Analysis of Fama-French Five-Factor Model Applicability in Chinese A-Share Market

Zeyu Zhu(✉)

Department of Economics, University of Southampton, Southampton, UK
zz44u22@soton.ac.uk

Abstract. As it known that Fama and French proposed the five-factor model in 2015 and has been widely discussed by scholars and public. Being an emerging market, studying the Chinese stock market is of crucial importance, and Fama-French 5-factor model can be a very typical and effective tool for stock market analysis. To test the effectiveness of the 5-factor F&F model for the A-share market, this paper selects the 300 A-share equities from 2017 to 2021 as the data for the sample. Constructing weighted portfolio by crossing the size to B/M ratio, profitability, and investment, then analyzing the average monthly return of portfolio. Furthermore, by conducting the regression and GRS test, the results show that the 5-factor model overperforms the 3-factor model even though RMW and CMA have little influence on the A-share market. In general, the new factor profitability and investment improve the model slightly and the Fama&French 5-factor model is valid to the A-share market during 2017 to 2021.

Keywords: Factor Analysis · Fama&French 5-Factor model · Regression · A-share Market

1 Introduction

Proposed by Fama and French (2015), the 5-factor asset pricing model, as an extension of his previous 3-factor model, captures a large amount of attention in finance and the financial market. According to Fama&French, the 5-factor model intended to capture value (HML), size (SMB), profitability (RMW), and investment (CMA) in average stock excess returns overperforms the 3-factor model developed by Fama and French in 1993 [1]. After the emergence of this model, it was tested and applied by many international scholars and practitioners. Feng pointed out that the model has been extensively tested and validated in a variety of developed markets, such as the US, Europe, and Japan, but there is still debate about its applicability in emerging markets. In recent years, however, the validation and implementation of the 5-factor model has attracted attention in the Chinese market, which has become one of the world's largest stock markets [2]. This research is a continuation of previous studies based on some specific characteristics of the Chinese stock market and aims to test the effectiveness and applicability of the five-factor model.

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Academic research on multivariate models has been going on for almost 30 years, ever since Sharpe and Lintner (1965) [3] published and presented the first factorial CAPM model. Since then, many new models have been proposed that have had a significant impact on people's perception of the market. Among them, the 3-factor model (1993) and the 4-factor model (1997) [4] do a good job of explaining many market anomalies that the CAPM model cannot explain and adds multiple other systematic risk factors that cannot be explained by CAPM. In recent years, many new multi-factor models have also been introduced and built. Stambaugh-Yuan four-factor model (2013) uses two clusters that including z-score, net stock issues, composite equity issues, o-score and other seven anomaly factors that constructing two factors: management (MGMT) and performance (PERF) to explain some mispricing stocks [5]. Daniel, Hirshleifer, and Sun (2020) augment the CAPM with a funding component based on external funding (FIN) and a post-earnings announcement drift factor (PEAD) in order to quantify the commonalities in mispricing caused by psychological biases [6]. However, Huang noted that the 5-factor model introduced by Fama and French, which accounts for market, size, value, profitability and investment, could have greater explanatory power for stocks' excess return [7]. According to Han, Fama and French (2015) tested the 5-factor model for global markets and found that it is reliable and significantly improves the performance of these abnormal patterns for most of the world's regions [8].

Nonetheless, it shows a great deal of inconsistency across regions that the five factors do not have the same high explanatory power to reflect stock returns. Kodongo, for example, has made it clear that profitability and investment, both of which have remarkable effects for North Africa, Europe and Australia while showing little level of significance on average Japanese stock returns [9]. Previous studies have applied the 3-factor model to regression tests for the Chinese stock market, and Zhuo emphasized that the model's intercept terms are all not significantly, which means that the regression of the three-factor model is valid and robust [10]. However, the three-factor model has been challenged by a number of scholars as having limited ability to explain the A share in the Chinese stock market. However, the 5-factor model's effect on the Chinese market has not been widely explored. Zhang found that the excess stock return in stock market A is strongly correlated with the three characteristics of size, value and profitability [11]. Although the power of the investment has not yet been decided and it is difficult to analyze the return of the investment on the excess stock return due to certain special traits of this large emerging and highly developed stock market. Therefore, it's meaningful to apply the 5-factor model for the Chinese stock market, particularly the A-share and test its applicability, while taking into account a few other new factors that have a significant ability to explain the Chinese market.

