An Empirical Analysis of the Fama-French Three-Factor Model in A-Share Market

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Abstract: Compared with the characteristics of the early start and mature development of the stock market in Western countries, the Chinese stock market has many particularities. With the rapid growth of China's economic construction, the healthy development of the stock market is increasingly related to the healthy development of the national financial system. Therefore, based on the particularity of the Chinese stock market, it is of great significance to continuously use the latest data to test the adaptability of asset pricing models. The empirical study in this paper uses the theoretical framework of the Fama-French three-factor model to test the applicability of the Fama-French three-factor model empirically. This empirical study shows that the Fama-French three factors have good applicability in the Chinese stock market, which can almost entirely explain the stock returns of the Chinese A-share market from 2001 to 2019. Besides, it also proves that there are apparent small-scale effects in the Chinese A-share market, but the book-to-market ratio effect is weaker.

1. Introduction

In the past half-century, the discussion of capital pricing in the capital market has become one of the key topics discussed by many scholars. Among them, the Fama-French three-factor model developed based on the capital asset pricing model CAPM has been widely used abroad. It is used in various aspects such as risk management, fund performance evaluation, and yield prediction. With the rapid development and improvement of China's capital market in the past two decades, more investors expect to build the best combination in the stock market with high returns and high risks to obtain benefits higher than the average market rate of return, which makes The research of asset pricing model has more practical significance. Therefore, the latest stock market data is used for analysis to understand the factors that affect China's stock returns correctly, and the operating characteristics of the Chinese stock market will provide a strong basis and guidance for improving investor decision-making. Based on the theoretical framework of the Fama-French three-factor model, this article explores the applicability of the Fama-French three-factor model in the Chinese A-share market.

2. Literature review

The earliest research on asset portfolio pricing came from the mean-variance investment portfolio constructed by Markowitz [1], which gave the mathematical definitions of returns and risks and became the cornerstone of modern investment theory. Sharp and Lintner further improved the mean-variance model, added market risk factors, and proposed a new mainstream theory: capital asset pricing model (CAPM) [2]. Fama and French said the company scale factor (SMB) and book market value ratio factor (HML) based on the CAPM model. They proposed a three-factor model, which significantly improved the ability to explain the market excess return rate [3]. The model is used in the empirical analysis. Most Chinese scholars' empirical analysis of the CAPM and Fama-French three-factor models have confirmed that the three-factor model has a better fit than the CAPM model. The regression results of Luo Xiaolei indicate that the three factors have better explanatory power than the ChiNext on the A-share mainboard and small and medium board markets in China [4]. At the same time, some scholars have obtained different results in the

empirical analysis. Feng Shujun and Liu Zhuo confirmed that the model's ability to explain significant market value stock returns needs to be improved [5]. Based on the existing three-factor model, some scholars try to add more factors to form a new asset pricing model. Shi Yuyou, Ma Jun, Chen Yan, and Zhong Weizhou added stock equity ratio factors based on the book-to-market ratio factor and scale factor and used cluster analysis to study the impact on risk [6].

In summary, most of the existing research on the Chinese market lacks empirical research from 2012 to recent years [7]. After 2012, China's economy has developed rapidly, the stock market has become more sophisticated, and combined with the impact of strategies such as the "Belt and Road", whether the three-factor model can still be applied to the Chinese market remains to be investigated, so this article uses data from 2001 to 2019 to test the applicability of the three-factor model.

3. Sample data and definition of factors

3.1 Sample selection

The data in this article are derived from the stock trading database and company research database in the Guotai An database (CSMAR), using the A-share market motherboard from January 2001 to December 2019 in stock market transactions. Monthly data of all stocks in China, SME, and GEM, are used as research samples. Eliminating all stocks in ST, PT, and financial industries make the sample data more accurate; at the same time, excluding data within six months of listing [8].

