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A Study of Stock Returns in China's A-share Market Based on the Fama-French Three-factor Model

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Abstract: In recent years, the world's financial boom, all kinds of financial products are emerging, how to rationalize the pricing of financial assets, is a new test of asset pricing theory. The capital asset pricing model of the 1970s, although set up rigorously, many studies have shown that it is unable to fully explain the stock returns. In view of this, academics began to explore other variables affecting stock returns and gradually focused on multifactor models. In this regard, the Fama-French three-factor model stands out. In addition to focusing on the impact of the market premium factor on stock returns, it also simultaneously takes into account that the market capitalization factor and the book-to-market ratio factor also have a significant impact on stock returns. Although the explanatory power of the Fama-French three-factor model on stock returns has been verified in major developed capital markets abroad. However, when applying the three-factor model to the Chinese market, the views of various scholars are different. This paper examines the data of SSE A-shares for the past 10 years and tests the adaptability of the three-factor model in the Chinese market with monthly data, and finds that the market premium factor and the market capitalization factor are significantly effective in explaining stock returns, in contrast, the book-to-market ratio factor is relatively weak in its ability to explain stock returns.

Keywords: Three-factor model, A-share stock returns, Newey-West adjustment.

1. Introduction

Since the establishment of the Shanghai Stock Exchange (SSE) and Shenzhen Stock Exchange (SZSE) in the 1990s, China's securities market has developed for more than a decade, and now has more than 5,000 listed companies, including Shanghai and Shenzhen A-shares, B-shares, Growth Enterprise Markets (GEM) boards, and the new three boards, and other multilevel capital market modules. Currently, the Fama-French three-factor model is widely used in foreign countries for risk management, yield prediction, and fund performance evaluation. However, whether this model, which is extremely effective in the Western securities market, can be equally applicable to the Chinese stock or bond market is a question that requires in-depth research. This study applies the Fama-French three-factor model to provide a detailed empirical analysis of the key factors affecting stock returns. On the one hand, this study tests the applicability of the model; on the other hand, it analyzes the factors affecting stock returns. Specifically, this study conducts a regression analysis with a sample of Chinese A-share data for the past 10 years to assess the validity of the Fama-French three-factor model in the Chinese A-share market, especially the explanatory power of the market premium factor,

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the firm size factor, and the book-to-market ratio factor in explaining stock returns. In addition, by revealing the factors that can explain the changes in stock returns in China's stock market, and by using them to provide a practical basis for portfolio selection, risk management, and performance evaluation, this paper can also provide some guidance for China's securities market and offer a direction for future reforms.

2. Theoretical Analysis and Research Preparation

2.1. Model Preparation

2.1.1. Modeling

Systematic risk beta plays a central role in the financial asset pricing process. However, Fama and French's study proposes that in addition to β, the size of the firm and its book-to-market ratio are also determinants, and these two parameters can profoundly reflect differences in firms' profitability and their persistence. Therefore, in addition to the consideration of systematic risk, it is important to include two factors that are highly sensitive to risk, namely the size factor (Size) and the book-to-market ratio (B/M).

The Fama-French model consisting of the three key factors is formulated as follows:

$$R_{pt} - R_{ft} = \alpha_{pt} + S_{pt}SMB + h_{pt}HML + \beta_{pt}(R_{mt} - R_{ft}) + \varepsilon_{pt} \quad (1)$$

In this model, Rpt represents the return of portfolio p in month t; while Rft represents the risk-free rate in month t; and small minus big (SMB) and high minus low (HML) represent the size and book-to-market factors. The former is "small minus large", calculated as the difference between the returns of a small-cap portfolio and a large-cap portfolio, a factor designed to compensate for the so-called small-company effect. Similarly, HML, or "high minus low," is calculated as the difference in returns between a portfolio of "value" stocks and a portfolio of "growth" stocks; Rmt identifies the market return in month t; α month market return; αpt is the intercept term in the model; Spt, hpt, and βpt are the sensitivity coefficients to SMB, HML, and market excess return, respectively, and εpt is the error term in the model.

The constant term α is used to assess whether a portfolio has the ability to generate excess returns, similar to the Jenson index derived from a one-factor CAPM (Capital Asset Pricing model) where if α is greater than 0, the asset earns a return greater than it should at its level of risk, and vice versa. This measure is known as "Jason's alpha" and is a widely used tool for assessing the profitability of a portfolio.

2.1.2. Characterization of Each Sensitivity Factor

In general, the difference between the returns of a small-cap portfolio and a large-cap portfolio is positive because small-cap stocks are not liquid enough, only some closed-end funds are willing to hold small-cap stocks, and large institutions are unlikely to hold small-cap stocks that are less liquid and have poorer performance, which creates the small-cap premium phenomenon. This means that the return on a portfolio of small-cap stocks will exceed that of large-cap stocks, and Rpt (the return on asset p at time t) is positively correlated with SMB, so Spt is positive.

