Research on the Applicability of Factor Model to Chinese and American Stock Markets

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Abstract. A three-factor model for the price of shares which is based on the CAPM was suggested by Fama. Two factors derived from public market information are added: market value (SMB) and book-to-market ratio (HML). Based on the stock data from June 30th, 2018 to May 31st, 2020, this article used a Fama-French three-factor model to test its applicability to equity markets in China and the United States through portfolio construction, and then compared the recognized factor model regression results in two countries. The study revealed that pattern adjustment of America is better than China, that is, the applicability of this factor model to the Chinese equity market is inferior to that of the US equity market. Chinese development characteristics and market conditions are unique, and its equity performance is affected by many factors. Methods for explaining China stock market still need to be further optimized. The model for explaining Chinese stock market still needs to be further optimized.

Keywords: Applicability · Fama-French three-factor model · factor construction

1 Introduction

As the economy continues to develop, the factors that determine the performance of the equity portfolio remain a longstanding research topic. Based on numerous empirical studies, the famous CAPM model cannot fully account for the difference in individual equity returns. Fama put forward a three-factor model of stock pricing based on CAPM [1]. Two new factors, market value (SMB) and book-to-market ratio (that also is accounting/market ratios) (HML) from public market information were added to the previous one which significantly improved the overall interpretation ability for the excessive yield on the financial market, and consolidated the efficient market hypothesis. After that, Fama added CMA and RMW factors and created five-factor model [2]. Nevertheless, the explanatory power of five-factor was not much improved compared with the three-factor. There is a strong co-linearity between the two newly added factors and HML factors, so the canonical factor model is still widely used. This pattern generally has strong explanatory power for foreign financial markets. However, due to the late start of China's financial market, its development path, formation characteristics and current situation are different from foreign capital markets. As a result, whether this model is suitable for Chinese equity market is still uncertain.

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After this pattern was put forward, many scholars have discussed the influence of three factors on stock returns and the prediction effect from different angles. Banz Rolf pointed out that the difference in the historical average return of different stocks can be reflected by market value, and small-cap stocks has higher average return [3]. Longzhen Fan and Shidian Yu pointed out that some economic effect of Chinese stocks cannot be used by the market β while these effects can be well explained by adding two factors: SMB factor and HML factor [4]. Lin, Wang and Cai proved that the excess yield of China's stock can be greatly elucidated by that pattern [5]. Peng Zhao and Mei Zhou used that template to do an empirical analysis, and they found that small and large firms with low accounting/market ratios have a demonstrable efficiency effect on a scale and an accounting-to-market effect, whereas these two factors were insignificant in large corporations with a high accounting/market ratio [6]. Shujun Feng and Zhuo Liu proposed that the method can comprehensively explain the cross-sectional yield of small-cap stocks, while the explanatory power of large-cap stocks' yield needs to be improved, and the excess yield cannot fully explain market risk [7]. Zunhan Yang believed that the equity yield criterion using the factor model is less relevant for the entire A-share market and for a particular industry, and explaining equity performance solely through systemic risk is not sufficient [8]. Xueqing Zang also pointed out that the volatility of portfolio returns can be explicated by Rm-rf factor, SMB factor and HML factor [9]. From the perspective of a specific industry, Zhonghang Ou studied Chinese property sector from 2014 to 2019. The results showed that the three factors mentioned above were quite effective [10]. Shuai Li and Qiang Zhang conducted an empirical study on the changes of the US stock medical industry before and after the COVID-19 epidemic based on the method, and found that the matching degree of the model has improved after the epidemic [11]. Haotian Shi used the factor method to analyze the stock of 1618 companies on the main board of SSE in China, he found that this model has great ability to explain the surplus yield of the SSE stocks [12].

To sum up, scholars at home and abroad have conducted relatively comprehensive research and analysis on the accepted model, but it still has research value on whether the current financial market is suitable. This paper used it for Chinese and American equities respectively to empirically analyze and compare the functionality, so as to provide some reference for the portfolio pricing in China.

2 Method

2.1 Introduction of Model

In 1992, Fama and French conducted a study on the factors that determine the difference in yields of individual stocks on the US stock market. They discovered that the different yields of the various securities could not be explained by β value of stock market. However, they could be strongly expounded through the three factors mentioned earlier. Finally, Fama et al. developed this classical model.

