

# Study on the Applicability of the Fama-French Three-factor Model and Five-factor Model to the American Biopharmaceutical Industry during the COVID-19 Period

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## ABSTRACT

At the end of 2019, a huge black swan, COVID-19, came and erupted in 2020. Both our daily life and investment activities are more or less affected by COVID-19, which is a new opportunity and challenge for the biopharmaceutical industry. In order to analyse the current situation of the American biopharmaceutical industry during the COVID-19 period and promote the development of the financial market, the author studied three biopharmaceutical industry funds, selected the data from January 2020 to September 2021, and introduced the three-factor model and the five-factor model to carry out multiple regression analysis. The results show that during the sample period, both the three-factor model and the five-factor model have strong applicability to the stocks of the American biopharmaceutical industry, which means that all five factors have a strong ability to explain the changes in stock returns of this industry. In addition, the five-factor model has a higher positive correlation and fitting degree for the three funds.

**Keywords:** American biopharmaceutical industry, Fama-French three-factor model, Fama-French five-factor model, multiple regression analysis

## 1. INTRODUCTION

### 1.1. Background

In 2020, COVID-19 began to spread rapidly in the United States. Since the outbreak of the epidemic, the United States has been deeply trapped in the quagmire of the epidemic and is constantly facing the pressure of the rebound of the epidemic, which has had a great impact on many traditional industries. So far, the cumulative number of confirmed cases of COVID-19 has reached 47,314,139 and the death toll has reached 775,104, which has brought unprecedented impact to the United States.

With the rapid development of modern science and technology, the development of biopharmaceutical industry is also advancing by leaps and bounds. Pharmaceutical industry and biotechnology industry are the two pillars of modern biopharmaceutical industry. Biopharmaceutical industry consists of biotechnology industry and pharmaceutical industry. With the changes

of the times and the development of society, whether basic medicine or preventive medicine, clinical medicine, health care medicine, rehabilitation medicine and traditional Chinese medicine are facing new topics and challenges. In particular, the epidemic is undoubtedly a severe challenge for the biopharmaceutical industry.

### 1.2. Related research

Ji et al. introduced Fama-French three-factor model to explore the extent to which certain factors fully explained the returns of blockchain-related stocks in the Chinese stock market. There was no scale effect or book to market ratio effect in Chinese blockchain industry, according to the findings [1]. Jackson used Fama-French three-factor model to model the earnings of 33 US-listed REITs over a period of 20 years. The results showed that the higher the capitalization degree of the REIT market, the higher its exposure in the market. He also expounded that the longer the real estate investment trust was in the market, the more market risk it faced.

[2]. Samir et al. used the data of the Moroccan Stock Market (MSM) from 2005 to 2009 to test the applicability of Fama-French three-factor model. They believed that stocks with high book price-earnings ratio and small capital operation led to negative scale premium of small capital operation companies [3]. In order to examine the robustness of the estimates under various approaches to portfolio formation and provide additional evidence for the "relevance" debate of the Fama-French three-factor model, based on regulatory decisions in Australia, Vo used the Fama and MacBeth's two-stage cross-sectional regression technique from July 2009 to May 2014. He stated that although the application of Fama-French three-factor model was of great significance to the research work, which was problematic to apply the model to public policy [4].

Taking 187 companies as samples, Taneja investigated the capital asset pricing model (CAPM) and Fama-French three-factor model from June 2004 to June 2009, a period of five years was observed. Research showed that the efficiency of Fama-French three-factor model was a good predictor, which could not be ignored in India, but two factors (scale and value) may improve the model [5]. Gaunt added Australian literature on the explanatory power of scale effect, book value (BM) effect and Fama-French three-factor model to these effects, as well as improving the asset pricing power of CAPM. The results showed that the interpretation ability of the three-factor model to CAPM was significantly improved, which proved that the BM factor played a role in asset pricing [6]. Using 465 BSE-500 index companies from 1996 to 2010, Sehgal and Balakrishnan tested the effectiveness of the single factor CAPM and Fama-French three-factor asset pricing model to explain the returns of various portfolios based on the characteristics of company size and value. They elaborated that Fama-French three-factor model could better explain the returns of most portfolios based on corporate characteristics than CAPM, and different versions of Fama-French three-factor model were robust in explaining the returns of portfolios with different characteristics [7].

By studying the effectiveness of the Fama-French five-factor model in the BIST30 index in Borsa Istanbul and the DAX30 Index in the Germany Stock Exchange, Molla Ahmetoğlu explained that the four-factor model was more applicable than the five-factor model [8]. Liu argued that the outbreak of COVID-19 had a negative impact on the hardware industry, based on the multiple regression analysis of the Fama-French five-factor model. In addition, after the outbreak of the epidemic, the whole hardware market was more in line with the CAPM [9]. Wang et al. used the Fama-French five-factor model to explain the cross-sectional stock returns during the bubble period, but as the price changed from random walk to bubble period, the explanatory power of the five-factor model decreased. They also found that

speculative investor behaviour could explain why the explanatory power of the model declined during the bubble period [10].