In this context, the rest of paper will focus on the establishment of the five-factor model and the regression analysis using the latest Shang Hai Securities Composite Index SSEC data. By discussing about both overall significance level and particular factor's performance and cross-section relations between the stocks' returns and those five factors to test the effectiveness and robustness of the 5-factors model on the Chinese Stock market and search for some potential improvements for the model specifically for the Chinese stock market.

2 Methods

2.1 Data Source

As following the F&F five factor model, 300 stocks in Shanghai and Shenzhen Stock Exchanges from January 1, 2017 to December 31, 2021 including 547,500 observations are selected as the samples. These stocks are from Main Board, Small and Medium Enterprise Board (SME), Star Market (SSESM) and Second Board. All necessary data including book-to-market value ratio (B/M), market capitalization (CAP), earnings before taxes and interest (EBIT), shareholders' equity, total assets and the daily closing price are downloaded from China Asset Management Research Center. Especially, these data are pre-processed: Firstly, some stocks are discarded because those companies that were delisted during the sample period. Secondly, Data for the first six months after IPO (including listing month) are excluded. Finally, Stocks with negative book value are excluded.

2.2 Factors and Model Construction

In order to build the Fama-French model and analyze applicability, this paper will focus on the overall fit of the model and the significance level, as well as the explanatory power of each variable and the correlation between each variable, and finally the applicability of the five factor model as determined by the GRS test according to the five-factor model regression that Fama and French proposed. Table 1 provides every variable definition:

$$R_{it} - R_{Ft} = \alpha_i + \beta_1 x_{1i} + \beta_2 x_{2i} + \beta_3 x_{3i} + \beta_4 x_{4i} + \beta_5 x_{5i} + \varepsilon_{it} \quad (1)$$

The five elements of market excess return, size, value, profitability, and investment are incorporated into the model, and the current research constructs these five factors using the technique provided by Fama in the 2015 study. The first step will be to sort all stocks by median stock market capitalization, with the top 50% representing the group (S) and the bottom 50% representing the group (B). The value of B/M, profitability and investment will then be divided into three groups according to the breakpoints of 30% and 70%. By combining two indicators, market capitalization and book-to-market value, it can create a 2*3 portfolio matrix. The size- B/M matrix is shown in Table 2, Table 3, and Table 4, and all stocks can be divided into 18 combinations.

Table 1. Variables Definition

	Variables	Definition
x_{1i}	MKT	That is the market excess return
x_{2i}	SMB	portfolio returns that were simulated at time t for the market capitalization factor
x_{3i}	HML	portfolio returns that were simulated for the B/M factor at time t
x_{4i}	RMW	the variation between a portfolio with strong earnings and bad earnings
x_{5i}	CMA	The variation between the return of a portfolio with high and low investment

Table 2. The Cross-Section Matrix

Size	B/M Ratio			
		High	Middle	Row
	Small	S/B	S/M	S/L
	Big	B/H	B/M	B/L

Table 3. The Size-OP Matrix

Size	Profitability			
		Robust	Neutral	Weak
	Small	S/R	S/N	S/W
	Big	B/R	B/N	B/W

Table 4. The Size-Inv Matrix

Size	Investment			
		Aggressive	Neutral	Conservation
	Small	S/R	S/N	S/C
	Big	B/A	B/N	B/C

