The research on Fama-French 5-factor model in the medicine industry during COVID-19

Tingyu Sun[1, a, †], Yansu Wang[2, *, †], Menglong Yang[3, b, †]

[1]Central University of Finance and Economics, Beijing, China

[2]The University of Sheffield, Sheffield, the United Kingdom

[3]Dalian University of Technology Dalian, China

*Corresponding author: ywang585@sheffield.ac.uk, [a]2019311943@email.cufe.edu.cn, [b]13455599156@email.dlut.edu.cn

[†]These authors contributed equally.

Abstract. During COVID-19, the diease has changed various aspects on the stock market so dramatically that the stock prices in different industry fields. While Fama-French 5-factor model is one of the most effective stock prices assessment models, the worldwide change during these several years could have the unexpected influence on this professional method. In this research, attempting to find the relationship between medicine policy and the stock price, in order to explain the huge change on the economics progress with this model, the linear regression is adopted to cope with this issue. Results indicate that most of the regression coefficients of the explanatory variables under the five factors have the same significance, with only the difference in the size of the coefficient values. Besides, the larger the value of the policy, the higher the risk premiums of pharmaceutical companies will be, additionally, small minus big, high minus low, robust minus weak, and conservative minus aggressive average returns will decrease, and vice versa. In summary, this paper investigates the effectiveness of Fama-French 5-factor model with the new variable, the medicine policy, based on linear regression and other mathematics methods. In the future, it is of great importance to investigate stock prices under such situation and take other factors into seriously account while doing research. Overall, these results shed light on guiding future policy making and different perspective on medicine industry development.

Keywords: Fama-French 5-factor model; Medicine industry; COVID-19; Policy Making.

1. Introduction

Since the end of 2019, the outbreak of COVID-19 has affected every aspect of the financial market [1]. The society and economy have developed rapidly, and the living standards of residents have correspondingly improved significantly [2], the country has now become the world's second largest economy and the world's largest export country [3]. However, from the perspective of deep-seated economic development and the deepening development of the stock market, facing a major public health emergency with the rapid spread of COVID-19, extensive scope of infection and great difficulty in prevention and control, which seriously threatens the lives of people around the world, the market has faced incidents that cause the great panic among investors and increased volatility in stock prices and the broader market.

COVID-19 affects the survival and development of many industries, indirectly affecting the stock prices of most industries through trade exchanges [4], declining international trading volume, industrial production as well as the declining labor mobility. However, at the same time, with the invention of vaccines [5], medical measures, e.g., the investment market has been gradually optimistic about the pharmaceutical sector stocks. In addition, in response to public health emergencies, government departments will issue specific policies, laws and regulations for the pharmaceutical industry in light of the epidemic situation [6], as well as offset the negativity of the weaknesses about basic medical infrastructures, to ensure the safety of the national health issues. On this basis, it leads to the pharmaceutical industry stock price fluctuations [7]. Therefore, according to COVID-19 and the country's relevant policy response, it is of social significance to study the general sdevelopment of

pharmaceutical industry, the trend of stock investment market preference and the overall economic development of our country.

Based on APT theory and CAPM model, Fama-French 3-factor model could solve many problems CAPM could not and developed to explain unusual financial situations in 1996. In practice, the CAPM model extended its field by involving small minus big (SMB), saying smaller companies outperform larger ones over long-term, and high minus low (HML), indicating value stocks tend to outperform growth stocks [8]. However, during the research process, 3-fator model could not explain various aspects successfully on asset risks, as well as have no capacity in predicting the ideal prices. In 1997, based on the historical tendency about stock prices, Carhart added winners minus losers (WML) factor into the model constructing the 4-fator model because of the stable tendency. Moreover, in 2014, Fama and French introduced robust minus weak (RMW) and conservative minus aggressive (CMA) factors based on the previous 3-factor model thus built Fama-French 5-factor model [9].

Therefore, in the article, we will figure out the following issues. Primarily, the performance of Fama-French five factors model fare in pharmaceutical stocks. Whether we could draw further conclusions from this model. Second, after the policy of pharmaceutical industry is taken into account, if the stock price of the industry could be explained based on this new factor. Thirdly, we should find out the explanatory influence of Fama-French five factors model. In this case, we could put forward corresponding prospects and countermeasures for future development [10].