The expression is as follows:

$$R_{it} - r_f = \alpha_i + \beta 1_i\left(R_{mt} - r_f\right) + \beta 2_i SMB_t + \beta 3_i HML_t + \varepsilon_{it} \quad (1)$$

Table 1. Grouping Rules

		Book-to-market		
		L (Low) 30%	M (Medium) 40%	H (High) 30%
Market value	S (Small) 50%	SL	SM	SH
	B (Big) 50%	BL	BM	BH

where R_{it} is the return on assets and rf is the risk-free interest rate. $R_{mt} - r_f$ is the premium factor, SMBt is the market value factor, and HMLt is the book market value factor, $\beta 1_i$, $\beta 2_i$, $\beta 3_i$ is the coefficient of $R_{mt} - r_f$, SMB_t, and HML_t t, ε_{it} is the residual item, α_{it} is the intercept term.

2.2 Factor Construction

Due to the fact that when the error of the coefficients is not completely positive correlation, the regression coefficients obtained by constructing a stock portfolio are more accurate than those estimated by individual stock regression, this article uses the method of constructing a stock portfolio to test the three-factor pricing pattern.

Firstly, based on the market value of listed companies, they are sorted by their size and divided into two parts, S means the stocks with small market value while B means the large market value. Then, they are sorted by the book-to-market ratio of 30% (L), 40% (M), and 30% (H), as shown in Table 1. Finally, monthly returns of SL, SM, SH, BL, BM, and BH portfolios can be calculated through weighted average (weighted by the total market value).

The two factors can be obtained from the yields of six portfolios mentioned above, and the calculation methods are as follows:

$$SMB_t = \frac{(SL_t + SM_t + SH_t)}{3} - \frac{(BL_t + BM_t + BH_t)}{3} \tag{2}$$

$$HML_t = \frac{(BH_t + SH_t)}{2} - \frac{(BL_t + SL_t)}{2} \tag{3}$$

At the same time, this paper assumes that stock returns follow a normal distribution, so the least squares estimation and the maximum likelihood estimation are consistent. After that, the OLS least square method is used to estimate each stock portfolio and obtain the corresponding estimation measurement.

2.3 Data Source and Data Processing

For the China stock market, this article takes the corresponding risk-free interest rate and daily trading data of the 50 constituent stocks of the SSE 50 Index from June 30th, 2018 to May 31st, 2020 as the research object. These data are obtained from the CSMAR database. For the US ticket market, this article also obtains daily data and risk-free interest rates for US stocks from June 30th, 2018 to May 31st, 2020, which are sourced from Kenneth R. French - Data Library.

Table 2. Descriptive statistics of Chinese Stock portfolio (%)

	SL	SM	SH	BL	BM	BH
min	−0.764	−0.989	−0.915	−0.640	−0.694	−0.563
max	0.700	0.657	0.661	0.669	0.518	0.596
mean	0.010	−0.001	−0.003	0.011	−0.001	−0.001
std	0.191	0.173	0.154	0.167	0.114	0.103

Table 3. Descriptive statistics of American Stock portfolio (%)

	SL	SM	SH	BL	BM	BH
min	−1.406	−1.273	−1.251	−1.140	−1.265	−1.446
max	0.941	0.957	0.965	0.902	1.084	1.305
mean	0.003	−0.002	−0.006	0.007	0.001	−0.002
std	0.195	0.198	0.211	0.163	0.175	0.216

According to the stock portfolio construction method described above, six stock portfolios are obtained. Then, SMB factor and HML factor are obtained through the above three factor calculation formula. Table 2 and Table 3 present descriptive statistics for six stock portfolios in China and the USA, respectively. On both of them, the average return for small equities is typically lower than for large equity portfolios, and the small-scale equities have larger standard deviation than that of large-scale equities.

3 Results and Discussion

After grouping and obtaining the factors, this article further uses this factor model for regression analysis. Tables 4 and Table 5 list some indicators of regression analysis.

From the results of Chinese stock regression in Table 4, for the six stock portfolios, the goodness of fit is relatively large, all of which are above 0.90, indicating that the equation has good explanatory power overall. The P value of the t-test and F-test are both close to 0, which is significant at levels above 0.001, indicating that these three factors are very important explanatory factors for stock returns. At the same time, the obtained MSEs (mean squared error) are all small, proving that the regression is indeed effective.

