

Analysis of Chinese stock market based on Fama-French five-factor model

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Abstract. After almost 25 years of expansion since its founding in late 1990, our stock market has expanded to rank second in the world in terms of market capitalisation. However, the stock market's speculative nature, information asymmetry, and extreme volatility can frequently raise serious concerns. The Fama-French five-factor (FF) model is used in this study to determine the variables affecting stock returns. and compares it to the three-factor model to see which model has a stronger ability to explain stock returns in the A-share market in the People's Republic of China from the standpoint of asset pricing. The monthly data of A-share listed businesses for a total of 264 months between January 2000 and December 2021 are chosen as the sample in this article. Five factors are built using these data. Additionally, descriptive statistics and correlation analysis are carried out for the Chinese A-share market's five-factor model. The returns of the first four variables for regression are used to explain the returns of the fifth component in a five-factor model redundancy test. Finally, the three-factor intercept model and the five-factor intercept model are then obtained by doing a linear regression on the five-factor model. The results of the empirical test allow for the following inferences: All five factors are significant and have more explanatory power than the three factors since the CMA factor is redundant in the five-factor intercept model and is replaced by CMAO. Significant variables in the three-factor intercept model include MKT, SMB and HML.

Keywords: Fama-French five-factor model; Correlation analysis; A share market; asset pricing.

1. Introduction

The Shanghai Stock Exchange and the Shenzhen Stock Exchange were founded in the early 1990s [1]. More than 2,800 companies are currently listed on the stock market of the People's Republic of China, including the main boards in Shanghai and Shenzhen [2].

The SME board, and the GEM board, after 25 years of expansion. Japan was overtaken by A shares in terms of overall market capitalization, placing it second on the stock market. Despite the remarkable progress, it is important to remember that China's securities market is still far from ideal in many respects and lags behind that of industrialized nations.

Currently, China's securities market has been restricted to the stock market, small bond market, and the derivative market such as options and futures market has few tradable varieties and unreasonable variety structure. It makes it challenging for it to fulfill its normal function as pricing in the market. and is unfavorable to foster eligible investors. Moreover, the market is driven by casual investors, with a strong speculative atmosphere, focusing on internal details and disregarding the fundamental risks of companies. This has led to inefficient markets and an urgency to bring in a large number of institutional investors. Another is the problem of fraud and unsymmetrical information. There is often the phenomenon of listed firms taking advantage of their own information and disclosing false financial information with accounting firms to make profits, which severely harms the interests of other investors. The final point is that the relevant laws and regulations should be refined, with insufficient supervision and inefficient law enforcement. Obviously, both the Chinese capital market and investors remain under-developed, which is directly reflected in the fact that every shock in the capital market affects investors in a profound way.

From the point of view of the stock market regulator, a market with great fluctuations and risks will only encourage speculation among investors, which is unfavourable to the sound working of the stock market with respect to investment and financing. For investors, the aim of investing in the stock market is to retain value and generate income. For most investors, the intention to preserve value is

stronger than the intention to increase value, and volatilities of the stock market are not conducive to the realization of their asset preservation function. It can be seen that both regulators and investors cannot get rid of risks when considering returns, like a double-edged sword, benefits and risks have always coexisted. Research on the relationship between risk and return can, for one thing, be of positive significance to investors in controlling risk, identify new investment opportunities and have positive implications for the pricing of financial products. For another, it can improve the efficiency of capital markets and the capacity to allocate resources. In general, the relevant research is of great significance to regulators and investors.

Currently, both scholars and practitioners have conducted a lot of observation and research on these phenomena and problems, expecting to have a sound appreciation of the rules of how capital markets work and identify the elements behind the excess earnings of stocks. Meanwhile, it has important theoretical and practical meanings for improving the operation function of China securities market and enhance the investment and financing function of the market.

The FF 5 factor model has been validated and accepted by most people in the U.S. stock market and other major stock markets worldwide. The five-factor model is now widely applied in return forecasting, risk management and fund performance assessment. However, it remains to be studied if FF model works for the U.S. equity market also works for the Chinese equity market and bond market. According to the aforementioned analysis, the research significance of this study is as follows:

1. As a frontier model of asset pricing, the validation of the FF 5 factor model for the People's Republic of China's A-share market aids China in deepening and broadening its financial pricing research, and it is a crucial fundamental work for the advancement and development of asset pricing theory in China by absorbing and learning from the advanced research experiences abroad.

