Research on the application of Fama-French 5-factor model in the steel industry during COVID-19

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Abstract. Based on the Fama-French 5-factor model (FF5), this paper analyzes the market changes of the American steel industry before and after the epidemic. In this paper, the Data from Kennethr French-Data Library were used to make multiple regression analysis of the U.S. steel industry before and after the epidemic. The Fama-French 5-factor model was also used for analysis. According to the results of multiple linear regression, due to the influence of COVID-19, the coefficient of market risk (Betam) decreased; Robust minus Week (RMW) changed from significant to insignificant; Small minus Big (SMB) and High minus Low (HML) were significant and the change of epidemic situation was not significant, while Conservative minus Aggressive (CMA) was not significant. The impact of the outbreak on the U.S. steel industry has been dramatic and has led to a huge decline in the entire industry.

Keywords: Fama-French 5 factor model, Steel industry, COVID-19.

1. Introduction

Capital asset pricing model (CAPM) was proposed by William Sharpe in 1964, which is referred to as CAPM model [1-3]. This model is based on the portfolio theory proposed by Markowitz in 1952 [4, 5]. Markowitz hopes to disperse and even resolve risks through research, while based on Markowitz's theory, CAPM tends to reveal the relationship between returns and risks. CAPM model believes that income and risk are homologous. Market risk is the only risk that can bring excess returns to stocks. However, in fact, in addition to market risk, Fama-French believed that market value risk, book-to-market ratio risk and so on existed in the market, and the model established accordingly was called "Fama-French three-factor model". On the basis of CAPM, the model added factor Small minus Big (SMB) to explain market value effect and factor High minus Low (HML) to explain value effect. The empirical results also show that the model can effectively explain the difference between stock portfolio returns and has stability among different markets. The three-factor model constructed by Fama and French has a good explanatory power for analyzing the return rate of cross-section stock portfolios, which has been widely sought after in a certain period of time [6-8]. However, with the continuous development of social economy, the applicability of this model is challenged, and its explanatory power is declining. Fama and French then put forward the five-factor model [9-11]. Compared with the three-factor model, it mainly
In recent years, many scholars have applied the Fama-French model to different markets and industries. Chabi-Yo shows that the variance of Fama-French factors, the variance of the momentum factor, as well as the correlation between these factors, predict an important fraction of the time-series variation in the post-1990 aggregate stock market returns [12]. This predictability is particularly strong from one month to one year, and it dominates that afforded by the variance risk premium and other popular predictor variables.

Nartea et al. use Hong Kong stock market data from 1982-2001 to test the persistence of the size and value premia and the robustness of the Fama-French three-factor (FF3) model in explaining the variation in stock returns. We further find a large improvement in explanatory power provided by the FF model relative to the CAPM but that the FF model is misspecified for the Hong Kong market. [13]

Suh presents the results of time-series tests of the Capital Asset Pricing Model (CAPM) and the Fama-French 3-factor (FF3) model in the estimation of equity capital from a perspective of corporate investment decision-making. We further find a large improvement in explanatory power provided by the FF model relative to the CAPM but that the FF model is misspecified for the Hong Kong market. [13]

Fama and French decry the importance of the β as a major explanatory variable for stock returns. Jian et al. continue in that fashion and attempt to discover other variables that may have an importance in explaining stock returns. [15]

Racicot et al. further investigate the FF5 model using an improved generalized method of moments (GMM)-based robust instrumental variables technique. A further purpose is to explore the relationship between the FF factors and the Pastor–Stambaugh (PS, 2003) liquidity factor. They find that except for the market factor, all of the factors, including liquidity, are not significant at even the 5% level, using our GMM approach for almost all of the FF 12 sectors. [16]

Mackay et al. describes the use of the Faff (2015) [17] pitching template to formulate a research concept into a formal research proposal. It outlines our experience in applying the various sections of the pitch template and the challenges experienced in doing so. Overall, the adoption of the pitch template has significantly improved our approach to developing research projects. [18]

With the outbreak of the COVID-19 epidemic, the American economy had a great crisis, and four circuit breakers occurred. Therefore, this study discusses the factor changes of the steel industry before and after the epidemic based on FFM, and analyzes the reasons and provided corresponding investment suggestions.