Table 5. Factor Calculation

Combination	Factor Construction
2 × 3 Matrix	$\mathrm{SMB}_{\mathrm{B/M}} = \frac{\mathrm{SN+SH+SL}}{3} - \frac{\mathrm{BS+BN+BL}}{3}$
	$\mathrm{SMB}_{\mathrm{Inv}} = \frac{\mathrm{SC+SN+SA}}{3} - \frac{\mathrm{BC+BN+BA}}{3}$
	$\mathrm{SMB}_{\mathrm{OP}} = \frac{\mathrm{SR+SN+SW}}{3} - \frac{\mathrm{BR+BN+BW}}{3}$
	$\mathrm{SMB} = \frac{\mathrm{SMB_{B/M}+SMB_{OP}+SMB_{Inv}}}{3}$
	$\mathrm{HML} = \frac{\mathrm{SH+BH}}{2} - \frac{\mathrm{SL+BL}}{2}$
	$CMA = \frac{SC+BA}{2} - \frac{SA+BA}{2}$
	$\mathrm{RMW} = \frac{\mathrm{SR+BR}}{2} - \frac{\mathrm{SW+BW}}{2}$

The matrices for dimension-OP and dimension-Inv are shown in Tables 3 and 4. Replicating earlier processes but using operating profitability and investment strategy in place of the book-to-market ratio, all stocks can be categorized into the following 12 groups, where the top 30% of operating profitability is low (W), the middle 40% is

Table 6. Portfolios' Return

	B/M ratio				
Size	Low	2	3	4	High
Small	1.352	1.427	1.512	1.541	1.192
2	1.761	1.122	1.113	1.104	1.095
3	1.045	1.053	1.102	1.111	1.010
4	1.311	1.207	0.883	1.075	0.894
Big	1.322	1.051	0.794	0.711	0.702

Table 7. Portfolios' Return

	Profitability				
Size	Low	2	3	4	High
Small	1.232	1.322	1.576	1.389	1.531
2	0.956	1.237	1.293	1.355	1.271
3	1.033	1.067	1.072	1.244	0.876
4	1.09	1.021	1.054	1.201	1.167
Big	0.867	0.872	0.826	0.876	1.158
	Investment				
Size	Low	2	3	4	High
Small	1.258	1.401	1.365	1.548	1.347
2	1.109	1.233	1.167	1.254	1.388
3	1.102	0.984	1.103	1.036	1.058
4	1.114	1.146	1.117	1.027	1.143
Big	0.786	0.856	1.002	0.992	1.015

Table 8. Summary Statistics

	Mean	SD	Min	P50	Max
x_1	0.781	7.803	−26.835	0.959	29.604
x_2	0.204	3.654	−16.603	0.298	14.981
x_3	−0.384	4.513	−28.874	−0.381	18.296
x_4	0.079	3.333	−15.273	0.075	13.570
x_5	−0.068	2.474	−10.576	−0.142	8.615

Table 9. Correlation Matrix

	x_1	x_2	x_3	x_4	x_5
x_1					
x_2	0.083^{***}	1.000			
x_3	−0.121	-0.189^{***}	1.000		
x_4	-0.422^{***}	-0.651^{***}	−0.065	1.000	
x_5	−0.107	0.106^{*}	0.529^{***}	-0.615^{***}	1.000

Note: a. * < 0.1, ** < 0.05, *** < 0.01 are the 10%, 5% and 1% Significant Level respectively.
b. data in Table 7 are percentages.

