Research on the Chemical Industry during COVID-19 Based on Fama-French Five Factors Model

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Abstract. The COVID-19 outbreak in 2020 has had a significant impact on many industries around the world. Regarding the impact of the epidemic, reasonable pricing of capital assets has an important reference value for investors' investment planning. This study helps investors make more reasonable investment plans by analyzing the changes in the Chemical industry's key factors in the US stock market during the period before and after the epidemic. Fama-French five factors model was adopted, which is effective in asset pricing. The target industry introduced in this research is a chemical that has been developed for decades but also has some new opportunities at the same time. Additionally, multiple linear regression is also performed in the analysis process to obtain the coefficients of five factors in the model. The results suggest that the beta of rm-rf factor changed from 1.065 to 0.909, which means the chemical industry tends to less sensitive to the market. The SMB and CMA factors are basically unchanged, with the HML factor changing from insignificant to significant due to the market's downward trend, while RMW performed in the opposite direction. Therefore, it concludes that investors should prefer to invest in the chemical industry with a smaller market scale and higher price-to-book ratio during COVID-19.

Keywords: COVID-19; Fama-French Model; Chemical Industry

1. Introduction

Capital asset pricing is an important analytical tool that rational investors need to use in their investment activities. Through capital asset pricing, it can provide a basis for securities pricing and a reference for capital assets' market transaction price. The diversification and efficiency portfolio investment theory of Markowitz first showed how a risk-averse investor could construct the optimal portfolio among many risky assets through rigorous mathematical tools [1]. In the early 1960s, some economists represented by Sharpe, Lintner and Mossin constructed CAPM (capital asset pricing model) based on Markowitz's theory of diversification and efficiency portfolio investment [1-4]. In 1992, Fama and French studied the factors determining the difference in return rates of different stocks in the American stock market [5]. They found that the stock market's beta value could not explain the difference in return rates of different stocks, while the market value, book-to-market ratio and price-to-earnings ratio of listed companies could explain the difference in return rates of stocks. Therefore, in 1993, they established a three-factor model to explain the stock return rate, namely the Fama-French three factor model [6]. Although Fama-French three factor model is now widely used, there is evidence that it does not fully explain the cross-sectional return on stocks. In 2015, Fama and French expanded their model by adding two factors: the profitability factor (RMW) and the investment factor (CMA) [7].

The Fama-French five-factor model is well known for financial academia. Many scholars from different regions research Fama-French five factor model or use it as a practical tool in their own projects. Chiah et al. used a large sample from 1982 to 2013 to study the Fama-French five factor model's performance in pricing Australian stocks [8]. They found that the five-factor model could explain more asset pricing anomalies than a series of other asset pricing models, which supported the Fama-French five-factor model's advantages. Guo provided out-of-sample tests of Fama-French five

factor model for the Chinese stock market [9]. They find strong size, value and profitability patterns in average returns, but weak investment pattern. Martins and Eid Jr tested the Fama-French five factor model based on the Brazilian market for asset-pricing and claimed that the five factor model works better than both the CAPM model Fama-French three factor model do [10]. After the augmented dickey-fuller test was used for the Fama-French five factor model's stationary testing, Hongsakulvasu and Liammukda built a time-varying coefficient model on previous five factors model according to Japanese stock exchange data for further research [11]. Balakrishnan demonstrated research about Fama-French five factor model with stock in Indian, showed the five factors that strongly influence the Indian stock market [12]. Dhaoui revised the Fama-French five factor model by incorporating two additional variables into value, the profitability and the investment, finding that the model's validity predicts expected returns [13].

The epidemic of COVID-19 has caused dreadful damage to the global economy since March, 2020, which leads to countless losses among a wide range of industries during the half-year period of time. This article focuses on chemical industry based on Fama-French five factor model, and the purpose of the research is trying to explain how the chemical industry is influenced by the epidemic situation with some official economic data. In addition, the article also provides some advice about future investments related to the chemical industry, and how to conform to the changeable and unpredictable stock market properly.