For the return difference between the "value" and "growth" portfolios, since the "value" portfolio is more likely to earn higher returns, Spt is positive. Rpt (the return on asset p at time t) is positively correlated with HML, so hpt is positive.

In the long run, the average market return is higher than the average risk-free rate of return, and the risk premium is likely to be positive, so it can be assumed that the expected return is positively correlated with the risk premium, so βpt is positive.

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2.1.3. Jensen's Alpha

Jensen's Alpha is a risk-adjusted performance evaluation metric used to measure the performance effect of a fund manager or portfolio. It measures the difference between the actual return of the portfolio and the return expected based on the Capital Asset Pricing Model (CAMP). The single factor model is given below:

$$\alpha = R_i - [R_f + \beta \times (R_m - R_f)] \quad (2)$$

where Ri is the actual return of the portfolio or fund, Rf is the risk-free return, Rm is the market portfolio return, and the beta coefficient of the portfolio indicates the sensitivity of the portfolio to market returns.

Under the efficient market hypothesis, the expected α should be zero. This is because in an efficient market, all available information is fully reflected in asset prices and investors are unable to achieve sustained excess returns through any systematic method. Therefore, if the market is efficient, the expected alpha should be close to zero.

2.2. Sample Selection

The sample data involved in the discussion of this paper includes all the stocks in A-share (after excluding the stocks that do not fulfill the conditions), and the time distribution of the sample is from December 2010 to December 2020, and the relevant data in this paper comes from databases such as Cathay Pacific.

This paper selects the data of these 10 years for empirical analysis for the following reasons: this paper selects the time from December 2011 to December 2020, in this decade, China's stock market has experienced a bull market, bear market and sideways oscillation, the stock index fluctuation of the interval is larger, and at the same time, the completion of the reform of the equity distribution, by the development of these 10 years, China's stock market is gradually becoming more mature, and the same in the circumvention of the After avoiding the impact of black swan events on stock returns, such as the Xin Guan epidemic, it can be expected that the empirical analysis using the data of this decade will be fully representative. At the same time, due to the large amount of data, the possibility of significant random errors in the analysis results is small [1].

2.3. Sample Classification

First, stocks are sorted based on their total market capitalization, where the top 50% in terms of market capitalization are classified as the small-sized stock group (s) and the remaining are categorized as the large-sized stock group (b). Subsequently, the stocks are sorted based on their book-to-market ratio, with the top 30% as the low book-to-market ratio group (l), the bottom 30% as the high book-to-market ratio group (h), and the remaining 40% as the medium book-to-market ratio group (m).

The stocks after the two forms of grouping according to the above methodology are cross-grouped between the groups so that it gets 6 stock portfolios. The stocks within these six portfolios are used to calculate the average monthly return of each portfolio according to the total market capitalization weighting method within the group.

Based on the calculated monthly average return of each portfolio, the risk factor can be calculated:

$$SMB = \frac{1}{3}(SH + SM + SL) - \frac{1}{3}(BH + BM + BL) \quad (3)$$

$$HML = \frac{1}{2}(BH + SH) - \frac{1}{2}(BL + SL) \quad (4)$$

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As for the selection of the dependent variable, most of the literature directly adopts the data for calculating the combination of independent variables, but considering the small number of groups, it is not appropriate to make comparisons. In this paper, all eligible stocks are categorized into 5 groups according to market capitalization, and similarly, all eligible stocks are categorized into 5 groups according to book-to-market ratio, and then by cross-grouping between the groups this will result in 25 stock portfolios.

2.4. Data Preprocessing

When performing stock screening, it is first necessary to exclude all stocks in the financial sector, as they usually have high financial leverage and large enterprise size due to the special valuation mechanism and China's specific conditions; if not eliminated, most of these stocks would be categorized into a large-scale and high book-to-market ratio portfolio, which would lead to a large market capitalization share of the portfolio and a more significant impact on the average rate of return. It is also necessary to eliminate stocks that have had ST status in the past year, are still in ST status, or have a history of trading suspensions, as these stocks tend to have dramatic fluctuations in market capitalization and book value, and analysis using this type of data may introduce errors that affect the accuracy of the results [2].