The rest part of the paper is organized as follows. The Sec. II will introduce the dataset group members used, as well as models and metrics. The Sec. III will explain results including correlation analysis and regression analysis. Moreover, this part will discuss the limitation in the research. Eventually, a brief summary will be given in Sec. IV.

2. Methodology

2.1 Data

We selected the medical industry as the object of analysis. The data source is from CSMAR in GuoTai'an database, which is the first and largest professional high-tech company engaged in the design and development of accurate database of financial and economic information in China.

From the database, fifteen factors were taken into account and after consideration we select these factors from monthly data Size, BM, OP, and Inv data from 2021.01 to 2021.12. Then based on these raw data, we did some data cleaning and constructed 5 factors: MKT, SMB, HML, RMW, CMA by Fama-French 5 factor model. These 5 factors were used as independent variables in the following regression model.

The dependent variables were selected as whether there were any medical policies enacted this month, and the criteria for selecting medical policies were compiled according to the official website of the State Council, National Development and Reform Commission, National Health and Welfare Commission, Ministry of Industry and Information Technology and Health Insurance Bureau.

2.2 Models & Metrics

Based on the above independent and dependent variables, it is attempted to analyze the impact of the five risk factors on the independent variable of whether a pharmaceutical policy was enacted during the month using a simple regression analysis model.

Firstly, the two-by-two correlation coefficients are calculated between the variables before the regression analysis to analyze which variables were significantly correlated. The correlation matrix shows that the dependent variable has a correlation coefficient of -0.8085 with HML, i.e., the dependent variable has a strong negative correlation with HML. The correlation coefficient of the dependent variable with CMA is -0.8118, i.e., the dependent variable has a strong negative correlation with CMA. The dependent variable also has a negative correlation with MKT and SMB, but the correlation coefficient is minimal, and the correlation is relatively weak. There is a positive correlation between the dependent variable and RMW, but the correlation coefficient is relatively small, and the

correlation is equally weak. Looking at the correlation coefficients between the dependent variables, we find that only a very strong positive correlation exists between HML and CMA, with a correlation coefficient of 0.8856. In contrast, none of the other variables have a strong correlation.

Subsequently, we construct regression models based on these variables. The results of the regression model are shown below. Firstly, the p-value for the F-test of significance for the whole regression model is 0.061<0.1. At a significance level of 0.1, we have good reason to consider the entire regression model significant. The current regression model is meaningful. Secondly, the R-squared of the regression model is 0.7689, which means that 76.89% of the variance in the dependent variable can be explained by the regression model we have constructed. The fit of this regression model is currently relatively good. The root MSE of the regression model is 0.32. Finally, we look at the regression coefficients for each independent variable. The regression model is:

$$policy = 0.68 + 0.03MKT - 0.02SMB - 0.01HML - 0.05RMW - 0.13CMA \quad (1)$$

The interpretations of the regression coefficients are given as follows:

- MKT=0.03: the difference in a policy probability as MKT changes. For each 1 unit increase in MKT will lead to, on average, an increase of policy probability by 0.03, holding all the other factors unchanged.
- SMB=-0.02: the difference in a policy probability as SMB changes. For each 1 unit increase in SMB will lead to, on average, a decrease of policy probability by 0.02, holding all the other factors unchanged.
- HML=-0.01: the difference in a policy probability as HML changes. For each 1 unit increase in MKT will lead to, on average, an increase of policy probability by0.03, holding all the other factors unchanged.
- RMW=-0.05: the difference in a policy probability as RMW changes. For each 1 unit increase in RMW will lead to, on average, a decrease of policy probability by 0.05, holding all the other factors unchanged.
- CMA=-0.13: the difference in a policy probability as CMA changes. Each 1 unit increase in CMA will lead to, on average, a decrease of policy probability by 0.13, holding all the other factors unchanged.

3. Results & Discussion

3.1 Correlation analysis

Correlation analysis in research to find the relationship pairwise comparison among five factors of MKT, SMB, HML, RMW and CMA, furthermore, compute their association. TableIgives the Correlation analysis of the model. In Fama-French 5-factor model with 12-months data, the correlation coefficients of each factor are between [-0.4565,0.8856], it shows reasonable model because the correlations are within a reasonable interval. Analysis of the correlation among the five factors and relevance of pharmaceutical industry of policies making. the correlations of the five factors are -0.0768, -0.2811, -0.8085, 0.0164 and -0.8118, among which the correlation with HML and CMA is high, indicating that elaborates separately differences in policy making affect companies with different market value, and more positive industry policies might yield more gains.