2. In the process of validating the FF 5 factor model, the impact of firm characteristics and the risk premium of fundamentals on stock returns is explored, as well as the factors influencing stock prices in China are studied. This research offers empirical references and opinions for investors to help them develop sound investment strategies and improve their investment philosophies.

This paper investigates the correlation between idiosyncratic risk and stock returns based on the FF 5 factor model for exploration, which is conducive to understanding the volatility of different levels of macro, industry and company and the cyclical conditions they are in. The stock market is a barometer of the national economy, and idiosyncratic volatility is an indicator of individual stock idiosyncratic risk in asset pricing models. Its magnitude and relationship to stock returns reflect not only speculation in the stock market, but also the degree of differentiation of different companies in the economy and the ability of the market to outperform. It also reflects the transparency of information in the stock market and the effectiveness of it and the research of its relationship with expected stock returns complements and validates the capital asset pricing model.

The research ideas are presented below. Firstly, this study reviews the relevant theories for a comprehensive understanding of the model foundation of this study, we focus on the link between risk and return, with particular attention to the multi-factor pricing model: then we introduce the progress of the original factor-based model in testing and improving the Chinese securities market to appreciate its uniqueness. Then, the sample selection and data sources in this study are introduced; and the brief derivation and analysis process of the FF model has been provided as the groundwork for the empirical test analysis. Next, the effects of size, value, profit and investment in China's A-share market are empirically examined to obtain an intuitive understanding of the phenomenon under study; the factors being studied are defined, constructed and calculated as regressors in the succeeding regression test; and generalized statistics on the magnitude of the factors are conducted to obtain quantitative analysis results of the factors themselves. Finally, the excess returns of benchmark portfolios under different construction methods are regressed using the previously calculated factors to get the regression intercept terms to assess the suitability of the FF model in the A-share market of the People's Republic of China, and regression coefficients of each factor to assess significance of the factor effects. Finally, the conclusions of this paper are given.

The research of this paper consists of five main parts as follows. Section 1 is introduction, outlining the background and meanings of this research, the research idea and research organization. Section 2 is the methodology, which gives a simple derivation and analysis process of FF model, with the subsequent a description of the sample selection and data sources in the empirical study. Section 3 presents the results, with further regression tests of the market, size, value, profit, and investment factor on the excess return of the benchmark portfolio include correlation analysis and descriptive statistics of the FF model's variables [3]. Section 4 concludes with a summary of all and the implications of the study and the outlook for the future.

2. Method

2.1 Fama-French five-factor pricing model

2.1.1 Model derivation

Fama and French (2015) added two new variables to the FF asset pricing model, taking into account how profitability and investment propensity affect the anticipated return of an equity portfolio [4]. The theory is based on the discounted dividend model, in which a stock's market value is represented as the discounted value of the projected dividend for each share.

$$m_t = \sum_{\tau=1}^{\infty} E(d_{t+\tau}) / (1+r)^\tau \quad (1)$$

In equation (1), M_t stands for the stock price at time t, $E(d_{t+\tau})$ for the expected dividend per share at time $t + \tau$, and so on. And r, also known as the internal rate of return on expected dividends, is the anticipated long-term average return on equity. Equation demonstrates that if the projected dividend per share for two stocks is the same over time t. Long-term average returns will be higher for the stock with the lower price. Provided a certain level of efficiency in the stock market, it necessarily implies that the lower priced stock has a higher risk of future dividends.

