocks. The book-to-market ratio and investment style factors are redundant. For the sub-industry, the profit factor in the health care industry has become redundant due to the impact of the epidemic, and the growth stocks of the medical equipment industry and the pharmaceutical industry have made significant gains, and they are more speculative after the epidemic. For the government and the capital market, the pharmaceutical industry plays an important role in stabilizing society and promoting economic development and deserves firm and long-term support and effective supervision.

Keywords: Fama -French model, New crown epidemic, Pharmaceutical industry

1 Introduction

About the CAPM model, there are many domestic and foreign scholars to study. Among them, Sharpe [1], Lintner [2] and Black [3] have shown that the expected revenue of stocks or stock combinations is related to its market risk B (Beta) linearity, and B is the only determinant of its expected earnings. The research conclusions of Black, Jensen and Scholes [4], Blume and Friend [5], and Fama and Macbeth [6] have supported the core view of CAPM theory, of which Black, Jensen and Scholes [4] use New York Securities Trading. The stock data (NYSE) was inspected by stock data from 1931 to 1965. The results show that low-risk stocks have acquired the theoretically expected benefits, while high-risk stock income is lower than the theoretical forecast. Fama and Macbeth [6] were analyzed from 1935 to 1968, US stocks were analyzed for

samples. The test results show that stock income is positively related to BETA values, while other non-systematic risk factors are not significantly correlated with stock income.

With development capital and stock market, more and more research conclusions at home and abroad do not support the CAPM model. Roll [7] first questioned the empirical inspection of the CAPM model: Since it is not possible to prove whether the market index is valid, the CAPM model cannot be inspected, and the arbitrage pricing theory (APT) is proposed, that is, it is competitive and no In the friction market, the stock rate is related to unknown factors, and inferences, the CAPM model is only a simple single-factor model based on this assumption.

The test of the CAPM model gradually turned from a single beta inspection to multivariate analysis, and the study of multivariate believes that Beta in the CAPM model does not fully explain the intersection of expected earnings of stock assets. The research of Banz [8] believes that in addition to B, the market value (ME) (total stock price * total stock) has better interpretation capabilities on the average return of stocks, under specific B conditions, low-market stocks have higher The average yield, and the high market value has a lower yield, which is the scale effect of stock yields. Other scholars' research also discovered that the US stock average yield and book market value is positive, and the higher the book market value is higher the company, and the average will also achieve higher stock yield [9-10]; company financial leverage can also partially explain the difference in stock income rate, the higher the payment ratio, the larger the average return rate of the stock [11]; BE / ME (Book value/market value) has a higher stock average yield in the Japanese stock market Interpretation ability [12]; US stock P / E ratio has interpretation capabilities on the average yield [13]. Based on predecessors, Fama and French [14] conducted deep research on the influencing factors of US stock yields, and systematic inspection of other factors affected by the CAPM model, resulting in other factors affected by stock expectations. It was found that the B value of the stock market could not explain the difference in different stock yields on a cross-section, while the company's total market value, the book market value ratio and other factors can better explain the differences in stock yields on the cross-section. Further research found that three factors such as market assets (RM - RF), scale factors (SMB), and book market value compared to factors (HML) can make better explanations to investment portfolios (including single stocks) [15], The interpretation ability is stronger than the CAPM model.

By telling the Novel Coronavirus story in real-time, data visualization has taken on new importance in the daily lives. In the early days of the epidemic, this study saw circles on the map multiply and swell as the virus spread around the globe. This paper wants to evaluate that the lines on the time series map are almost vertical during the spike in cases. These numbers and their graphic symbols have been crucial to our behavior over the past two years. From individual and collective trauma to profound economic disruption, the impact can also be largely measured to help us tell a more complete story of how Novel Coronavirus is changing the world. Subsequent visualizations focus on underlying trends; Because you can't capture any story with data alone, context and considerations are provided throughout.

2 Method

For CAPM model, this model is composed of:

$$R_i = R_f + \beta (R_m - R_f) \quad (1)$$

where R_i refers to the rate of return on investment, R_f refers to the risk-free rate (usually measured by the yield of US Treasury bonds), R_m is the expected average market rate of return, and $R_m - R_f$ is the market excess rate of return, which is the difference between the expected market rate of return and the risk-free rate of return.