Likewise, when HML and CMA rise or fall too fast, government policy adjustments should be made in a timely manner. Moreover, HML is completely explained by the other four factors, and it is most notably CMA which has a high correlation with HML [1], Therefore, it is believed that the change of pharmaceutical policy affects the CMA the most. Additionally, it shows that under the influence of COVID-19, formulating government policies for the pharmaceutical industry can more change the portfolio of investment stability of pharmaceutical companies, and affects the profitability of pharmaceutical companies.

3.2 Regression analysis

Table II presents the regression analysis of the model. By Analysis of variance (ANOVA) which is used to split the overall variability observed in the dataset into two parts of the table with observation data in twelve groups, because of p-value of F-statistic is equal to 0.0609 > 0.05 in hypothesis testing, the model correlation is good to fit original data, and MSE = 0.32 means the predictive ability of the model is good. The coefficients of regression model, it shows the regression of five elements is:

$$policy = 0.68 + 0.03MKT - 0.02SMB - 0.01HML - 0.05RMW - 0.13CMA \quad (2)$$

The policy maker uses each coefficient in the linear regression formula to change the same value, resulting in a different policy. Policymakers will prioritize the absolute value of the data coefficient with CMA = -0.13, because changing the policy can cause fluctuations in the CMA, which also justifies the correctness of the correlation analysis. Which claim when the market's CMA fluctuates violently, policy adjustments should be made immediately. At the 95% confidence interval, we make small modifications to the model in each factor because of error of model.

Table 1. Correlation analysis

	Medical Policies	MKT	SMB	HML	RMW	CMA
Medical Policies	1.0000					
MKT	-0.0768	1.0000				
SMB	-0.2811	0.1079	1.0000			
HML	-0.8085	0.1173	0.0233	1.0000		
RMW	0.0164	0.0124	-0.4565	0.0154	1.0000	
CMA	-0.8118	0.2684	0.3374	0.8856	-0.3133	1.0000

Table 2. Regression Analysis

.reg Medical Policies MKT SMB HML RMW CMA			
Source	SS	df	MS
Model	2.05042097	5	0.41008419
Residual	0.616245696	6	0.10270762
Total	2.66666667	11	0.24242424
Overall statistics	Number of obs	=	12
	F(5, 6)	=	3.99
	Prob > F	=	0.0609
	R-squared	=	0.7689
	Adj R-squared	=	0.5763
	Root MSE	=	0.32048

3.3 Explanation

To analyze by building a linear regression model, and research on the impact of government policies on the pharmaceutical industry under the background of the COVID-19. It can be seen from the corresponding regression results that most of the regression coefficients of the explanatory variables under the five factors have the same significance, with only the difference in the size of the coefficient values. Under this model, only MKT > 0, and other 4 factors (SMB, HML, RMW, CMA) are smaller than zero.

With this in mind, it illustrates the larger the value of the policy, the higher the risk premiums of pharmaceutical companies will be, additionally, small minus big, high minus low, robust minus weak, and conservative minus aggressive average returns will decrease, and vice versa. Furthermore, stimulative industry policies promote the increase in profits of listed pharmaceutical companies and ensure the stability of pharmaceutical companies' operations, while inhibitory industry policies

suppress profit growth and are not conducive to the stability of pharmaceutical companies' operations. Pharmaceutical companies should also change their investment scale and investment direction according to policy changes.

3.4 Limitation

Nevertheless, it should be noted that this paper has some shortcomings and drawbacks. To be specific, the model also has some limitations that lead to inaccurate predictions or lack of certain functions, especially in the following aspects.

3.4.1 Imprecise confidence intervals

When analyzing the 95% confidence interval, the range of the confidence interval is too large, which will lead to more possibilities for the value of the model coefficients, so that policy makers cannot accurately make policy changes according to the market. A 99% confidence interval can be used instead.