Table 10. Regression Test

	B/M Ratio									
Size	Low	2	3	4	High	Low	2	3	4	High
	α					t				
Low	0.293	0.296**	0.425***	0.352***	0.182	1.615	2.397	3.465	3.302	1.384
2	0.484**	0.076	0.101	0.132	0.225**	2.151	0.594	0.847	1.162	2.150
3	0.125	0.082	0.079	0.141	0.195	0.986	0.633	0.545	1.116	1.431
4	0.191	0.107	0.097	0.204	0.162	1.203	0.747	0.616	1.420	1.189
High	0.326**	0.134	0.032	0.031	0.222*	2.317	0.770	0.205	0.206	1.692
	β (MKT)					t				
Low	10***	1.035***	1.041***	1.011***	1.032***	27.955	46.799	57.03	57.01	53.62
2	1.083***	0.983***	0.980***	1.039***	1.057***	29.550	43.456	60.05	54.55	54.75
3	0.990***	1.025***	1.034***	1.078***	1.056***	41.617	46.332	44.83	54.12	58.00
4	0.988***	1.075***	1.036***	1.078***	1.035***	36.198	35.836	30.76	45.80	58.18
High	0.983***	1.093***	0.987***	0.991***	0.960***	50.122	31.951	45.11	42.33	40.02
	β (SMB)					t				
Low	0.934***	1.015***	1.040***	1.109***	0.978***	17.169	23.851	22.27	25.60	20.14
2	0.826***	0.951***	0.973***	0.943***	0.793***	14.544	18.049	18.70	23.30	23.16
3	0.645***	0.805***	0.783***	0.756***	0.598***	11.635	12.901	13.01	13.95	12.44
4	0.364***	0.464***	0.601***	0.525***	0.298***	6.806	7.517	11.41	9.799	6.059
High	0.323***	0.193**	0.144***	0.198***	0.337***	5.927	2.483	2.725	3.002	6.664

neutral (N) and the bottom 30% is robust (R). 1 We also consider the following three groups. In addition, it can classify stocks into three groups. The group (C), the middle group (N), and the group (A) make up the first 30% of the portfolio, and average returns weighted by market value in each period are calculated for each portfolio. Table 5 shows the detailed calculation for each factor.

Table 11. Regression Test

	β (SMB)					t				
Low	0.934***	1.015***	1.040***	1.109***	0.978***	17.169	23.851	22.27	25.60	20.14
2	0.826***	0.951***	0.973***	0.943***	0.793***	14.544	18.049	18.70	23.30	23.16
3	0.645***	0.805***	0.783***	0.756***	0.598***	11.635	12.901	13.01	13.95	12.44
4	0.364***	0.464***	0.601***	0.525***	0.298***	6.806	7.517	11.41	9.799	6.059
High	0.323***	0.193**	0.144***	0.198***	0.337***	5.927	2.483	2.725	3.002	6.664
	β (HML)					t				
Low	0.560***	0.379***	0.214***	0.014	0.192***	8.912	8.686	5.038	0.344	5.357
2	0.704***	0.393***	0.176***	0.038	0.282***	11.403	7.677	3.369	1.052	9.363
3	0.757***	0.462***	0.194***	0.054	0.305***	13.640	6.755	4.295	1.137	5.998
4	0.885***	0.456***	0.141***	0.180***	0.327***	15.149	10.680	2.623	3.576	6.700
High	0.855***	0.30***	0.038	0.134*	0.531***	18.713	5.748	0.696	1.812	9.497
	β (RMW)					t				
Low	0.126	0.221**	0.168**	0.248***	0.152**	1.373	2.400	2.190	3.752	2.101
2	0.037	0.233**	0.079	0.208***	0.207***	0.135	2.498	0.971	2.672	3.331
3	0.117	0.240**	0.279***	0.201**	0.208**	1.099	1.973	3.214	2.097	2.492
4	0.240*	0.223**	0.218**	0.213***	0.091	1.910	2.000	2.332	2.638	1.179
High	0.083	0.147	0.063	0.098	0.071	0.770	1.398	0.698	1.046	0.688
	β (CMA)					t				
Low	0.398***	0.439***	0.318***	0.255***	0.259***	2.857	5.490	3.882	3.231	4.024
2	0.007	0.198**	0.230**	0.263***	0.168**	0.022	2.028	2.384	3.213	2.493
3	0.346***	0.099	0.272***	0.034	0.196***	3.699	1.130	2.937	0.471	2.941
4	0.239**	0.152	0.099	0.103	0.206***	2.145	1.404	0.806	1.259	2.710
High	0.084	0.133	0.086	0.054	0.031	1.097	1.191	0.943	0.471	0.286

$^{*} < 0.1$, $^{**} < 0.05$, $^{***} < 0.01$ are the 10%, 5% and 1% Significant Level respectively.

