Test and Analysis of the Leading Factor of Excess Return of Industry Sector in China Stock Market

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Abstract. We use Fama-French to empirically analyze 2,288 portfolios of 26 China stock market industry sectors from 2016 to 2020 of industry sectors. The results show that: Although factor effect is common in China stock market industry sector, it shows obvious difference in factor dominance, among which 19 and 21 industry plates have positive size effect and reverse value effect respectively. In terms of *RMW* and *Inv*, only 8 and 9 industry segments' excess return can be explained by *FF-4* and *FF-5*. *SMB* and *HML* play a leading role in explaining the excess return of 12 and 15 industry groups. The research conclusion provides support for further research on the yield interpretation model suitable for China stock market characteristics.

Keywords: Fama-French · Industry sector · Asset pricing

1 Introduction

The discussion on the factor model of China stock market excess return has always been one of the concerns of the academic community. Studies have shown that for a subset of stocks that are closely correlated by a certain attribute, they tend to have a strong correlation in return, and this correlation is significantly different from other stocks [1]. For example, from 1950s to 1970s, returns of stocks with higher *P/E* in the US stock market was lower than that of those with lower P/E, and in the 1980s, there was a phenomenon that small stocks had better return than big stocks [2]. In order to explain these phenomena, the academic circle is keen to improve *CAPM* [3] proposed based on the market efficiency hypothesis, hoping to optimize its explanatory ability for stock returns. In this context, Fama and French (1993) integrated stock style on the basis of *CAPM* and proposed *FF-3*, that is, the excess return of venture portfolio can be explained by *Mkt*, *SMB* and *HML* [4]. Later, they further proposed *FF-4* (Fama, French, 2012, 2014), adding *RMW* and Inv respectively, in order to better explain the value effect [5].

For a long time, Chinese scholars have also carried out active studies on the *Fama-French*, hoping to use or integrate the model to explore its interpretation of the domestic

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stock market. Based on the differences between the Chinese market and other developed economies such as the United States, Liu et al.(2018) questioned the explanatory power of the *Fama-French* on the Chinese market and proposed the China stock market factor model, which had A great impact[6]. However, a large number of scholars still put forward new views on the *Fama-French*, such as Bin Guo etc. [7] (2017), Li et al. [8] (2017), Du [9] (2019) and Wang et al. [10] (2022). In particular, in recent years, the implementation of measures related to financial opening-up such as Growth Enterprise Board, Science and Innovation Board and registration system, as well as the promotion of continuous opening-up policies of various markets, has become a new concern whether the applicability of *Fama-French* to China has been improved. From the perspective of industry, *Fama-French* is mostly used to analyze a class of industry stocks. For example, Gou and Wang (2016) used *FF-3* regression results of four risk portfolios to explain the research on volatility sensitivity of Chinese listed bank stocks [11], but there are few holistic studies extending from industry sectors.

We select 26 industry sectors in the China stock market market as research objects to study the leading factors that play a major role in explaining the stock returns of different industry sectors, and then study the explanatory effect of *Fama-French* on China stock market industry sectors from a medium-perspective. It mainly includes three research objectives. Firstly, judging the range of four factor effects from the actual excess return of factor portfolio. Then *GRS* was used to judge the applicability of the overall interpretation of different factor models. Finally, multiple regression is used to test the dominant factor of the explanation of excess return. We try to deepen the understanding of the overall market through three-dimensional comparison of the industry based on the risk portfolio division and model research of each industry sector market.

2 Research Methods and Data

Fama and French (2014) found through the Dividend Discount Model of Miller and Modigliani (1961) that an enterprise's profitability and investment style would enhance the explanatory ability of an enterprise's *B/M* to stock returns, that is, the explanatory ability of *HML* would be made up by the introduction of factors [12]. The *FF-5* formula is as follows:

$$R_{it} - R_{Ft} = a_i + b_i(R_{Mt} - R_{Ft}) + s_i SMB_t + h_i HML_t + r_i RMW_t + c_i CMA_t + e_{it} \quad (1)$$

where, R_{it}-R_{Ft} represents the expected excess rate of return of venture portfolio i in period t; R_{Mt}-R_{Ft} represents the market excess rate of return (i.e. *Mkt*) during t period. SMB_t stands for size factor; HML_t represents value factor; RMW_t stands for profitability factor; CMA_t stands for investment style factor.