3.4.2 Inaccurate fit of the model

In the ANOVA analysis, the value of the goodness of fit r-squared is 0.7689, and the closer the value of R^2 is to 1, the better the fit of the regression line to the observed value. In general, linear fitting, it is necessary to ensure that $R^2 > 0.95$, indicating that in addition to the five factors analyzed in this paper, there are other reasons that affect policy formulation.

3.4.3 Long-term predictions are not possible

It is impossible for all policies to be effective in the long term, so new policies should be considered in the analysis, which makes it impossible for pharmaceutical companies to make long-term forecasts based on current policies. During the COVID-19 epidemic, it should be renewed every quarter of year to forecast.

3.4.4 Insufficient number of samples

The value of this sample is only a 12-month sample during COVID-19 infection. The relationship between pharmaceutical companies and the policy period during the epidemic of other infectious diseases, such as SARS, MARS, etc., can be considered for comparison.

4. Conclusion

In summary, this paper investigates the effectiveness of Fama-French 5-factor model with the new variable, the medicine policy, based on linear regression and other mathematics methods. According to the analysis, Fama-French five-factor model is combined with the impact of policy on stock price. The explanatory influence of Fama-French five-factor model is enhanced by adding the policy of pharmaceutical industry to the model. Based on this consequence, in addition to the fact that most of the retail investors in the stock market are not professionals, institutional investors are homogenous, and in order to deal with the turbulence of the investment market caused by the large-scale fluctuation of stock prices and maintain the sound operation of financial order, the government should disclose information to investors properly, gradually improve the information disclosure mechanism, reduce the cost of obtaining information from investors, and reasonably guide public sentiment to avoid causing public panic. Besides, investors and pharmaceutical companies need to pay real-time attention to the relevant policy-oriented and diversified organizational asset composition, effectively avoid risks, and strive to keep their assets safe under the influence of COVID-19.

Nevertheless, the study stills have its own limitations which indicate imprecise confidence intervals, the inaccurate fit of the model, the impossibility of long-term predictions and insufficient number of samples. In the future, it is of great importance to investigate stock prices under such situation and take other factors into seriously account while doing research. Overall, these results offer a guideline for the future policy making and different perspective on medicine industry development.

References

[1] C. L. Mann, “Real and Financial Lenses to Assess the Economic Consequences of COVID-19.” Economics in the Time of COVID-19, vol.1, 2020, pp. 81 - 86.

[2] H. Y. Liu, A. Manzoor, C. Y. Wang, et al., “The COVID-19 outbreak and affected countries stock markets response.” International Journal of Environmental Research and Public Health, vol. 17 (8), 2020, 2800.

[3] S. C. Ludvigson, S. Ma, S. Ng, “COVID-19 and The Macroeconomic Effects of Costly Disasters”, COVID-19 and the macroeconomic effects of costly disasters. No. w26987. National Bureau of Economic Research, 2020.

[4] W. Ding, R. Levine, C. Lin, et al., “Corporate Immunity to the COVID-19 Pandemic.” Journal of Financial Economics, vol. 141.2, 2021, pp. 802 - 830.

[5] A. M. Al-Awadhi, et al. "Death and contagious infectious diseases: Impact of the COVID-19 virus on stock market returns." Journal of behavioral and experimental finance, vol. 27, 2020, 100326.

[6] R. M. del Rio-Chanona, et al. "Supply and demand shocks in the COVID-19 pandemic: An industry and occupation perspective." Oxford Review of Economic Policy vol. 36, 2020, pp. 94 - 137.

[7] S. Girish, and K. Desai. "An Analysis of Accounting Variables and its impact on Market price per Share: Evidence from Nifty Pharma Index Companies of India." Asian Journal of Management, vol. 9 (1), (2018, pp. 333 - 336.

[8] E. F. Fama, K. R. French. “Common Risk Factors in the Returns on Stocks and Bonds.” Journal of Economics, vol. 33, 1993, pp. 3 - 56.

[9] E. F. Fama, K. R. French, “Multifactor Explanations of Asset Pricing Anomalies.” Journal of Finance, vol. 51, 1996, pp. 55 - 83.

[10] E. F. Fama, K. R. French "A Five-Factor Asset Pricing Model". Journal of financial economics vol. 116.1, 2015, pp. 1 - 22.