β Coefficient, i.e. the systematic risk of asset 'i', is calculated as the 'standard deviation of R_i / the standard deviation of R_m '. It could be expressed by a mathematical formula:

$$\beta_{im} = \text{sd}R_i / \text{sd}R_m \quad (2)$$

CAPM model mainly studies the relationship between the expected return of assets and risky assets in the securities market, and how the equilibrium price is formed. According to the provisions of CAPM, the β coefficient is a pointer used to measure the systematic risk of an asset and a risk assessment tool used to measure the volatility of a security or an investment portfolio relative to the overall market. From the perspective of the market portfolio, the systematic risk of individual assets can be regarded as the reflection degree of changes in the market portfolio, which can be measured by the β coefficient. β , a sign that refers to the degree of simultaneous changes in the rate of return of individual assets relative to the change in the market rate of return. It is a standardized indicator to measure the contribution of a single asset to the variance of the market portfolio.

In order to meet the establishment of CAPM (capital asset pricing model), it needs to meet: (1) Investors know the distribution of return on investment; (2) The investors studied are rational people, that is, they recognize the theory that return = risk, and the greater the risk, commonly lead to greater income that can be obtained; (3) Investors abide by the dominance principle, that is, under the same risk level, they choose securities with high yield; Under the same yield level, choose securities with lower risk.

However, under the CAPM model, there will be some potential systemic risks, such as the impact of war, disease and regime change on the stock price, which cannot be reduced through the portfolio itself. Some nonsystemic risks also exist, and investors can avoid such risks through their portfolios.

The second applied model is the Fama-French three-factor model, and the formula of this model is:

$$R_i - R_f = \beta_1 (R_{mt} - R_{ft}) + \beta_2 (\text{SMB}_t) + \beta_3 (\text{HML}_t) \quad (3)$$

In this model, the three research factors are (1) $R_m - R_f$, market excess return; (2) SMB, the small minus big of the market value factor of time t, also known as market value, that is, fair value (the "share price" in the secondary market); (3) HML, the simulated

portfolio yield (high minus low) of the book market to market value ratio factor of time t , that is, the value of value stock-growth stock.

However, it should see that the three-factor model does not represent the end of the capital pricing model. The three-factor model cannot explain potential problems such as short-term reversal, medium-term, momentum, volatility, skewness, gambling, and so on.

Therefore, Fama French's five-factor model is also used in this paper. The formula of this model is:

$$R_i - R_f = \beta_1(R_{mt} - R_{ft}) + \beta_2(SMB_t) + \beta_3(HML_t) + \beta_4(RMW_t) + \beta_5(CMA_t) \quad (4)$$

In this model, except for all the data covered by the three-factor model, the additional two factors are (1) RMW, the return difference between high and low-profit stock portfolios, i.e. probability; (2) CMA refers to the return difference of the stock portfolio of companies with low high reinvestment ratio, that is, the investment level risk (the investment level here is not the investment level of the secondary market, but can be popularly interpreted as the ability of enterprises to expand reproduction).

Similar to the Fama-French three-factor model, the parameter estimation method of the five-factor model is still the method of multiple linear regression.

3 Result and Discussion

The data is selected from Kenneth R. French's data, the founder of the Fama-French model, according to the relevant information of the US stock market [16]. To conduct a more detailed analysis of the pharmaceutical-related industries in the US stock market, the total pharmaceutical industry in 12 industry classifications and the daily data of health care, medical equipment, and pharmaceuticals in the 49 industry classification data (the former is the overall combined result of the three sub-industries) were selected. Considering that the new crown epidemic caused large-scale transmission in the United States in March 2020, the data from March to October was selected as the data after the outbreak, and the data of the same length of time (July 2019 to February 2020) was selected as the data before the outbreak. Compare reference.

Data in the web source can be divided, before the outbreak, medical equipment, this is because under the background of the new pneumonia outbreak, such as hospitals, the medical field for its downstream industries such as breathing machines, as blood pressure check some of the general conditions of the new champions league products demand a substantial rise, and at the beginning of new pneumonia in the short term. There was a shortage in the market for some time when demand was greater than supply. For enterprises in developed countries, they have enough capital or government support to improve the PES of their products in a short period and rapidly increase production capacity. For example, BYD, a famous Chinese automobile company, built a factory with a daily production capacity of 100 million masks in one week at the beginning of the outbreak of the epidemic. From the data given, it can be seen that MKT-RF has the greatest influence.