When calculating the specific values of the five factors of different industry sectors for empirical test, factor calculation was carried out based on the 2×3 venture portfolio excess return of Fama and French (2014). The 2. 2×2 combination and $2 \times 2 \times 2$ combination are not considered for two reasons. First, the calculation of 2×2 combination is too simple in terms of grouping details compared with the other two methods. Second, when the venture portfolio construction based on industry sector classification

is faced with large differences in the number of samples among industry sectors, the 4-dimensional classification method will cause a large increase in the extreme rate of return of some portfolios, which brings difficulties in objective and quantitative evaluation of various factors.

The data comes from Choice financial database, and the sample range is from January 2016 to December 2020. It includes the monthly closing price, monthly market value, monthly *B/M* of each enterprise in the 26 industry sectors in the China stock market first-level classification of SWS Research 2021, and corporate earnings, interest payable, operating costs, selling expenses, administrative expenses, book equity and other indicators in the annual financial statement. At the same time, one-year national debt interest rate is selected as the risk-free interest rate.

The data are processed in two ways. First, the *Banks*, *Non-banking Finance*, *Beauty Care*, *Conglomerate* and *Coal* among the 31 industry sectors in the China stock market first-level classification of SWS Research 2021 are excluded. The reason why the *Banks* and *Non-banking* are excluded is that their profit methods cannot be directly applied to the calculation method of profitability of listed companies proposed by Fama and French (2014), which may lead to the lack of consistency in the comparison of test results on the division of risk portfolios based on profitability among subsequent industry sectors. The reason for excluding the *Beauty Care*, *Conglomerate* and *Coal* is that the number of enterprises listed in these sectors is too small, less than 35, which will directly affect the results of regression test.

3 Empirical Results

3.1 Factor Yield Analysis

We judge the range of four factor effects by factor yield. According to the calculation method, the five-factor rate of return of each sector is calculated. According to our calculation, average *SMB* of each industry ranges from −0.6% to 1.57%, among which average *SMB* of 21 industries is positive, which means that the size effect can bring positive returns while leading the market premium, and its maximum value is 1.57%. Meanwhile, the comprehensive average *SMB* of each industry is 0.54%. It can be seen that although all industries generally conform to the size effect, *SMB* of 30% industries is not significant. Among them, *Telecommunication* has the most outstanding performance, with average *SMB* of 1.57%, and the average value of *Machinery Equipment*, *Textile & Apparel* and *Chemical* is about 1.20%, indicating that the return rate of *Telecommunication* is more dependent on the size, which is consistent with the reality. It can be believed that while the industrial sectors show size effect as a whole, a few industrial sectors are dominated by size effect. Although some industrial sectors do not deviate from size effect, they are not affected by it. On the whole, there is little difference between the maximum and standard deviation of *SMB* of individual stocks in the industry sector, but there are also sectors that are more volatile than other sectors, such as *National Defense*, whose minimum value of −23.29 is much lower than other sectors, and the maximum value of 18.43 is also much higher than other sectors, indicating that the size factor is not the dominant factor of *National Defense*.

Average *HML* of the overall market is −0.32%, of which 25 industry sectors are within the range of [−1%, 1%], and only *Computer* and *Telecommunication* are outside the range, which are −1.17% and −1.25% respectively. The horizontal comparison shows that the standard deviation of *HML* is the lowest among all the five factors, and the mean value of 80% of the industry sectors is below 0, indicating that in fact, there is A certain degree of deviation from the value effect in the overall China stock market market, and this phenomenon is relatively stable. While the standard deviation of all other industries is basically no more than 3.3, the standard deviation of *HML* of *Telecommunication* and *Petrochemical* is as high as 5.21 and 4.56, respectively, which reflects the lack of stability of the value effect of the two sectors, and the whole *Petrochemical* is more unbalanced. The minimum value of the factor is far away from the phenomenon of other plates, which reflects the highly unstable price of growth stocks and value stocks.

From the perspective of industry sectors, the average value of the China stock market market *RMW* is 0.03%, which is the same as the absolute value of the industry average value of *Inv*, indicating that the effect of profitability and investment style on the overall China stock market market is relatively weak. The absolute value of profitability factor of each industry group did not exceed 0.9%, among which *Utilities*, *Social Services*, *Household Equipment* and *Electric Automation Equipment* showed the largest positive effect. *Telecommunication* and *Culture & Media* showed the largest negative effect. Similarly, the average value of *Nonferrous Metal* and *Construction & Decoration* is significantly lower than that of other sectors. This indicates that the China stock market market is still a relatively immature market at present. Some factors have shown certain characteristics of mature market, while some factors have just shown certain effects.