3.2 Definition of factors

Refer to Fama-French (1993) three-factor model construction method for regression analysis.

$$R_{it} - R_{Ft} = a_i + b_i(R_{Mt} - R_{Ft}) + s_j SMB_t + h_j HML_t + e_{it}$$

The excess return rate $R_{it} - R_{Ft}$ as the explanatory variable is constructed by dividing all stocks in the A-share market from 2001 to 2019 into five groups according to the total market value at the end of June t from small to large. According to t-1 years, the book market value ratio is divided into five groups from small to large. The resulting groups are cross-combined 5 * 5 to generate 25 sets of sequences, and then the 25 sets of courses are calculated from the twelve-monthly returns of the market value-weighted average from July in t to June in t + 1. The monthly rate of return minus the risk-free rate yields 25 sets of monthly excess returns.

The specific construction methods and calculation methods of the explanatory variable scale factor SMB_t and book market value ratio factor HML_t are as follows:

Table 1 Factor construction method

Group	Grouped according to scale and book market value ratio 2 * 3
Grouping Point	Size: Median A shares; Book to the market ratio: 30th and 70th percentiles of A-shares
Calculation Method	$SMB_t = 1/3\,(SH + SM + SL) - 1/3\,(BH + BM + BL)$ $HML_t = 1/2\,(SH + BH) - 1/2\,(SL - BL)$

3.3 Descriptive statistical analysis

Table 2 The average monthly excess return rate of 25 groups (%)

Scale	Book to market ratio (B / M)				
	Low	2	3	4	High
小	0.623	1.710	2.088	2.200	1.729
2	0.593	1.343	1.204	1.500	1.498
3	0.827	1.016	0.759	0.924	1.093
4	0.790	0.579	0.673	0.502	0.896
大	0.552	0.415	0.447	0.393	0.707

According to Table 2, a descriptive statistical analysis of the average monthly excess returns of the 25 groups of portfolios can more intuitively find the following changes: First, the small-scale effect of China ’s A-share market is very significant, except for the lowest five outside the group, the monthly excess return rate of the remaining 20 groups of combinations decreased with the increase of the company's size; and the five groups with the lowest book market value, although their monthly excess return rate did not decrease with the growth of scale, but small. The excess return rate of large-scale companies is 0.623%, which is still significantly higher than the monthly excess return rate of massive companies of 0.552%. Second, there is no book-to-market ratio effect in the Chinese A-share market. Whether large or small companies, as the book-to-market ratio increases, the trend of monthly excess returns tends to be unclear, which can be seen. The verification of the effect of the monthly excess return rate of the A-share market on the book-to-market ratio does not provide a reasonable data basis, which is different from the research results of Fama-French (2012) [9]. Third, the combination of small and medium-sized, high book-to-market ratios in the Chinese A-share market tends to achieve higher monthly excess returns [10]. From large-scale low-to-book-to-market ratio to small-scale high-to-book-to-market ratio, the reduction in company size is accompanied by an increase in the book-to-market rate, and the monthly excess returns of the five portfolios increase sequentially, respectively 0.552% and 0.579 %, 0.759%, 1.500%, and 1.729%, it can be seen that the large-to-low book-to-market ratio portfolio has the lowest monthly excess return rate. In contrast, the small-to-high book-to-market ratio portfolio has the highest monthly excess return rate [11].

Table 3 Statistical data of explanatory variables weighted by total market value

Variable	Obs	Mean	Std.Dev.	t-statistic	Quantile with 5% confidence
$R_{Mt} - R_{Ft}$	216	0.464	8.114	0.9970	1.96
SMB_t	216	0.693	4.678	2.1768	1.96
HML_t	216	0.248	3.653	0.8409	1.96

According to Table 3, the average of the three factors is all positive. Still, the book market value is not significantly more significant than the factor HML_t, indicating that there is a particular high book value ratio effect in the Chinese stock market. For the t-statistics, the scale factor SMB_t has a T-statistic of 2.1768, which is the most positively significant, and the market factor $R_{Mt} - R_{Ft}$ has a t-statistic of 0.9970, which is the second most significant. The positive significance of HML_t is the weakest, with a T-statistic of 0.8490, indicating that company size has the most significant impact on stock returns, market factors have the second-largest impact on stock returns, and the book-to-market ratio has the smallest impact on stock returns.