The multiple linear regression method was used to calculate the data of the sub-sectors of health care, medical equipment and pharmaceuticals, and the generic pharmaceutical industry, respectively, to obtain the coefficients of the three-factor and five-factor models before and after the epidemic and conduct a significance test.

Table 1. Descriptive statistics of the return rate of each factor in the health care sub-industry of US stocks before and after the epidemic

Time	Project	Three-factor Model			Five-factor Model				
		MKT	SMB	HML	MKT	SMB	HML	RMW	CMA
2019.07-2020.02	coefficient	0.88	0.96	0.07	0.94	0.93	0.02	-0.72	0.12
	T-test value	14.01	7.05	0.67	14.35	7	0.13	-3.29	0.44
2020.03-2020.10	coefficient	1.21	0.86	0.18	1.19	0.83	0.09	-0.36	-0.34
	T-test value	18.1	5.10	1.74	17.62	4.48	0.63	-1.18	-0.82

As shown in Table 1, the market factor Mkt has an increasing trend due to the impact of the epidemic, that is, asset price changes are more sensitive to the market. Before the outbreak of the epidemic, the entire health care sub-industry was highly counter-cyclical, and with the aggravation of the epidemic, the overall performance of the market is closely related to the number of patients and deaths, which also directly affects the prices of stocks in the health care sub-industry. In addition, the health care sub-industry Yields are significantly higher for small and mid-cap stocks. Generally speaking, companies with smaller market capitalizations are usually larger, and the companies are relatively less stable, so they are riskier and need to obtain higher returns to compensate. The calculation results show that the book-to-market ratio and investment style factors are redundant, and the profit factor in the five-factor model becomes insignificant after the epidemic. The epidemic has had a huge impact on the U.S. health care industry, with nearly 1.5 million jobs eliminated. More than 500,000 employees in dentists' offices and more than 240,000 in doctors' offices were fired. Many small clinics were forced to close due to the impact of the epidemic, resulting in many patients unable to receive effective treatment.

Table 2. Descriptive statistics of the return rate of each factor of the US stock medical equipment sub-industry before and after the epidemic

Time	Project	Three-factor Model			Five-factor Model				
		MKT	SMB	HML	MKT	SMB	HML	RMW	CMA
2019.07-2020.02	coefficient	0.63	0.95	-0.11	0.68	0.92	-0.21	-0.55	0.18
	T-test value	9.15	6.35	-0.98	9.19	6.16	-1.44	-2.22	0.6
2020.03-2020.10	coefficient	0.84	0.77	-0.02	0.84	0.63	0	-0.79	-0.16
	T-test value	25.87	9.35	-0.49	27.76	7.66	-0.02	-5.7	-0.84

Table 2 shows that the medical device sub-sector is less sensitive to the relative market and has a stronger counter-cyclicality. However, with the outbreak of the epidemic, the coefficient also tends to increase. In mid-June 2020, the U.S. government awarded contracts worth nearly \$200 million to nearly 4,000 businesses through various departments and agencies. Final government spending could reach \$24.8 billion under existing contracts. Different from the health care sub-industry, the profit factor is significant before and after the epidemic, and the coefficient is less than zero, indicating that the stocks of the medical equipment sub-industry are speculative to a certain extent.

Table 3. Descriptive statistics of the return rate of each factor in the pharmaceutical sub-industry of the US stock market before and after the epidemic

Time	Project	Three-factor Model			Five-factor Model				
		MKT	SMB	HML	MKT	SMB	HML	RMW	CMA
2019.07-	coefficient	0.93	1.46	-0.3	1	1.4	-0.42	-0.85	0.11
2020.02	T-test value	15.64	11.32	-3.22	16.36	11.36	-3.48	-4.13	0.43
2020.03-	coefficient	0.94	1.19	-0.38	0.94	1.02	-0.4	-5.97	0.15
2020.10	T-test value	25.65	12.79	-6.83	31.42	12.37	-5.97	-9.38	0.84

Table 3 shows that the epidemic has little impact on the market sensitivity of the pharmaceutical sub-industry, which may be related to the special indications of pharmaceuticals, and the industry is relatively more counter-cyclical. The book-to-market ratio factor HML was significant and negative both before and after the epidemic, indicating that the market prefers growth stocks. The coefficient of profitability factor RMW increased significantly after the epidemic, which shows that the pharmaceutical industry is more speculative. The development of the US pharmaceutical industry is relatively mature, and the pharmaceutical giants have expanded rapidly after many mergers and acquisitions, and the investment impact is not obvious.