3.2 Analysis of *GRS* Results

After determining the existence of four kinds of effects in China stock market industry plates in Sect. 3.1, we further test the difference in explanatory ability of three, four and five factor models in each sector through *GRS*, and the results are shown in Fig. 1 (including *Mkt* and *SMB* by default). *GRS* helps us choose the most suitable model. *GRS* is the test proposed by Gibbons et al. (1989) to verify the effectiveness of the asset pricing model by testing whether all intercept items of the model are integrated to zero [13]. *GRS* first assumes that the tested asset pricing model can perfectly explain the current time sequence combination of excess returns, and then observes whether the joint regression intercept of this group of excess returns in the model rejects the hypothesis that the excess returns are equal to zero at the same time. Under the condition that the original hypothesis is maintained, the formula for calculating *GRS* is as follows:

$$GRS = \frac{T}{N} \times \frac{T-K-N}{T-K-1} \times \frac{\widehat{\alpha}' \widehat{\Sigma}^{-1} \widehat{\alpha}}{1+\overline{\mu}' \widehat{\Omega}^{-1} \overline{\mu}} \tag{2}$$

T on behalf of the observation time, N is the number validation portfolio, K is the number of asset pricing model factors, $\widehat{\alpha}$ represents the intercept a column vector, $\widehat{\Sigma}$ represent residual covariance matrix unbiased estimation, $\overline{\mu}$ representative factor to yield a column, $\overline{\Omega}$ representative factors yield unbiased estimate of covariance matrix. If *GRS*

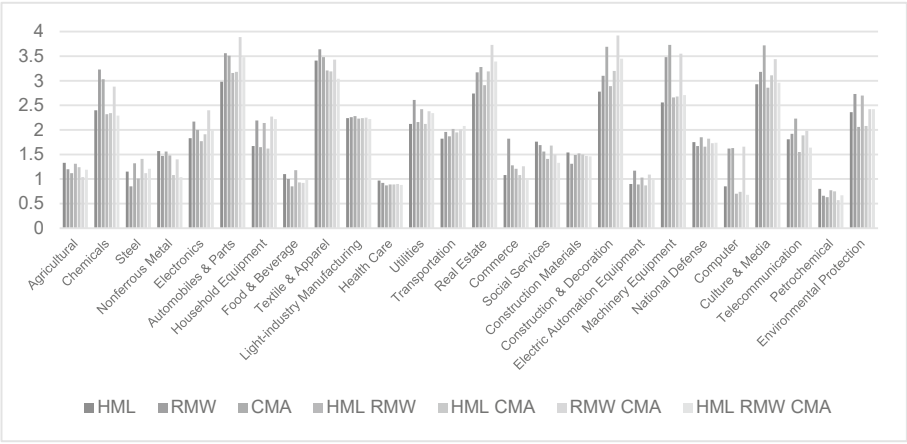

Fig. 1. GRS statistics explained by different types of three, four and five factors models on the excess return of China stock market industry sectors

explained by the corresponding factors in the models with different factors are smaller, that is, the error rate of the model factors in explaining the return series is smaller, that is, the model factors are more effective, and vice versa.

From the perspective of the overall industry plates in Fig. 1, *GRS* statistics of 54% of the industry sectors are significantly lower than those of other sectors, and in the process of increasing from three factors to five factors, *GRS* statistics are also significantly and gradually decreasing, indicating that the explanatory ability of the three models is improved with the introduction of new factors. From the perspective of each industry and plate, the difference law of each factor model is basically synchronized with the overall market, but the explanatory ability differs significantly among industries. The main performance is that when the three factor models have a good explanatory effect on an industry, *GRS* statistics tend to decrease with the introduction of factors, thus showing the explanatory advantages of the five-factor model. However, when the three-factor models have a poor explanatory effect on an industry, the introduction of new factors is difficult to improve the explanatory power of the model, reflecting the complexity of leading factors between industries.