Table 4 Multicollinearity test

Variables	VIF	1/VIF
$R_{Mt} - R_{Ft}$	1.420	0.706
SMB_t	1.350	0.739
HML_t	1.060	0.943
Mean	1.280	

As shown in the test results of the multicollinearity of the explanatory variables in Table 4, the VIF values of the market factor, scale factor, and book-to-market ratio are 1.420, 1.350, and 1.060, which are all less than 5, indicating that there is no multiple coexistences among the three factors. The linear problem, that is, the three-factor explanatory variables do not have redundancy in the A-share market testing process.

4. Empirical analysis

Perform multiple regression analysis on the Fama-French three-factor model to study whether

the market factor $R_{Mt} - R_{Ft}$, scale factor SMB_t, and book market value ratio factor HML_t can explain the A-share market asset portfolio well income. The regression results are as follows:

Table 5 three-factor model grouping regression results

Size	Book to market ratio (B / M)									
	Low	2	3	4	High	Low	2	3	4	High
	$R_{Mt} - R_{Ft}$: b_i					t: (b_i)				
Small	0.978	1.011	1.005	1.017	1.032	51.93 ***	30.31 ***	65.92 ***	70.21 ***	64.38 ***
2	1.041	1.038	1.024	1.015	0.996	57.20 ***	71.37 ***	66.74 ***	74.14 ***	73.38 ***
3	1.038	1.031	1.020	1.022	1.028	59.78 ***	65.66 ***	73.56 ***	73.00 ***	79.39 ***
4	1.013	1.033	1.060	1.066	1.063	66.83 ***	68.29 ***	70.11 ***	74.77 ***	74.04 ***
Big	0.999	1.059	1.078	1.084	1.035	79.81 ***	69.10 ***	69.34 ***	72.14 ***	76.79 ***
	SMB_t: s_j					t: (s_j)				
Small	1.214	1.260	1.263	1.330	1.191	29.02 ***	30.78 ***	40.89 ***	43.88 ***	35.74 ***
2	0.994	1.082	1.041	1.057	1.091	25.51 ***	35.50 ***	32.34 ***	33.88 ***	37.93 ***
3	0.803	0.830	0.851	0.911	0.838	21.91 ***	23.08 ***	24.77 ***	26.90 ***	32.27 ***
4	0.655	0.652	0.666	0.673	0.608	20.88 ***	22.24 ***	19.13 ***	22.03 ***	20.77 ***
Big	0.219	0.206	0.215	0.157	0.133	7.98 ***	6.59 ***	6.59 ***	4.97 ***	4.94 ***
	HML_t: h_j					t: (h_j)				
Small	-0.292	-0.313	-0.104	0.053	0.308	-6.08 ***	-6.26 ***	-2.780 ***	1.20	7.07 ***
2	-0.398	-0.247	-0.104	0.050	0.433	-9.83 ***	-6.85 ***	-2.47 **	1.29	12.56 ***
3	-0.521	-0.348	-0.101	0.055	0.462	-11.43 ***	-7.28 ***	-2.31 **	1.24	14.39 ***
4	-0.551	-0.347	-0.186	0.069	0.545	-13.94 ***	-9.77 ***	-3.84 ***	2.02 **	15.60 ***
Big	-0.619	-0.306	0.014	0.146	0.677	-18.32 ***	-8.30 ***	0.34	3.99 ***	21.25 ***
	Intercept term: a_i					t: a_i				
Small	-0.051	0.425	0.290	0.263	0.101	-0.47	3.19 ***	2.94 ***	2.53 **	0.89
2	-0.203	-0.101	0.044	-0.040	-0.100	-1.79 *	-1.09	0.45	-0.45	-1.08
3	-0.295	-0.110	-0.291	-0.275	-0.195	-2.61 ***	-1.03	-3.10 ***	-3.12 ***	-2.33 **
4	-0.348	-0.399	-0.304	-0.254	-0.220	-3.38 ***	-4.11 ***	-3.17 ***	-2.77 ***	-2.64 ***
Big	-0.255	-0.119	-0.226	-0.178	0.045	-2.75 ***	-1.16	-2.25 **	-1.87 *	0.65

*** p<0.01, ** p<0.05, * p<0.1

As shown in Table 5, the t value of the intercept term a_i is not significant in 9 of the 25 groups, 2 groups are significant at 10%, 3 groups are significant at 5%, and 11 groups are at 1%. Significantly, this shows that in addition to the three factors, there may be other factors that affect the cross-sectional differences in the returns of the Chinese A-share market.