2. Fama-French Model

The Capital Asset Pricing Model (CAPM) was developed by Sharpe and Lintner on the basis of modern portfolio theory [2, 3]. The CAPM provides a powerful and intuitive prediction of risk measures and the relationship between expected returns and risk [14]. CAPM theory implies that the full risk premium of securities and portfolios are represented by the Beta; expected return should not be explained by other variables. However, CAPM has encountered many challenges in explaining the reality of stock market returns because it relies on six assumptions that are difficult to fulfill. Fama and French identified two categories of stocks whose historical average returns were generally higher than the return predicted by the CAPM model - small company stocks and stocks with high book-to-market ratios(B/M) of equity [5]. The three-factor model estimates stock returns by introducing two new explanatory variables: B/M ratio and firm size, along with the market risk.

The Formula for the Fama-French Three Factors Model is:

$$r = r_f + \beta_1 * (r_m - r_f) + \beta_2 * SMB + \beta_3 * HML + \varepsilon \quad (1)$$

where r is the expected rate of return; rf is the Risk-free rate; ß is the factor's coefficient (sensitivity); rm-rf is the market risk premium; SMB (small minus big) is the historic excess returns of small-cap companies over large-cap companies; HML (High Minus Low) is the historic excess returns of value stocks (high book-to-price ratio) overgrowth stocks (low book-to-price ratio).

The size factor implies that small size-cap companies perform better in expected returns as compensation for investors who hold them. B/M ratio, also called the value factor, is the book equity divided by the market value. Small B/M ratio is generally considered to be undervalued by the market and led to a higher return.

Titman, Wei, and Xie presented that abnormal capital investments are negatively related to future stock returns [15]. Novy-Marx demonstrated the profitability strategies could generate significant abnormal returns [16]. The evidence shows that the three-factor model is flawed because it does not take into account profitability and investment associated with changes in the average rate of return. In 2015, Fama and French used a dividend discount model to demonstrate stock returns related to profitability and investment and expanded these two factors to the three-factor

The Formula for the Fama-French Three Factors Model is:

$$r_i - r_f = \beta_1 * (r_m - r_f) + \beta_2 * SMB + \beta_3 * HML + \beta_4 * RMW + \beta_5 * CMA + \varepsilon \quad (2)$$

where r is the expected rate of return; rf is the Risk-free rate; ß is the factor's coefficient (sensitivity); r_m-r_f is the market risk premium; SMB (small minus big) is the historic excess returns of small-cap companies over large-cap companies; HML (High Minus Low) is the historic excess returns of value stocks (high book-to-price ratio) over growth stocks (low book-to-price ratio); RMW (robust minus weak operating profitability) is the difference between the returns on diversified portfolios of stocks with robust and weak profitability; CMA (conservative minus aggressive investment) is the difference between the returns on diversified portfolios of the stocks of low and high investment firms.

3. Results

This paper chooses the data from Kenneth r. French - Data Library, and it selected the chemical industry of 48 Industry Portfolios. The length of time period selected for the data is 18 months. Regarding March 1st 2020 as the node, the data is equally divided into two groups, as the industry data before and after the outbreak of COVID-19. The data type is the chemical's daily five-factor actual data. Then the prediction data of five-factor is selected, corresponding to these 16 months from Fama-French Five Factors (2x3) [Daily]. Through data analysis, regression analysis was performed on the two groups of data to obtain the chemical five-factor regression analysis table of 8 months before and after the outbreak.

Table 1. Regression analysis results (July 2019-Feb 2020)

Factors	**Results**			
	Coefficients	***Standard error***	***t Statistic***	***P-value***
r_m-r_f	1.065	0.053	20.110	0.000
SMB	0.849	0.107	7.938	0.000
HML	0.190	0.105	1.816	0.071
RMW	0.459	0.177	2.587	0.011
CMA	0.355	0.213	1.665	0.098

[a]Calculation results of chemical industry before the outbreak

Table 2. Regression analysis results (Mar 2020-Oct 2020)