3. Analysis of Empirical Results

3.1. Descriptive Stats

3.1.1. Newey-west t-statistics

First, this article verified the validity of the grouping as follows: it first constructed a gap variable using the difference between the weighted portfolio returns of the fifth group and the first group. Then, in order to find the order of the lag term and at the same time to ensure the simplicity of the model and the smoothness of the time series, this artical chose to consider the use of empirical functions and finally chose the order of the lag term to be 4 [3]. Then, let each group and gap value do t-test, observe whether its value is significant to judge whether the score is valid or not, and get the t-value and significant level of each group as follows (see Table 1):

Table 1: Newey-West t-test results

	(1)	(2)	(3)	(4)	(5)
	gap	gap	gap	gap	gap
_cons	-0.442	-0.768**	-0.718**	-0.770**	-0.527
	(-1.101)	(-2.191)	(-2.050)	(-2.070)	(-1.251)
N	252	252	252	252	252
t statistics in parentheses			* p < 0.1, ** p < 0.05, *** p < 0.01		

From the table, it shows that the difference between the returns of the weighted portfolios of groups II, III and IV and the returns of the weighted portfolios of groups I and V is significant at the 95% level of significance, which also implies that our grouping is valid.

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3.1.2. Risk Factor (Dependent Variable) Descriptive Statistics

Table 2: Three-factor descriptive statistics

	N	mean	sd	min	max
MKT	252	0.79	7.97	-26.83	29.6
SMB	252	0.395	3.772	-16.68	19.36
HML	252	0.187	3.392	-15.52	16.38

As can be seen from Table 2, the average of the monthly data of the three factors in the past ten years is positive, and since both SMB and HML can represent the difference in returns between the required portfolios, there is a significant market capitalization effect and book-to-market ratio effect in China's A-share market in the long run. The standard deviations of all three factors are small, indicating that the three factors have some stability.

3.1.3. Correlation Analysis of Independent Variables

Table 3: Three-factor Pearson correlation coefficient table

	MKT	SMB	HML
MKT	1	0.2238	-0.00021
SMB	0.2238	1	-0.2525
HML	-0.0002	-0.2525	1

Pearson's correlation analysis of the three factors using Matlab yielded the results as above (see Table 3), as seen from the data provided, the correlation coefficient between the market capitalization factor and the market premium factor is 0.2238, while the correlation coefficient between the book-to-market ratio factor and the market premium factor is almost unaffected and recorded as -0.0002; and the correlation coefficient between the book-to-market ratio factor and the market capitalization factor is correlation coefficient is -0.2525. These low correlation coefficients indicate the lack of a strong linear relationship between these three factors [4]. Therefore, there is no need to be overly concerned about possible multicollinearity issues arising from these three explanatory factors in future regression analyses.

3.1.4. Analysis of Excess Returns on Dependent Variables

Table 4: Mean rate of return (25 groups)

	BM_group5				
BM_group5	1	2	3	4	5
1	1.151	1.430	1.501	1.537	1.225
2	0.755	1.149	1.345	1.323	1.186
3	0.623	0.989	1.004	1.089	1.146
4	0.726	0.944	0.989	1.147	0.985
5	0.709	0.662	0.783	0.767	0.698

As shown in Table 4, this research analyzes the average monthly excess returns of 25 portfolios, all of which exhibit positive returns, where the fluctuations in returns range from 0 to 2%. It is found that there is a significant negative correlation between the size of a portfolio and its return, i.e., smaller portfolios tend to realize higher returns [5]. However, the relationship between the book-to-market

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ratio and the rate of return is unclear due to common anomalies within each industry, and further in-depth research is needed to validate its specific impact on the rate of return.

3.2. Regression Analysis

Table 5: Regression results (intercept and dependent variable regression coefficients)

Book-to-market ratio					
scales	1	2	3	4	5
	α				
1	0.005	0.270**	0.303***	0.335**	-0.029
2	-0.362**	0.055	0.252*	0.080	-0.007
3	-0.338**	-0.061	-0.091	-0.063	0.013
4	-0.076	-0.045	-0.039	0.044	-0.092
5	0.254**	0.002	-0.071	-0.053	-0.008
	β				
1	0.987***	0.979***	0.994***	1.000***	1.010***
2	0.997***	1.000***	0.994***	1.025***	1.010***
3	0.976***	0.989***	1.028***	1.041***	1.028***
4	0.967***	1.055***	1.050***	1.083***	1.062***
5	0.989***	1.028***	1.066***	1.009***	0.944***
	s				
1	1.066***	1.090***	1.116***	1.067***	1.038***
2	1.006***	0.897***	0.856***	1.054***	0.844***
3	0.757***	0.826***	0.765***	0.813***	0.638***
4	0.443***	0.547***	0.538***	0.538***	0.390***
5	-0.365***	-0.204***	-0.032	-0.101***	-0.377***
	h				
1	-0.300***	-0.237 ***	-0.153***	-0.051	0.244***
2	-0.366***	-0.278***	-0.165**	0.089*	0.324***
3	-0.587***	-0.310***	-0.105**	0.042	0.368***
4	-0.738***	-0.327***	-0.075	0.185***	0.451***
5	-0.975***	-0.382***	0.130	0.336***	0.585***
	Adj-R^2				
1	0.922	0.959	0.967	0.962	0.950
2	0.944	0.955	0.953	0.964	0.961
3	0.947	0.957	0.956	0.958	0.950
4	0.932	0.939	0.942	0.948	0.951
5	0.940	0.929	0.914	0.911	0.936