2. Fama-French Model

In this paper, the analysis methods are used for the Fama-French multifactor pricing model. In view of the limitation CAMP, its accuracy of asset pricing in the market is under the social from all walks of life. Many research results show that there are serious pricing in the asset pricing model, and asset mispricing caused devastating damage to the economic market. It will lead to the financial crisis intensified triggering a financial bubble and the stock market crash. Therefore the Three-Factor-Model is proposed, as follow:

\[ R_i - R_f = \beta_{\text{M}} (R_m - R_f) + \beta_{\text{SMB}} \text{SMB} + \beta_{\text{HML}} \text{HML} \]  

Where \( R_i \) is the return rate of a particular industry; \( R_f \) is the risk-free return rate; \( R_m \) is the market average return rate; \( \text{SMB} \) is the return rate of the size factor of the industry, and \( \text{HML} \) is the return rate of book-to-market ratio. Among them, \( \beta_{\text{M}} \) is the coefficient of market risk; \( \beta_{\text{SMB}} \) and \( \beta_{\text{HML}} \) are the coefficient of the scale factor and book-to-market ratio factor respectively.

Frankel and Lee (1998) [19] found that in the portfolio formed by the ratio of market value to the stock price. Stocks with higher expected cash flow had a higher average return rate, but this phenomenon
was not captured by the FF three-factor model. Subsequently, Novy-Marx (2013) [20] proved that there was a close correlation between expected profitability and average return, and found that the FF three-factor model was unable to explain the changes between profitability and investment-related average return. To make up for these two defects, Fama and French (2015) [9] added profitability and investment factors to the FF three-factor model and constructed a new FF five-factor model, as follows:

$$R_i - R_f = \beta_{RMW}(R_m - R_f) + \beta_{CMA} + \beta_{SMB} + \beta_{HML} + \beta_{RMW} + \beta_{CMA}$$ (2)

Where $\beta_{RMW}$, $\beta_{CMA}$ are the coefficients of profit factor and investment style factor, respectively.

### 3. Results

Based on the Fama-French five-factor model, this paper studies the changes of the earnings, industry size, profit and investment style of the steel industry before and after the outbreak of the new crown disease. Using Data from Kennethr. French-Data Library, we selected Data from Fama-French 5 Factors [Daily] and Steel of 30Industry Portfolios, and performed multiple linear regression with 2019.6-2020.02 and 2020.3-2020.9 respectively to get the coefficients of FF-5.

#### Table 1. Coefficient of 5-factor model of steel industry before epidemic

| Coefficient | Std  | t Stat | P-value |
|-------------|------|--------|---------|
| Mkt-Rf      | 1.04 | 0.06   | 16.62   | 0.00   |
| SMB         | 1.15 | 0.12   | 9.81    | 0.00   |
| HML         | 0.46 | 0.12   | 3.82    | 0.00   |
| RMW         | 0.46 | 0.20   | 2.35    | 0.02   |
| CMA         | 0.21 | 0.23   | 0.90    | 0.37   |

#### Table 2. Coefficient of 5-factor model of steel industry after epidemic

| Coefficient | Std  | t Stat | P-value |
|-------------|------|--------|---------|
| Mkt-Rf      | 0.91 | 0.04   | 25.95   | 0.00   |
| SMB         | 0.99 | 0.10   | 10.343  | 0.00   |
| HML         | 0.45 | 0.08   | 5.77    | 0.00   |
| RMW         | 0.28 | 0.16   | 1.72    | 0.09   |
| CMA         | -0.08| 0.22   | -0.38   | 0.70   |

(principle: simply state the result)