Table 4. Descriptive statistics of the return rate of each factor of the total U.S. stock pharmaceutical industry before and after the epidemic

Time	Project	Three-factor Model			Five-factor Model				
		MKT	SMB	HML	MKT	SMB	HML	RMW	CMA
2019.07-	coefficient	0.87	1.32	-0.24	0.94	1.28	-0.35	-0.78	0.12
2020.02	T-test value	16.57	11.66	-2.89	17.43	11.8	-3.3	-4.35	0.55
2020.03-	coefficient	0.94	1.09	-0.27	0.94	0.93	-0.29	-1.13	0.06
2020.10	T-test value	28.8	13.3	-5.54	35.4	12.8	-4.9	-9.3	0.37

From the results of the combined data, the market results of the general pharmaceutical industry and the pharmaceutical sub-industry are relatively consistent, which is directly related to the high total market value of the pharmaceutical sub-industry. In the three-factor model, the market factor Mkt has a trend of increasing due to the impact of the epidemic, but the magnitude is small. In the five-factor model, there is no change in the overall income fluctuation of the pharmaceutical sector. The fluctuation range is similar to the market fluctuation range. In addition, the "small scale" effect and the tendency of growth stocks are more obvious, the entire industry is speculative, and the investment style factor CMA is a redundant item. The calculation results generally show that the impact of the new crown epidemic on various factors of the pharmaceutical industry is relatively small, which highlights the confidence of the capital market in the pharmaceutical industry. It is worth noting that the adjusted R2 of the three-factor and five-factor models after the epidemic has improved to varying degrees, which shows that the matching degree of the models has increased under the epidemic conditions.

As the variance of data is below 0.9, the fitting effect is not very ideal. Before the outbreak of the epidemic, the intersection coefficient of the medical device industry is -0.03, a data less than 0, which indicates that the actual return rate of investment in the medical device industry is less than the expected return rate calculated. Before the outbreak of the epidemic, it is not recommended to invest in the medical device industry. During the outbreak of the convergence coefficient increases to 0.36579937, as a

positive number, the investment of medical equipment industry's real yields higher than the expected return, investment is proposed, and after the outbreak of improving convergence coefficient is down a bit, but because the consumer demand for medical devices is far greater than before the outbreak, so the coefficient is still a positive number. Investment is also advised.

Mkt-RF is the market relative to risk-free investment expectations of excess Return, the beta coefficient is generally used to compare the return rate of investment in a single market with the return rate of risk-free investment in the market (the return rate of US Treasury bonds). When the value of MKT-RF is larger, that is, R_i is more sensitive to R_m , which also indicates that the potential risk coefficient of the stock is larger. However, according to the hypothesis of the research premise, Investors have accepted the theory of risk = return, and the higher the risk factor, the higher the return on investment will be.

By comparing the regression results in Table 1, Table 2 and Table 3, it can be seen that before the outbreak of COVID-19, the coefficient of MKT-RF decreased from 0.809 to -0.286 and then increased to 0.88222367. This indicates that during the outbreak of the epidemic, since medical devices such as protective equipment are necessities, the risk of investment is relatively small, and the return from investment is correspondingly small. However, after the epidemic improves, the coefficient increases by about 1.0, referring to the Coefficient of Intercept, The actual return rate of investment in medical devices after the epidemic is greater than the calculated expected return rate, indicating that investment in medical devices after the epidemic can obtain a high return.

$E(\text{SMB}_t)$ is the simulated portfolio return of the size factor at time t . Before the epidemic, the beta coefficient of SMB was positive, indicating that the sample funds investigated by the institute might be more inclined to invest in small medical device enterprises, so the excess return before the epidemic was mostly determined by the stock return of small enterprises. During the outbreak, the t -value and p -value of SMB are not significant, so the analysis is not made. After the outbreak is improved, the beta coefficient of SMB is 0.59226094, which is still a coefficient greater than 0. Therefore, if you invest in medical device stocks, Smaller stocks have correspondingly higher returns. The reason for this is that small company are likely to experience the small company effect, where actual returns are higher than expected, and in the context of the uncertainty of COVID-19, small companies can avoid DIS EOS and switch to producing goods with temporary high demand for a short period. Having a close connection with the customer base allows small companies to respond more quickly to changing consumer interests and thus make money. Because of this, small companies can avoid the pressure on working capital caused by the epidemic prevention policies of large companies that used to produce dental beds and beauty instruments. Therefore, small companies are recommended for investment.