The correlation between expected return, expected profit, and expected investment is obtained by splitting the expected dividend per share in equation (1). On the basis of equation (1), Miller and Modigliani proposed in 1961. Suppose the following equation represents the market value of all shares of enterprises at time t:

$$M_t = \sum_{\tau=1}^{\infty} E(Y_{t+\tau} - dB_{t+\tau}) / (1+r)^\tau \quad (2)$$

Using equation (2) and dividing by the owner's equity in period t, we get the following equation: $Y_{t+\tau}$ is the total equity income for period $t + \tau$ in equation(2), and $dB_{t+\tau}$ is the increase in owner equity from period $t + \tau - 1$ to period $t + \tau$. We obtain the following equation by dividing equation(2) by the owner's equity in period t:

$$\frac{M_t}{B_t} = \frac{\sum_{\tau=1}^{\infty} E(Y_{t+\tau} - dB_{t+\tau}) / (1+r)^\tau}{B_t} \quad (3)$$

From equation (3), several cognitive points can be obtained about the stock expected return r:

If all of the variables in equation (3) are fixed, with the exception of the stock's current price and projected return (r), the average return will be larger the lower the price or the higher the book-to-market ratio.

1. The risk-free rate is adopted from the RMB three-month lump sum deposit rate published by the People's Bank of China. The projected return on a stock increases in direct proportion to profit.

2. Fixing the incremental owner's equity in equation (3), i.e., the higher the investment and the stock expected return r , the higher the investment the lower the stock expected return r .

3. From (3) equation can be seen that stock expected return r is associated with book value ratio and prospective profits and investment.

From equation (1), it is clear that the return on a stock depends on the immediate price of the stock and the forthcoming earnings stream, and future earnings stream is split into future earnings and investment, we can obtain that the stock's return r is related to expected profits and expected investment.

2.1.2 Model analysis

The FF 5 factor model looks at the relationship between book-to-market ratio, profit, and price in relation to the average return of the security or portfolio (measured as the price multiplied by the number of shares). Table 1 shows the definition of variables.

$$R_{it} - R_{Ft} = a_i + b_i(R_{Mt} - R_{Ft}) + s_iSMB_t + h_iHML_t + r_iRMW_t + c_iCMA_t + e_{it} \quad (4)$$

Table 1. variable explanation

R_{it}	the portfolio i return for period t .
R_{Ft}	the risk-free rate
R_{Mt}	market capitalization-weighted average market portfolio return
$R_{Mt} - R_{Ft}$	the market risk premium
SMB_t	the market capitalization factor, which is the difference between the return of a small-cap and large-cap portfolio
HML_t	book-to-market ratio factor, which is the difference between the return of a high book-to-market ratio and a low book-to-market ratio portfolio
RMW_t	the profitability factor, the difference between the return of a portfolio of stocks with high operating margins and low operating margin
CMA_t	the investment style factor, the difference between the return of a portfolio with a conservative investment style and a portfolio with an aggressive investment style.

2.2 Data sources and sample selection

The database used in this study is the financial database offered by Beijing Quantum State Technology Co., Ltd., which combines official exchange data with reliable public information on listed firms to create the Quantum State financial database. Only A-share stocks are chosen for the stock sample in this article because domestic institutions, organizations, and people in China typically engage in A-share trading. Chinese stock market early stocks are few, unstable, and poorly indicative of information (Tian, Lihui et al., 2014), hence the majority of local researchers doing similar studies have opted to ignore the early data. The grouping approach of factors in Fama and French (2015a) cannot be completed with data on the Chinese stock market prior to 1994, hence this study chooses A-share listed businesses from January 2000 to December 2021, which covers 264 months of monthly data [4,5]. While the monthly individual stock returns in this paper use the monthly returns from the database taking into account the reinvestment of cash dividends, and the monthly individual stock returns are taken from the database taking into account the monthly returns of cash dividend reinvestment, the risk-free rate is taken from the RMB three-month lump sum deposit rate released by the People's Bank of China [6,7].

2.3 Factor construction

2.3.1 Market Factor

The market factor is computed as the market return subtracted from the risk-free return, while the market return is computed as a market capitalization weighted average, and the market return is calculated by using the SSE index instead.

2.3.2 Size factor

In this paper, the size and BM, profit or investment are grouped and divided in a 2*3 way different grouping points are obtained for all A-share stocks on the SHSE first [8], and then these grouping points are used to group and divide all stocks, including all stocks on the SZSE. Size factor: SSE median, BM: SSE 30th and 70th percentile, profit factor: SSE 30th and 70th percentile, and investment factor SSE 30th and 70th percentile. The five-factor model will yield a size factor under the size-to-book market capitalization ratio combination, a size factor under the size-to-profit combination, and a size factor under the size-to-investment combination because of the crossover of size with BM, profit, and investment, respectively. FF model uses the means of three types of factors as size factor.