Factors	**Results**			
	Coefficients	***Standard error***	***t Statistic***	***P-value***
r_m-r_f	0.909	0.031	28.990	0.000
SMB	0.786	0.085	9.218	0.000
HML	0.310	0.070	4.413	0.000
RMW	0.072	0.142	0.505	0.615
CMA	0.105	0.192	0.550	0.583

[b]Calculation results of chemical industry before the outbreak

According to Table 1 and Table 2, the coefficients, including r_m-r_f and SMB, is significant in both tables; HML changes from insignificant to significant; RMW changes from significant to insignificant; in addition, CMA is not significant in either period. In addition, the coefficients of rm-rf are greater than 1 in Table 1 and less than 1 in Table 2, indicating that the market sensitivity of these variables declines after the outbreak of epidemic.

4. Discussion

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This study has yielded coefficients and variations of these five factors of the Fama-French Model during the period before and after the epidemic, to explain the coefficients based on the characteristics of the chemical industry.

The result suggests that the chemical industry's beta changed from 1.065 before the outbreak to 0.909, implying that the chemical industry tends to be less sensitive to the stock market. According to the American Chemistry Council (ACC)'s Year-Mid 2020 Chemical Industry Situation and Outlook [17], its performance was mixed during 2020. Chemical production declines as the pandemic's commercial impact continues, while total chemical trade will decline by 7% to $220.8 billion in 2020 [17]. The automotive industry is an important end-use market for chemicals, with automotive production declining in line with supply chain output. Production of light vehicles was powerful in 2015-2019, averaging nearly 17 million units per year. Under the impact of COVID-19, sales are expected to decline, average just under 14.4 million by 2020. Furthermore, plastic resins are the only segment to achieve positive growth due to their role in COVID-related solutions. Other basic chemistry segments, especially key components in synthetic rubber tire manufacturing, have also declined. Global peak-to-trough performance of petrochemicals by end market decreased by 60% due to the COVID-19 crisis, leading to a decrease in investors' investment intentions for the chemical industry [18].

The HML factor turned out to be a significant indication that chemical companies with high B/M returns will perform better after the COVID-19. According to Petrochemicals Market Size & Share Industry Report, the chemical industry’s total worldwide revenue stood at some 3.94 trillion U.S. dollars [19]. Ethylene is the major product and propylene, butadiene, benzene, xylene, toluene and methanol etc., where ethylene accounts for 33% of the market share in 2019. The chemical industry is a traditional industry with consistency in industry development, resulting in a non-significant HML factor before the epidemic outbreak. Besides, chemical companies with low B/M ratios, which are overvalued before the COVID-19, will suffer substantial stock gain losses under conditions of a major industry-wide recession. Furthermore, for a high B/M company, it found a chemical company with a high B/M (1.67) named Rayonier Advanced Materials Inc in Yahoo Finance. Its stock prices have experienced a significant increase from $0.98 to $4.64 over the period from March to September.

RMW is the factor that can represent the profitability of an industry. The values shown in the results change from notable to insignificant due to the epidemic. As the chemical is an industry that highly relies on productivity, including supply and demand chains, which is influenced by social distance policy, the whole industry is less likely to gain profit. For example, it is predicted by the American Chemistry Council that in the U.S., the total industrial production would fall by 10.5 percent in 2020 [17]. Also, it claims that in 2020, U.S. chemical imports are set to fall by19.1 percent, while exports would decline sharply, falling by 14.5 percent, which leads to the situation where total U.S. chemicals trade falls by 16.4 percent for the whole year.

SMB represents the size factor where the company with the smaller market value may have a higher factor value. Since the results of both before and after the outbreak of the epidemic are significant, the T-values are both significant. The coefficients SMB of both periods is positive, which means the return on investment for a smaller company would be greater than the larger one. One possible reason is that with the workforce shortage during the pandemic, the larger company has a higher risk between demands, production, and supplies, which may not be confusion for the companies with fewer products. Moreover, CMA turns out to be insignificant, and the reason is accessible. Since the chemical has been a well-developed industry for decades, the market share in the whole industry is nearly settled. It would not change dramatically, as the monopolies have strong

competitiveness and a high threshold for the news. Thus, whether the investments are radical or not does not affect the results a lot.

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