Table 12. GRS Test Results

25 Size-BM Combination	GRS	$A\|\alpha_i\|$
x_2x_3	1.298	0.907
x_4x_5	1.365	1.145
$x_1x_2x_3$	1.561**	0.193

Table 13. GRS Test Results

25 Size-OP Combination	GRS	A$\|\alpha_i\|$
x_2x_3	1.541*	0.916
$x_{4i}x_5$	2.991***	1.153
$x_1x_2x_{3i}$	1.958***	0.188
$x_{1i}x_2x_{3i}x_4x_5$	1.331***	0.186
25 Size-Inv Combination	GRS	A$\|\alpha_i\|$
x_2x_3	1.283	0.920
x_4x_5	1.372	1.150
$x_1x_2x_3$	1.574**	0.186
$x_1x_2x_3x_4x_5$	1.505**	0.190

3 Results and Discussion

3.1 Qualitative Analysis of Factors Return

In the previous paper, the cross-section method that calculating the weighted monthly stocks' return is introduced. In this paper, all stocks are sorted firstly into 5 groups, which is from small to big, then on the basis of the B/M ratio, profitability and investment patterns respectively, these stocks are again divided into five groups from small to big, weak to robust and conservation to aggressive, which forming three 5 × 5 matrices with 75 portfolios. The next step, each portfolio's monthly average return would be calculated. Table 6 and 7 shows the average monthly return of all portfolios constituting in the above method.

First, Table 7 represents that the size factor has a significant impact on the A-share market, with the large-cap portfolio's excess return being lower than the small-cap portfolio's excess return in each region. These results also show that small and mid-cap companies have a significant impact on stock prices in both the 3-factor and 5-factor models. Second, as shown in Table 8, market capitalization has a positive effect on the Chinese A-share market: a higher B/M ratio leads to higher excess returns than a lower B/M ratio in the same size category. However, based on the fourth and fifth columns, which show a clear opposite trend and a significant bias, we can conclude that the indifference. In addition, these results demonstrate that the SMB has a major effect on stock value in both the 3-factor model and the 5-factor modulated that it is not always the higher value of B/M that is better. Zhang and Yao (2021) also find this result in their article. For most of the remaining portfolios, however, there is a positive correlation between the B/M ratio and portfolio performance. Third, although there is no significant positive correlation between average monthly returns and return/investment ratios for the OP and INV size ratio portfolios, it is generally the case in the investment model that holding stocks of the most stable and profitable firms will yield higher returns than those of less profitable firms. This is the case in the investment model. Subsequently,

the Table 8 and Table 9 report the summary statistics of five factors formed in Table 3 and their correlation.

Table 8 provides the mean, standard deviation, lowest, median, and maximum values for each component. The mean monthly portfolio excess return of Mkt is 0.78%, indicating that the market return slightly exceeds the risk-free rate and indicating that the A-share market experiences an upward trend from 2017 to 2021, while the standard deviation is the highest and reaches 7.8%, indicating that the market is not stable during this period.

For size and market capitalization factors, the mean of the monthly excess return is 2% and minus 3.8%, and the size effect and value effect describe that smaller and have net worth firms can create greater returns than the bigger and have low book-to-market ratio firms. Obviously, the CMA factor's mean value of monthly return is −0.068%, which reflects a reversal trend in China A-share market compared with American Stock market, and it demonstrates that the investment has a negative on A-share market return.