2.3.3 Value Factor, Profit Factor, and Investment Factor

Among the six sets of size-to-book market value ratio portfolios, the mean values of the average returns of the small and large size-to-high book value ratio portfolios are first found, and the mean values of the small and large size-to-low book value ratio portfolio. The difference between the two mean values is value factor. Both profit and investment factors were computed using the same method for the size-profit portfolio and the size-investment portfolio.

3. Results

In order to more thoroughly assess the five-factor model's applicability, this article looks at monthly data for the Chinese A-share market from January 2000 to December 2021. Only the results based on monthly data are shown due to space restrictions, although the primary conclusions of this study hold true when testing is conducted using daily data. The results of the five-factor model in the A-share market are reported in the section that follows, along with a comparison of its performance to that of other models.

3.1 Descriptive statistics

In fact, the mean values of factor returns are only preliminary descriptive statistics and are not sufficient to judge profitability and investment style effects as insignificant in the Chinese stock market on this basis [9]. This study performs descriptive statistics based on monthly data of the returns of each factor listed in China and find that in a sample size of 264, the mean values of MKT is 0.781, SMB is 0.398, HML is 0.225, RMW is 0.188, and CMA is -0.046, indicating that the mean values of each factor under the full sample of the overall mean stock market, except for CMA are significantly greater than 0 (table 2).

Table 2. Descriptive statistic

	count	mean	sd	min	p50	max
MKT	264	0.781	7.803	-26.835	0.957	29.604
SMB	264	0.398	3.672	-16.361	0.495	17.665
HML	264	0.225	3.798	-18.286	-0.037	18.272
RMW	264	0.188	3.179	-13.162	0.211	15.321
CMA	264	-0.046	2.169	-6.300	-0.181	7.994

3.2 Correlation analysis

From the above correlation analysis of MKT, SMB, HML, RMW and CMA, it can be seen that MKT and SMB have a correlation value of 0.182, significant at 1% level, with HML at -0.038, while RMW has a negative correlation with RMW at -0.363, significant at 1% level, MKT has a correlation with CMA at 0.026. SMB and HML have a value was -0.401, significant at 1% level, RMW was negatively correlated with SMB's at -0.611 significant at -0.611, specifically significant at 1%, CMA and SMB's value was positively significant at 0.154, specifically significant at 5% value. rMW and CMA were significant at -0.579, significant at 1% (table 3).

Table 3. Correlation analysis

	MKT	SMB	HML	RMW	CMA
MKT	1.000				
SMB	0.182***	1.000			
HML	-0.038	-0.401***	1.000		
RMW	-0.363***	-0.611***	-0.045	1.000	
CMA	0.026	0.154**	0.481***	-0.579***	1.000

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

3.3 Five-factor model redundancy test

After accounting for the risk of the other four components, the factor's risk premium is represented by the regression intercept term. The CMA factor is a "redundant" factor in the five-factor model for explaining stock portfolio returns, which is consistent with the findings of Guo et al. The regression intercept of the CMA factor on the other four factors does not contradict the original premise that the intercept term is zero (2017). Although the research does not examine this further, we hypothesize that this conclusion may have been impacted by the early sample of the Chinese stock market, where the "same up, same down" phenomena is significant, market risk predominates, and the CAPM has a great capacity for explanatory power. Therefore the early sample's CMA factor is "redundant." The "redundancy" in the early sample is easily understood. The A-share market, which differs from mature foreign capital markets, has unique characteristics of "equity separation" in its early stages. Since this market's data structure is likely to change before and after the equity separation reform, the factors' applicability may also change significantly (table 4).