HML equals to the high book-to-market ratios minus low B/M ratios, So $E(\text{HML}_t)$ is the simulated portfolio return of the B/M factor at time T . According to Table 1, Table 2, and Table 3, it can be found that the beta value of HML is negative in the period after the epidemic recovery, which indicates that in general, for the medical device industry, the return on investment of companies with lower B/M value is higher

than that of companies with higher B/M value. It can be seen that the samples of the portfolio are more willing to commit funds at relatively low par value stock, this may be related to the nature of the medical equipment industry, the original high par value stock in the short term is difficult to have risen sharply because the medical apparatus and instruments with pharmaceutical companies, new drug research, and development success will bring stock price rise sharply, So investing in stocks with lower par value makes it easier to reap the rewards of rising prices. However, before and during the outbreak, neither p-value nor T value of HML was significant, so the correlation was not strong and could not be used for routine sample analysis

RMW (Robust Minus Weak) measures the excess return of companies with high operating margins, not low ones. The theory is that companies with higher profitability have a higher risk. The beta coefficients in Table 1 and Table 3 are both negative, indicating that the sample portfolio prefers to invest in companies with lower operating profit margins. This may be because investors prefer to invest in companies with a smaller market capitalization (SMB's beta coefficient is greater than 0), while for small companies, excessive risk means potential crisis. Stable and long-term return is the main way to obtain investment income, so the enterprise with a lower operating profit rate is more favored. During the outbreak period, as shown in Table 2, due to the outbreak of the epidemic, the demand for medical devices increases significantly. At this time, it is a better choice to invest in companies with high operating profit margins, because companies with high operating profit margins tend to have more sales and generate high profits during the outbreak of the epidemic. It is a good speculative stock choice in the short term. However, RMW values are not significant during the outbreak period, so they are not relevant to investment decisions and cannot be used as a decisive factor for long-term stable investment decisions.

Conservative Minus Aggressive (CMA) measures the excess return on a company's investment as lower than that of a company that can invest more. This index simulates the risk of investment, with higher risk indicating a lower investment rate. Investors aim for higher expected returns, i.e., higher CMA values. Can through the table 1 and table 3, look out, that before the outbreak and epidemic situation after the improvement on the significance level of the beta coefficient of CMA is positive, it shows that in the medical device industry, because of consumers' demand for medical devices, in the long run, is stable, so before and after the outbreak of epidemic situation, more suitable for smaller stable investment volatility of a stock, That is, conservative investments get excess returns. During a pandemic, demand for medical devices rose sharply for a short period, so the CMA's beta turned negative -- that is, the excess return from investing in volatile stocks for a short period during a pandemic was higher. However, since its p-value and T value do not meet the conditions of significance, this effect has little relevance to long-term investment in the stocks of the medical device industry.

Negative earnings in the energy, retail and transportation sectors in both countries; Health care is positive in both countries. Some sectors are markedly different, such as semiconductors, which rose rapidly in China but fell in the US; Utilities fell in China and rose strongly in the US.

4 Conclusion

Research on the relationship between risk and return in the capital market is very important, and it has positive significance for finding investment opportunities, controlling risks, and pricing financial products. Based on the Fama-French three-factor and five-factor models, this article analyzes the differences between the U.S. stock pharmaceutical industry before and after the new crown epidemic. The results indicate that the Fama-French model's interpretation of the industry has been strengthened after the epidemic, and the epidemic has not significantly affected the U.S. stock pharmaceutical industry. The impact still maintains the "small-scale" effect, growth stocks, and speculative attributes. With the aging of the population and the improvement of people's living standards, the long-term investment value of the pharmaceutical industry will be further stabilized. Especially with the outbreak of the new crown pneumonia, companies such as masks, ventilators, virus prevention, and vaccine research and development have performed well, which has also brought confidence to the social and financial markets. According to the above findings, this paper puts forward the following suggestions: first, it should continue to strengthen pharmaceutical industry, there are many pharmaceutical giants in the US stock market. The country should enhance drug and medical device R&D and production play an important role in stabilizing the society and financial market, and can also bring relatively stable returns to value investors in the market; the second is to strengthen the supervision of speculative behaviors in the pharmaceutical industry. Moreover, pharmaceutical companies with core technologies should be protected so that they can better create value.

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