On the other hand, from the coefficient, it can be seen that the SMB coefficient of small market value stock portfolios is significantly positive, while the SMB coefficient of large market value stock portfolios is significantly negative, showing that the impact of the scale effect on the performance of small businesses is positively correlated, while the impact on returns of large market capitalization companies is negatively correlated. Observing the coefficient of the HML factor $\beta_{(HML)}$, it can be seen that for portfolios with low-level accounting/market ratios, the relationship between HML and portfolio excess

returns is negative. On the contrary, for portfolios with medium-level and high-level in accounting/market ratios, this relationship is positive. It can be seen that this classical model is applicable to the China stock market.

Compared to the US, it is obvious that the regression results are more significant, although the SMB is not significant on BM and BH. For the six stock portfolios, the goodness of fit of the regression is above 0.95, which has a better explanatory power than the China stock market. At the same time, the corresponding MSE (Only three decimal places are shown here) is also smaller than the China equity market. Therefore, this accepted pattern is more apposite to the America.

Table 4. Regression results of Chinese Stock Market

	SL	SM	SH	BL	BM	BH
$\beta_{(Rm\text{-}rf)}$	0.805^{***}	1.101^{***}	1.071^{***}	1.139^{***}	0.966^{***}	0.873^{***}
$\beta_{(SMB)}$	0.920^{***}	0.867^{***}	0.781^{***}	-0.223^{***}	-0.124^{***}	-0.084^{***}
$\beta_{(HML)}$	-0.699^{***}	0.126^{***}	0.515^{***}	-0.507^{***}	0.170^{***}	0.279^{***}
$t(\beta_{(Rm\text{-}rf)})$	47.308	54.408	69.729	64.982	85.598	72.119
$t(\beta_{(SMB)})$	33.469	26.529	31.487	−7.875	−6.811	−4.295
$t(\beta_{(HML)})$	−38.205	5.798	31.195	−26.898	14.025	21.420
adj-R^2	0.956	0.923	0.945	0.938	0.945	0.923
P(F)	0.000	0.000	0.000	0.000	0.000	0.000
MSE	0.000	0.000	0.000	0.000	0.000	0.000

Note: Significance level: *** $p < 0.001$.

Table 5. Regression results of American Stock Market

	SL	SM	SH	BL	BM	BH
$\beta_{(Rm\text{-}rf)}$	1.078^{***}	1.020^{***}	0.996^{***}	1.011^{***}	0.990^{***}	1.092^{***}
$\beta_{(SMB)}$	1.028^{***}	0.928^{***}	0.945^{***}	-0.083^{***}	−0.018	0.000
$\beta_{(HML)}$	-0.170^{***}	0.374^{***}	0.727^{***}	-0.246^{***}	0.322^{***}	0.857^{***}
$t(\beta_{(Rm\text{-}rf)})$	143.357	196.710	317.757	305.908	146.188	147.321
$t(\beta_{(SMB)})$	56.971	74.561	125.601	−10.403	−1.078	0.004
t(β(HML))	−13.157	42.127	135.239	−43.446	27.705	67.380
adj-R^2	0.982	0.991	0.997	0.995	0.981	0.985
P(F)	0.000	0.000	0.000	0.000	0.000	0.000
MSE	0.000	0.000	0.000	0.000	0.000	0.000

Note: Significance level: *** $p < 0.001$.

4 Conclusion

This article used the method of constructing stock portfolios to test the daily data of the stock markets of the two countries from June 30th, 2018 to May 31st, 2020, and compared the recognized factor model regression result of equities in two countries.

Compared to the China stock market, this classical model is more applicable to the US stock market. The author believes that the results can be explained from the following aspects.

Firstly, this model is derived according to the development status of the US equity market. The relatively mature western stock markets advocate value investment and focus on company characteristics, resulting in the canonical model which is used to explains the changes in stock yield of listed companies. China stock market started relatively late, and naturally there are many differences between the two stock markets. Therefore, it is not surprising that the result shows it has a higher explanatory power for the US stock market. Secondly, at the beginning of the establishment of the Chinese stock market, China was mainly engaged in a planned economy. The government's intervention in the stock market was relatively strong, and the market at the initial stage needed policy guidance and regulation to control its risks. However, government intervention increased market risks, which in turn affected stock returns.

It can be seen that the development characteristics and market conditions of Chinese stock market are significantly different from those of the United States, and the reasons for affecting stock returns are complex and diverse. The model for explaining Chinese stock market still needs to be further optimized.

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