By investigating the performance of the Fama-French three-factor model and the five-factor model in Singapore and Indonesia, Ekaputra and Sutrisno believed that in explaining excess portfolio returns, the five-factor model performed no better than the three-factor model in the two markets [11]. Using a large number of samples from 18 countries in three different regions, Foye tested the five-factor model's performance in a wide range of emerging markets and evaluated whether the new Fama-French five-factor model could better describe emerging markets stock returns than the three-factor model. He found that in Eastern Europe, as well as in Latin America, the five-factor model was always better than the three-factor model. In addition, profitability or investment premium could not be distinguished among Asian factors, and the five-factor model could not better describe the stock return in the region [12]. Lin used a wide range of samples from 1997 to 2015, made an empirical evaluation of the Fama-French five-factor model, and found that in the Chinese stock market, the performance of the five-factor model was always better than the three-factor model [13].

### **1.3. Objective**

Health has always been the pursuit of people. Since the outbreak of the epidemic, the biopharmaceutical industry has also ushered in new opportunities and challenges. By analysing the biopharmaceutical industry in the epidemic situation, on the one hand, people can understand the current situation of the biopharmaceutical industry. On the other hand, people can also promote the development of the financial market. Therefore, this study will analyse the applicability of three-factor model and five-factor model in the biopharmaceutical industry based on the US stock market.

## **2. METHOD**

### **2.1. Fama-French Three-factor Model Theory**

Fama and French studied the factors that determine the difference of stock returns based on the American stock market in 1992, and then found that the market value, book to market ratio and P/E ratio of listed companies can explain the difference of stock returns. This multi-factor equilibrium pricing model can be expressed as:

$$R_{it} - R_{ft} = \alpha_i + \beta_i(R_{mt} - R_{ft}) + s_iSMB_t + h_iHML_t + \varepsilon_{it} \quad (1)$$

In this formula,  $R_{ft}$  represents the risk-free return rate of time t,  $R_{mt}$  represents the market rate of return at time t,  $R_{it}$  represents the rate of return of asset I at time t,  $R_{mt} - R_{ft}$  is the market risk premium.  $SMB_t$  is the simulated portfolio yield (small minus big) of the market value (size) factor of time t, and  $HML_t$  is the simulated portfolio yield (high minus low) of the book to the market factor of time t.

**2.2. Fama-French Five-factor Model Theory**

In 2015, Fama and French optimized the three-factor model and added two new concepts: profitability and investment factor. Profitability means that the company's future earnings will usually bring higher returns, while investment means that companies whose profits mainly come from major growth projects may suffer losses in the market. The five-factor model is as follows:

$$R_{it} - R_{ft} = \alpha_i + \beta_i(R_{mt} - R_{ft}) + s_iSMB_t + h_iHML_t + r_iRMW_t + c_iCMA_t + \varepsilon_{it} \quad (2)$$

In this formula, RMW is the difference between the return of high-profit stock portfolio and low-profit stock portfolio, while CMA is the difference between the return of high reinvestment proportion company's stock portfolio and low reinvestment proportion company's stock portfolio. These two items describe profit level risk and investment level risk respectively.

**3. RESULT**

This study sets the time range from January 2020 to September 2021, and selects three index funds in the field of health care, namely Vanguard Health Care ETF (VHT), SPDR S&P Biotech ETF (XBI), iShares Nasdaq Biotechnology ETF (IBB). The results of regression analysis combined with three-factor model and five-factor model are as follows:

**Table 1.** VHT 3-factor regression

	Coefficients	Standard Error	t Stat	P-value
Intercept	-0.001	0.000	-2.891	0.004
Mkt-RF	0.009	0.000	47.197	0.000
SMB	-0.001	0.000	-2.855	0.005
HML	-0.001	0.000	-5.071	0.000

**Table 2.** VHT 5-factor regression

	Coefficients	Standard Error	t Stat	P-value
Intercept	-0.001	0.000	-2.804	0.005
Mkt-RF	0.009	0.000	47.133	0.000
SMB	-0.001	0.000	-3.448	0.001
HML	-0.001	0.000	-2.520	0.012

RMW	-0.002	0.001	-2.984	0.003
CMA	0.002	0.001	3.038	0.003

**Table 3.** XBI 3-factor regression

	Coefficients	Standard Error	t Stat	P-value
Intercept	-0.001	0.001	-2.374	0.018
Mkt-RF	0.010	0.000	29.250	0.000
SMB	0.011	0.001	15.959	0.000
HML	-0.005	0.000	-12.942	0.000

**Table 4.** XBI 5-factor regression

	Coefficients	Standard Error	t Stat	P-value
Intercept	-0.001	0.001	-2.041	0.042
Mkt-RF	0.010	0.000	33.576	0.000
SMB	0.007	0.001	11.268	0.000
HML	-0.005	0.001	-9.196	0.000
RMW	-0.012	0.001	-12.126	0.000
CMA	0.004	0.001	3.579	0.000