The regression coefficients b_i of the market factors $R_{Mt} - R_{Ft}$ are all positive, and all of them are very close to 1, indicating that the changes in asset portfolio returns are consistent with the changes in market returns. Except for the combination of "small scale, 2 book-to-market ratios", all other t-values are greater than 50, all higher than the t-values of different factor coefficients; and

their P-values are all less than 0.01, which is significant at the 1% level, indicating that market factors. Obviously, it is the most crucial reason for the change of stock returns and has durable explanatory power for the excess return rate of stocks.

The regression coefficient s_j of the scale factor SMB_t is positive, and as the size of the combined company decreases, the value increases and approaches 1;The t-value of small-scale companies is between 29.02 and 43.88, while the t-value of large-scale companies is between 4.94 and 7.98, which indicates that the smaller the company size, the higher the stock returns. The relationship verifies that there is indeed a scale effect in the Chinese stock market. Besides, the t value of the regression coefficient s_j is almost all greater than the t value of the book market value factor coefficient h_j, less than the t value of the market factor coefficient bi, the P-value of each combination is less than 0.01, which is significant at the 1% level, which indicates the scale factor is a secondary factor that affects changes in stock returns. It has a significant effect on changes in the performance of asset portfolios.

Regarding the regression coefficient h_j of the book-to-market ratio factor HML_t, the values of h_j are almost all significantly negative in the three groups of combinations with a lower book-to-market cost. All of the combinations with the highest book-to-market ratio are substantially more positive and are in the book. The fourth group with higher market value is not significant enough. Besides, when the company size is the same, the regression coefficient h_j increases as the book-to-market ratio increases, and the compan's book-to-market ratio is positively correlated with the stock return rate. Besides, the P-value of the regression coefficient h_j is greater than 0.1 in the four groups, and the rest of the combinations are less than 0.05, which is significant at the 5% level. The explanation of the rate is not as good as the market factor $R_{Mt} - R_{Ft}$ and the scale factor SMB_t, but it still plays an important role.

All in all, the Fama-French three-factor model is applicable in the Chinese A-share market. To make the results more robust, this article will continue to explore the explanatory power of the model through the GRS test.

Table 6 Fama-French three-factor model GRS statistics

25 SIZE-B/M Group	GRS Statistics	A$\|a_i\|$	t-value	P-value
$R_{Mt} - R_{Ft}$、SMB_t、HML_t	-0.036	0.142	1.360	0.128

According to Table 6, the GRS statistic is -0.036, the t statistic is 1.360, and the P statistic is 0.128 greater than 0.1, which means that we cannot reject the null hypothesis that the intercept term is zero, that is, the probability that the null hypothesis is rejected, which means that the three-factor model can fully explain the excess return of all stocks in the cross-section. Comprehensive multiple regression results and GRS test results show that the factors in the model can almost explain all the performances, and the factors that determine the stock returns have few other potential factors other than the above factors.

5. Conclusion

This paper uses the Fama-French three-factor model as the basis and uses the monthly data of the Chinese A-share market from 2001 to 2019 as the research sample. Cross-sectional regression analysis and GRS test are performed. The analysis results can draw the following conclusions.

First, the Fama-French three-factor model considering the influence of company size and book-to-market ratio can fully explain the cross-sectional differences in stock returns. The market factor $R_{Mt} - R_{Ft}$ is the essential reason for changes in stock returns, and it has a reasonable explanation for the excess returns of stocks; the scale factor SMB_t is a secondary factor that affects changes in stock returns. In contrast, the book-to-market ratio factor HML_t has reduced explanatory power, indicating that the book-to-market ratio factor has a limited impact on the portfolio return rate constructed in this paper.

Second, there is a significant small-scale effect in the Chinese A-share market. The company 's size is negatively correlated with the average monthly excess return rate; that is, the average

monthly excess return rate of small-scale companies is significantly higher than the same book market value ratio. The average monthly excess return rate of large-scale stocks and the effect of scale effect on small-scale stock portfolios are also more significant. As the size of the company decreases, the volatility of its return rate increases. Any positive news may greatly increase the stock price. While large-scale companies do the opposite.

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