It is also one of our purposes to analyze the explanatory power of quantitative asset pricing models with different factors to different industry sectors. According to Fig. 1, with the introduction of profitability factor and investment style factor, the explanatory power of *Fama-French* on the industry sectors of China stock market is improved overall, but the improvement degree is limited. In addition, for some industries, with the introduction of new factors, the decline of explanatory ability exceeds the increase of explanatory ability. Among them, the explanatory ability of *Computer* and *Chemical* increased significantly with the introduction of the new factor, while that of *Household Equipment* and *Real Estate* decreased significantly.

3.3 Multiple Regression Test Analysis of Factor Model

Under the premise that the effects of the four factors are found to exist widely in various China stock market industries and the changes in the number of factors significantly affect the explanatory power of the model, this section uses multiple regression to test and analyze the model in different China stock market industries to further explain the leading factors of excess return. The results are shown in Fig. 2.

According to Fig. 2, the coefficient of *Mkt* of various industry sectors is generally maintained near 1.0, and the average value is just close to 1.0. In addition, except for some portfolios in *Food & Beverage*, *p* of *Mkt* is basically less than 0.05, indicating that the influence of *Mkt* is significant, and the overall market background has a direct positive impact on individual stocks in various sectors. However, the coefficient of *Mkt* of some industries is around 0.8, which reflects that their stock prices do not fluctuate completely with the market situation.

Among them, *SMB* coefficient of various industry plates is also basically maintain the phenomenon that small stocks are positive and big stocks are negative. Not only are *SMB* of big and small stocks in the same sector and the same model basically similar, but the absolute sum of *SMB* of small and big stocks in most industries is close to 1.0, that is, when *SMB* has a strong influence on small stocks in the industry, big stocks in the industry will have a weak influence on the other side, and vice versa. Among various industries, *Food & Beverage* shows obvious differences. Not only is *Mkt* coefficient about 0.8, but *SMB* coefficient of small stocks is also less than 0. From the portfolio return details, in recent years *Food & Beverage* big weak profit stocks have been difficult to be affected by the overall market situation. *HML* coefficient of this plate is far lower than that of other sectors, and *p* of the other four factors is basically the highest in all industries. It can be seen that among *FF-5*, only *HML* is suitable for the reverse interpretation of this sector by virtue of its very low coefficient. From the perspective of factor significance, *SMB* and *HML* contained in *FF-3* are generally the most significant factors in most industries, but their significance shows two completely different rules. When *SMB* of a certain plate

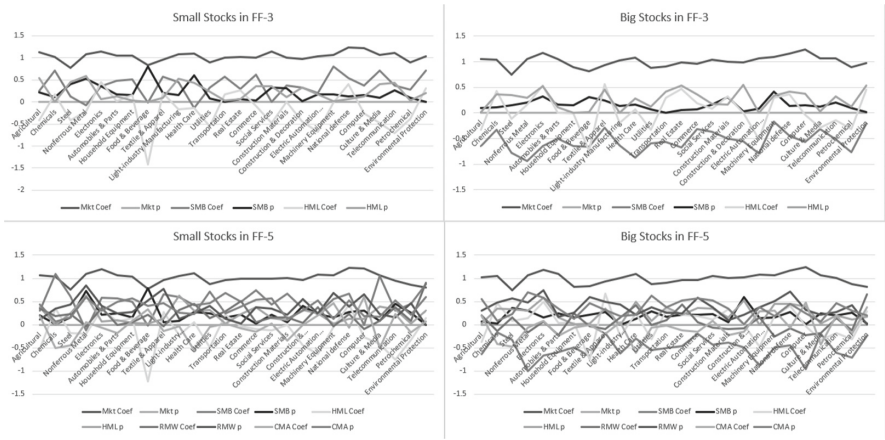

Fig. 2. Multiple regression test results of China stock market industry sectors

is significant, big stocks and small stocks in the same model jointly show significance, while other models have no significance. When *HML* of a certain sector is significant, it will be performed simultaneously in the big stocks or small stocks of all models.

It can be seen that although the newly introduced factors of *FF-5* do not show obvious explanatory properties, they have horizontal influence on the original three factors. For example, *SMB* of *Chemical*, *Textile & Apparel*, *Light-industry Manufacturing*, *Construction Materials* and *Computer* becomes more significant after the introduction of the new factor. *HML* of *Automobiles & Parts* and *Utilities* is significantly more significant after the introduction of the new factor than before. At the same time, *SMB* of *Utilities*, *Transportation*, *Real Estate* and *Social Services* decreased significantly after the introduction of the new factor, while *HML* of *Social Services* and *National Defense* lost its significance after the introduction of the new factor. However, according to *GRS* results, *FF-3* could not provide the best explanation for the return rate of each industry of China stock market, and the four - and five-factor models containing new factors were still used instead.