Table 9 displays the correlation between each factor. In sum, the size factor is negative correlated to the value and profitability factor and positive related to the investment. It seems rational and reasonable because those firms with small size usually have low market capitalization and weak profitability power, but they are very attractive to investors. However, there are many factors whose correlation is anomalous and very large, for example, HML has a positive correlation with the RMW and significantly negative correlation with CMA, which is contrary to the usual high net worth companies that are more profitable and prefer to make aggressive investments. Moreover, it reports that the value of correlation between SMB and RMW, CMA and RMW is relatively high. Therefore, the profitability factor needs to be orthogonalized before the regression test.

3.2 Regression Test and Analysis

To further evaluate the applicability of the 5-factor model in the A-share Stock market, and test each factor's significance, in this paper, STATA17 is used for regression analysis on the stock's excess return. Due to the paper spaces, this paper concentrates on the analysis of the regression on Size-B/M weighted portfolio's rate of return. Table 10 and Table 11 report the coefficients regressed for each combination of each factor and the t statistics.

Depending on the dataset, the intercept term, alpha, is barely significant from zero, meaning that the F&F5 model cannot completely explain the excess return on the portfolio, especially for these large companies. The beta on both the market factor and the value factor are almost positive and statistically significant. Although beta (x_4) and beta (x_5) do not have the same meaning as the first two factors. Overall, the five-factor model has some explanatory power, but profitability and investment both have a relatively small impact on the market for Chinese A stocks. On the other hand, for different coefficients in different portfolios, most of the different beta values for the smaller portfolios are more significant than those for the larger portfolios, these results imply that smaller firms have a larger impact on the A stock market than do larger firms. The main reason for this result is that the Chinese A stock market has a severe price reversal effect and information asymmetry. Moreover, retail investors are the main investors in the A-share

market, and most are only interested in short-term information rather than making the right judgment of those companies.

In addition, it is reasonable that x_4 and x_5 are not as important and influential in the A-share Market compared to the American Stock market. Because Chinese retail investors care only about the change in the price of their shares so that they will easily follow the trend but neglect the profitability and investment value of the firm. Compared to the 3-factors model, however, the 5-factors model has some improvement in excess stock returns for the A-share market.

3.3 GRS Test

The GRS test is an academic method for evaluating asset pricing models by determining whether all components of the intercept are equal to zero. Under the assumption that the asset pricing model is able to fully explain the portfolio excess returns in the horizontal cross-section, the joint test of the overall regression intercept shows that the model performs well if the initial assumption of joint equality with zero cannot be rejected. In contrast, the GRS t-statistic follows the F distribution. Table 12 and Table 13 show the results of the GRS tests for the 3-factor model, the 5-factor model, the combination of profitability and investment and the combination of size and value.

From Table 12 and Table 13, The GRS statistics for the 5-factor model are smaller than those for the 3-factor model, and the model containing only the value and size factors has lower GRS statistics than the model with the cost-effectiveness and investment factors, indicating that the 5-factor model has better explanatory power than the 3-factor model in the A-share market, and factors related to size and value have better explanatory power than those related to profitability and investment.

4 Conclusion

The purpose of this paper is to examine the resilience and application of the F&F five factor model to the Chinese A-share market. The purpose of this study is to examine the returns of each 25*3 portfolio, the correlation between each component, the construction of a regression model, and the GRS test in order to determine the significance level of each factor as well as the applicability of the 5-factor model for the A share market. Finally, both the size and value factors have high explanatory power in the 5-factor model, with the size factor having a large effect on the average stock market return on A. This contrasts with Fama & French, who think that the value factor is redundant to the model, our empirical findings suggest that the CMA of investment and the profitability factor should be redundant. In regression analysis, the beta of CMA and RMW factor is not as significant as the other four factor and in GRS test, the performance of the combination of RMW and CMA is not as effect as the size and value factor. The probable reason is that most Chinese investors pay more attention to the price of the stocks and most of them believe that big-size firms with high net worth can usually bring more required return for them. However, selecting data from different time periods may also cause the problem that the significant of model varies with time. Therefore, the effectiveness of model should be determined also by the context and policy of China over time. Overall,

the profitability and investment factor slightly improve the model performance compared with three-factor model.

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