Table 4. A-share market style effect test and redundancy test

	(1) MKT	(2) SMB	(3) HML	(4) RMW	(5) CMA
MKT		-0.037 (-1.522)	0.014 (0.436)	-0.106*** (-5.863)	-0.052*** (-3.228)
SMB	-0.309 (-1.505)		-0.528*** (-6.527)	-0.430*** (-8.070)	-0.022 (-0.510)
HML	0.087 (0.429)	-0.403*** (-7.001)		-0.017 (-0.323)	0.246*** (6.804)
RMW	-1.601*** (-5.907)	-0.786*** (-9.990)	-0.041 (-0.321)		-0.443*** (-8.574)
CMA	-1.258*** (-3.168)	-0.063 (-0.518)	0.944*** (7.339)	-0.712*** (-9.727)	
_cons	1.128** (2.333)	0.663*** (4.375)	0.475*** (2.936)	0.414*** (3.459)	0.032 (0.335)
<i>N</i>	264	264	264	264	264
adj. R^2	0.187	0.556	0.456	0.676	0.566

3.4 Linear regression results for the five-factor model

3.4.1 Panel I: Three-factor intercept model

From the above three-factor intercept model, it is seen that within the 25 grouping, the two-, three-, and four-factor of group 1 constants are significant, and the values of MKT are significant on 1% for each factor value, and the rest of the data are seen to be significant on 1% for the data models of SMB and HML (table 5).

Table 5. Three-factor model analysis

ME _{gr} oup5	t_cons	p_cons	star_ cons	t_MKT	p_M KT	star_ MKT	t_SMB	p_SMB	star_S MB	t_HML	p_HM L	star_H ML
1	0.0339	0.9729		37.10030		***	15.92910		***	-2.9779	0.0032	***
1	2.3088	0.0218	**	43.46060		***	18.93870		***	-4.1727	0.0000	***
1	2.9284	0.0037	***	64.59470		***	26.74210		***	-3.5699	0.0004	***
1	2.5705	0.0107	**	49.46610		***	22.46510		***	-1.0145	0.3113	
1	-0.2246	0.8225		37.19960		***	15.76370		***	3.2924	0.0011	***
2	-2.4595	0.0146	**	30.75930		***	17.35020		***	-6.7334	0.0000	***
2	0.3947	0.6934		52.00440		***	17.20790		***	-4.3611	0.0000	***
2	1.9368	0.0539	*	49.12410		***	13.9611	3.37E-33	***	-2.2539	0.0251	**
2	0.6773	0.4988		55.37050		***	25.09260		***	1.8025	0.0727	*
2	-0.0565	0.9550		66.50460		***	21.32550		***	7.7689	0.0000	***
3	-2.4862	0.0136	**	50.12390		***	13.2149	1.21E-30	***	-9.4752	0.0000	***
3	-0.5640	0.5733		52.31360		***	14.8775	2.34E-36	***	-5.8035	0.0000	***
3	-0.7662	0.4443		56.15590		***	13.5110	1.18E-31	***	-2.1728	0.0307	**
3	-0.5379	0.5911		56.21060		***	16.15050		***	0.8311	0.4067	
3	0.0961	0.9235		56.51600		***	13.3539	4.05E-31	***	8.0969	0.0000	***
4	-0.5370	0.5917		36.91780		***	8.1526	1.68E-14	***	-12.9952	0.0000	***
4	-0.3342	0.7385		49.21930		***	9.2087	1.33E-17	***	-4.8553	0.0000	***
4	-0.2506	0.8024		43.20860		***	10.3052	5.22E-21	***	-1.2398	0.2162	
4	0.3219	0.7478		54.29490		***	10.4968	1.28E-21	***	3.5593	0.0004	***
4	-0.8311	0.4067		51.37830		***	8.3351	5.05E-15	***	10.1299	0.0000	***
5	2.1240	0.0346	**	53.96050		***	-6.9984	2.33E-11	***	-16.8000	0.0000	***
5	0.0119	0.9905		52.82290		***	-4.3470	2E-05	***	-6.7403	0.0000	***
5	-0.4185	0.6759		41.60230		***	-0.3300	0.741676		1.1579	0.2480	
5	-0.3719	0.7103		40.90740		***	-1.4763	0.141105		5.2528	0.0000	***
5	-0.0728	0.9420		36.71030		***	-6.5276	3.65E-10	***	9.1643	0.0000	***