### 4. Discussion

#### 4.1. The coefficient of Mkt - RF

As shown in Table 1 and Table 2, it is obvious that $\beta_{RMW}$ was shown before the epidemic. It can be seen that the American steel industry was sensitive to the economic fluctuations of the whole market before the epidemic. The United States is the largest economy globally and has a diversified economic structure with key industries including automobiles, aircraft manufacturing, telecommunications, chemicals, electronics and computers. The United States is one of the world's largest auto markets, with 13 enterprise giants such as General Motors, Ford and Chrysler, and an annual output of more than 17 million vehicles. With the outbreak of the disease in the United States, Nissan and Honda announced the suspension of production in the United States on the evening of March 18. General Motors, Ford, FCA, the three American giants formally announced the temporary closure of all factories in North America from March 20. The resumption of work time to be determined. Tesla has announced that it will halt production at two U.S. plants starting from March 24. At this point, the vast majority of automobile factories in the United States and shut down. In addition, the outbreak has had a major impact on the U.S. construction industry. Overall, the United States annual steel consumption decline has
become a foregone conclusion. U.S. crude steel production from June to February 2020 is 584,21 kilotons and from March 2020 to September 2020 is 38,264 kilotons. Since March, the crude steel production has been falling off a cliff because of the epidemic, and it has only gradually recovered since July. And the U.S. capacity utilization rate has been maintained in a good range of 70% to 80%, falling to 64% from April 2020. This shows that both steel production and energy efficiency in the steel industry has been hit hard by the epidemic. As a result, the US steel industry has been very weak throughout the outbreak, and this is reflected in Betam.

4.2. The coefficient of RMW

The COVID-19 pandemic and its disruption to industrial production have begun to impact metal production, especially steel. This comes on the heels of a difficult period for the industry in 2019 when it struggled with tariffs and experienced early signs of a demand slowdown. The industry is in a day-to-day mode of monitoring and forecasting the demand for products from end-users, including the automotive sector, oil and gas industries, and others, such as white-goods (large home appliances) manufacturers.

As this crisis plays out, metal manufacturers will need to improve forecasting related to the potential for slackening demand among downstream steel consumers — especially industries that may be classified as “non-essential.” For instance, the automotive industry, a major consumer of US steel, may already be slowing down production in numerous plants.

The engineering and construction industry may experience its own slowdown — with some construction sites are locked down, which could also reduce demand for steel products. Additionally, aluminum producers and makers of specialty metals such as titanium should look closely at the aerospace and defense industry for possible signs of market demand, both on the upside and downside. However, the metals industry's operational nature — with long leads required to idle and then restart mills and smelters — presents challenges that require nimble and swift reactions to market dynamics.

Against this backdrop, U.S. steel companies have also experienced heavy losses. For example: United States Steel projected an adjusted EBITDA loss of approximately 315 million dollars (2.23 billion yuan) for the second quarter, well ahead of market expectations for a loss of $86.5 million. US Steel reported a net loss of $391m for the first quarter of 2020, compared with a net profit of $54m for the same period in 2019. That means U.S. Steel lost $706 million (about 5 billion yuan) in the first two quarters. It is one of the world's worst steelmakers to have reported operating numbers so far.

The loss was due to a portion of the steel-making business idled during the quarter due to Novel Coronavirus. U.S. Steel continues to expect the second quarter to be the trough of the year, saying demand began to show improvement in June. As a result of the pandemic, particularly in the automotive and energy end markets, pandemic results are expected to be significantly lower for the flat material business results in the second quarter than in the first quarter. However, due to the demand for welded and seamless steel pipe, tubular market conditions remain "challenging," and the pipeline has declined significantly, and the rig count continues to decline. The company also expects its working capital needs to be approximately $700 million by the end of 2020, in line with the comparable level of $700 million previously disclosed on May 21.

4.3. Both SMB and HML were significant, then there was little change, and CMA remained insignificant

SMB coefficient and HML coefficient have little and significant changes before and after the epidemic, which indicates that the epidemic has only brought some insignificant impact on the steel industry's market value. At the same time, with the booming development of new energy, the prospect of the development of the steel industry has been declining year by year, and the epidemic has not changed this trend.

The coefficient of CMA was not significant before and after the epidemic, which was closely related to the development of the steel industry. This also indicates that investors in the steel industry have a higher demand for yield.
5. Conclusion
The significance of capital asset pricing is to establish the relationship between capital risk and return, clearly indicate that the expected rate of return of securities is the sum of risk-free rate of return and risk compensation, and reveal the internal structure of securities return. Based on the FF 5 factor model, this paper studied the coefficient changes in the steel industry before and after the epidemic and analyzed the causes. It was found that the epidemic had a severe impact on the steel industry, leading to a huge decline in the whole industry, making the stock insensitive to the market and making RMW ineffective.

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