**Table 5.** IBB 3-factor regression

	Coefficients	Standard Error	t Stat	P-value
Intercept	-0.001	0.000	-2.469	0.014
Mkt-RF	0.009	0.000	32.795	0.000
SMB	0.005	0.001	9.351	0.000
HML	-0.005	0.000	-14.125	0.000

**Table 6.** IBB 5-factor regression

	Coefficients	Standard Error	t Stat	P-value
Intercept	-0.001	0.000	-2.166	0.031
Mkt-RF	0.009	0.000	34.941	0.000
SMB	0.003	0.001	5.182	0.000
HML	-0.004	0.000	-8.975	0.000
RMW	-0.007	0.001	-8.539	0.000
CMA	0.003	0.001	3.054	0.002

The above are the three-factor and five-factor regression parameters of the three biopharmaceutical industry funds. In addition, the author also made regression statistics. The following is the comparison of multiple R and R square of various regression:

**Table 7.** comparison of multiple R and R square

	Multiple R	R Square
VHT 3-factor	0.915	0.837

VHT 5-factor	0.918	0.842
XBI 3-factor	0.859	0.737
XBI 5-factor	0.899	0.808
IBB 3-factor	0.862	0.743
IBB 5-factor	0.884	0.782

## 4. DISCUSSION

According to the above experimental results, when  $P < 0.05$ , it can be considered that the level of 0.05 is significant, that is, the confidence is 95%. When  $P < 0.01$ , it is reasonable to believe that it is significant at the 0.01 level, or the confidence is as high as 99%.

In regression statistics, multiple R represents the correlation coefficient  $r$ , whose value falls between -1 and 1. The higher the negative correlation, the closer it is to -1. On the contrary, the greater the positive correlation. R square denotes the measurement coefficient, which is the square of the correlation coefficient R, which ranges from 0 to 1. The greater the value, the better the fit of the regression model to the actual data.

Therefore, the analysis of the three funds is as follows:

### 4.1. VHT

By comparing Table 1 and Table 2, it can be seen that in the three-factor model, the confidence of the three factors is very high, in which the P-value of Mkt-RF and HML are close to 0, indicating that the three-factor model is applicable to VHT, and the applicability of Mkt-RF and HML is stronger than that of SMB. For the five-factor model, the P-value of HML is slightly higher, indicating that its applicability is weak.

As can be seen from Table 7, for VHT, the multiple R and R square of the five-factor model are higher, which means that the VHT and the five-factor model have a higher positive correlation, and the degree of fit between the model and the actual data is also higher.

### 4.2. XBI

For XBI, whether a three-factor model or a five-factor model is used, the P-value of each factor is 0, which shows that each factor of the two models is very applicable to XBI.

By comparing multiple R and R square of the two models in Table 7, it can be found that the five-factor model has a stronger positive correlation with XBI and a higher degree of fitting.

### 4.3. IBB

According to Table 5 and Table 6, the confidence of each factor in the three-factor model is very high, that is, the three-factor model is very applicable to IBB. The five-factor model also shows a similar situation. Although the value of CMA is high, in general, these five factors are applicable to IBB.

For IBB, the multiple R and R square of the five-factor model are higher than those of the three-factor model, which means that the five-factor model has a stronger positive correlation with IBB, and the model has a higher degree of fitting with the actual data.

On the whole, by horizontally comparing the three funds, it can be found that the applicability of Mkt-RF is very strong, whether it is in three-factor model or in five-factor model. In the three-factor model, SMB is more applicable to XBI and IBB, while HML is applicable to all three funds. In the five-factor model, Obviously, CMA is more applicable to XBI because it has a very high degree of confidence. In addition, SMB, HML and RMW in the five-factor model are more applicable to XBI and IBB than VHT. In addition, in terms of multiple R and R square, the positive correlation and fitting degree in the five-factor model is stronger for the three funds.

## 5. CONCLUSION

In the last two years, the COVID-19 has had a huge impact on our work and life. By analysing the applicability of the Fama-French three-factor and five-factor model, on the one hand, this study can help people understand the current situation of the biopharmaceutical industry in the United States during the outbreak of COVID-19, and on the other hand, this study can help investors establish an appropriate portfolio based on the analysis, so as to promote the development of financial markets.

This study examined the ability of the Fama-French three-factor and five-factor model to explain changes in stock return of the American biopharmaceutical industry. It is found that both models are suitable for the biopharmaceutical industry, and the five-factor model has a higher positive correlation and fitting degree for this industry. This may be because COVID-19 is closely related to the biopharmaceutical industry. The outbreak of the epidemic has brought great opportunities and challenges to the biopharmaceutical industry, which is why both models are applicable to the biopharmaceutical industry. Therefore, in the face of the black swan, the original investment decision should be changed in time, combined with current events and different models for analysis and comparison, so as to find suitable industries for investment in the chaotic market.

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