3.4.2 Panel II: Five-factor intercept model

This paper uses the 2×3 grouping method to construct the factors in the regressions. Due to the limitation of space, as Table 6 finds that the A-share market is "redundant" in terms of the CMA factors from the three factors, we will focus here on the regression results of the 25 Size-Inv dependent variable stock portfolios, and focus on the regression coefficients of the investment style factors. A detailed comparison of the performance of the intercept terms for each model will be presented in the next section. For the five-factor model regressions, we strictly follow the treatment of "redundant factors" in Fama and French (2015a) and construct the orthogonalized investment style factor CMAO instead of the CMA factor [4]; as explained in that paper, when the CMA factor is replaced by CMAO for the regression, the regression intercept As explained in the paper, the regression intercept term, residuals, and risk loading coefficients of the investment style factor are unchanged when the CMAO is used in place of the CMA factor for regression, and therefore the conclusions in the later section are not affected when the results of the model regression intercept term are evaluated. Since the table finds no significant risk premium for the momentum factor after adjustment for the three-factor model, its inclusion does not significantly improve model performance.

Table 6. Five-factor model analysis

	model1	model2	model3	model4	model5
t_MKT	29.98981	47.53925	52.45057	50.06136	55.90279
p_MKT	0	0	0	0	0
star_MKT	***	***	***	***	***
t_SMB	16.33337	19.19658	26.25189	23.34081	20.23434
p_SMB	0	0	0	0	0
star_SMB	***	***	***	***	***
t_HML	-6.27295	-5.85897	-3.492	0.950652	4.48782
p_HML	1.44E-09	1.38E-08	0.000562	0.34265	1.08E-05
star_HML	***	***	***		***
t_RMWO	0.027664	-0.73533	-1.30792	-2.17531	-2.16622
p_RMWO	0.977951	0.462794	0.192039	0.030494	0.031189
star_RMWO				**	**
t_CMA	1.660725	4.293304	3.136552	1.281018	2.832268
p_CMA	0.097956	2.47E-05	0.001903	0.201312	0.004978
star_CMA	*	***	***		***

4. Conclusion

Monthly data of A-share listed businesses are used as the sample in this article for a total of 264 months, from January 2000 to December 2021. The Renminbi three-month lump sum deposit rate announced by the People's Bank of China serves as the basis for the risk-free rate., while the monthly individual stock returns are adopted from the database considering the monthly returns of cash dividend reinvestment [10]. The applicability of the 5 factor model in the Chinese stock market is tested according to the FF (2015a) method [4].

This paper shows that: First, the size impact and book-to-market ratio effect are substantial. There are still large profitability and investment style effects in the A-share market throughout the entire sample, but there are no notable momentum or reversal effects. Second, the 5 factor model's explanatory ability is extremely strong, which is in line with the findings of worldwide market tests. Second, the 5 factor model has far stronger explanatory power than the 3 factor model, which is in line with the findings of worldwide market tests. Third, in line with the findings of Guo et al., the CMA component is a "redundant" element for explaining stock portfolio returns (2017).[11] It is possible that the early sample of the Chinese stock market, where the serious "same up, same down" phenomenon and market risk predominate, influenced this conclusion. Since the CAPM has a great

explanatory power, it is simple to identify the "redundancy" of the CMA component in the early sample. The CMA variables can be simply interpreted as "redundant" in the early sample and the CAPM has a good capacity for explanation. The A-share market, which differs from mature foreign capital markets, has unique characteristics known as "equity separation" in its early stages. As a result, its data structure is likely to change both before and after the equity separation reform, and the factors' applicability may also change significantly. We examine the 5 factor model's applicability to the A-share market of the People's Republic of China over a 21-year period, enhancing the empirical data pertinent to the scholarly debate on the model's viability. This has important implications for understanding the Chinese market, providing a regulatory basis, and aiding investment practice.

There is still room to increase the depth and breadth of the paper research, and the subsequent research work can primarily be in-depth from the following aspects: This paper is constrained by the scope of the chosen topic, the authors' cognitive limitations, the availability of data, and other restrictions. The FF 5 factor model can be further enhanced and new factors can be created when combined with the current state of the Chinese market. In addition, also can verify the reversal effect and inertia effect that exist in China's market.

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