4 Conclusion

Our research object is the 26 China stock market industry sectors from 2016 to 2020. Based on *Fama-French*, through descriptive statistical analysis of factor yield, analysis of two-dimensional portfolio GRS test results and detailed analysis of portfolio multiple regression, we explore successively: 1. Existence of factor effect in China stock market industry sectors; 2. The explanatory power of different portfolio factor models to the portfolios of different sectors; 3. Dominant factors in the income explanation of each sector.

From the fact that *Mkt* yield is the lowest among the five factors, it can be seen that there are four factor effects in the China stock market industry. When the explanatory power of scale effect covers 70% of China stock market sector, its average return rate is generally ahead of other factors. *HML* showed similar significance to *SMB* in the regression test, but the factor coefficient was basically negative. The explanatory power of profitability effect in large and small stocks in various industries lacks regularity. The investment style effect is common but its intensity is low, but higher than the value effect. For the industry sectors that are difficult to be explained by the factor model as a whole, the factor with strong significance, the dominant factor, can be found in the regression detail analysis. However, the explanatory ability of other factors is limited, resulting in the insufficient explanatory ability of the overall model. There is no three-factor model in any form that can explain the return rate of all sectors than the four-factor model and the five-factor model. Among them, 31% and 23% of the excess return rate of industry sectors can be explained by various four-factor model or five-factor model combining *Mkt* and *SMB*.

The results of the regression test of the model correspond to the performance of the four effects in the yield of various industries. The factors that explain the significant effect of the factor model of most industries are basically *SMB* (positive coefficient) and *HML* (negative coefficient). Although there are few industry sectors with significant *RMW* and *Inv*, the significance of *SMB* and *HML* of most industry sectors will change

due to the introduction of these two new factors. At the same time, although a small number of industry sectors do not show significant factors, their returns can still be provided by some factor models to provide better explanatory power.

References

1. Christopherson Jon A.. Equity Style Classifications[J]. The Journal of Portfolio Management, 1995,21(3).
2. Banz R W. The relationship between return and market value of common stocks[J]. Journal of Financial Economics, 1981, 9(1):3-18.
3. William F, The R . SHARPE. Capital Asset Prices: of Market Equilibrium under Conditions of of Finance. [J]. Journal of Cell Biology, 1964, 98(2):407–16.
4. Fama E F , French K R . Common risk factors in the returns on stocks and bonds[J]. Journal of Financial Economics, 1993, 33(1):3-56.
5. Fama E F , French K R . A Five-factor Asset Pricing Model[J]. Journal of Financial Economics, 2014, 116(1).
6. Jianan Liu, Robert F. Stambaugh, Yu Yuan. Size and value in China[J]. Journal of Financial Economics,2019,134(1).
7. Bin Guo, Wei Zhang, Yongjie Zhang, Han Zhang. The five-factor asset pricing model tests for the Chinese stock market [J], Pacific-Basin Finance Journal, Volume 43, 2017. PP 84-106.
8. Li Zhibing, Yang Guangyi, Feng Yongchang, Jing Liang. Fama-FrenchFive Factor Model in China Stock Market[J]. Journal of Financial Research, 2017(06):191-206.
9. Du WeiWang. An extended study of fund investment style analysis model based on FF five-factor model [J]. Wuhan Finance,2019(10):52-57.
10. Wang Xi, Wu Fei, Huang Dejin, Chen Yi, Xiang Zhen. Time - varying multi - factor model of A - share market [J]. Journal of Southwest University (Social Sciences Edition), 2022, 48(06):137-152
11. Gou Dongning, Wang Weijia. An empirical test of Chinese listed bank stocks based on Fama-French three-factor model [J]. Statistics & Decision,2016(21):158-161
12. Modigliani M F . Dividend Policy, Growth, and the Valuation of Shares[J]. The Journal of Business, 1961, 34(4):411-433.
13. Gibbons M R , Ross S A , Shanken J . A Test of the Efficiency of a Given Portfolio[J]. Econometrica, 1989, 57(5):1121-1152