Considering that the sample belongs to time series data, and in time series analysis, the temporal autocorrelation will make the standard error of OLS (ordinary least squares) estimation increase, which makes the estimation result inaccurate, so this paper adopts the new Harvey-West estimator (Newey-West estimator), the Newey -West method adjusts the standardized weights by introducing the autocorrelation term weight matrix, so as to obtain more accurate estimation results. At the same time, the Newey-West method also takes into account the problem of heteroskedasticity, and further improves the correctness and robustness of the estimation by weighting the covariance matrix.

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As shown in Table 5, the three-factor model shows good results in fitting these 25 portfolios (dependent variables), and its adjusted R-squared value (Adj-R^2) proves the applicability and accuracy of the model, all of which reach 0.9, which shows that the three-factor model has a low degree of overfitting and an excellent ability to explain the excess return.

Setting the significance level at 0.05, the seven portfolios of Main Board and SMB stocks show a high significance of t-value of their intercept α, while the other portfolios have an intercept value close to zero and their t-values do not show significance. This result indicates that the Fama-French three-factor model shows better results in explaining the cross-sectional differences in the returns of our main board and SME stocks.

When analyzing the beta coefficient of market risk premium, this artical notice that its t-value shows high significance, with t-values of all portfolios exceeding 30 while the beta coefficients are generally greater than 0.9. These results emphasize the importance and strong explanatory power of market risk premium in explaining the cross-sectional differences in stock returns.

Based on the regression analysis, it is found that the coefficient s of the size factor SMB is significantly positive for all four portfolios except for the largest firms' portfolio where the coefficient s of the size factor SMB is less significant, suggesting that stocks of smaller firms typically earn higher returns than those of larger firms. In addition, the coefficient s of the size factor shows a gradual decline as the size of the firm increases, which further reveals that in the Chinese stock market, the excess returns of stocks of small firms often exceed those of large firms, and that there is an obvious inverse relationship between stock returns and firm size [6]. This phenomenon not only reconfirms the negative correlation between stock returns and firm size, but also emphasizes the existence of an obvious scale effect in the market. Taken together, smaller firms face greater market uncertainty and greater volatility in returns, so investors tend to seek higher returns to compensate for these risks, resulting in relatively higher expected returns for these firms [7]. Relatively speaking, the returns of large firms are more stable, resulting in lower expected returns for investors. Therefore, the firm size factor plays a key explanatory role in explaining the cross-sectional difference between the returns of main board and small and medium-sized board stocks in China's A-share market.

According to the results of the regression analysis, the indicator of book-to-market ratio (BE/ME) shows different characteristics: in the first three groups with low BE/ME, the regression coefficient h is mostly negative and significant. The significance of the coefficient h decreases when in the fourth group with moderate BE/ME. In the fifth group with the highest BE/ME, the coefficient h is significant and significantly greater than 0. In addition, the coefficient h gradually increases as the firm's BE/ME increases, indicating that the excess stock returns of firms with high BE/ME are significantly higher than those of firms with low BE/ME, which further suggests that there exists a positive correlation between stock returns and firms' book-to-market ratios [8]. In short, when a company has a low book-to-market ratio, this usually indicates that the market has overvalued the stock over the past period of time. Once investors reassess, the overvaluation is corrected, leading to a decrease in the price of the stock and thus a lower expected rate of return. Conversely, a higher book-to-market ratio indicates that investors hold a pessimistic view of unfavorable news about the company and perceive it as risky, thus requiring a higher expected return to compensate for this risk [9]. Through regression analysis, it can be observed the effectiveness of book-to-market ratio in explaining the cross-sectional difference between the returns of main board and SME stocks in China's A-share market.

4. Conclusion

The application of the Fama-French three-factor model in China's A-share market shows excellent performance in explaining stock returns compared to the CAPM model. The market risk premium effectively explains the variation of stock returns whether in the main board, SME or GEM of A-

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share. In particular, among companies listed on the Main Board and SMB, this articul find that stock returns are significantly negatively correlated with firm size, a phenomenon that is more pronounced among smaller companies. In addition, stock returns are positively related to the book-to-market ratio of the firm, and this positive correlation is especially significant among firms with higher book-to-market ratios. These analytical results further validate the broad applicability and explanatory power of the Fama-French model in diverse market environments.

In addition, this thesis does not consider the robustness test of the three-factor model, but it can give a more appropriate test method: it can firstly select the first 60 months of time series data, and then each time backward one month in order to obtain a new 60 time series data for the regression, so by using the 120 time series data to regress cyclically, it can get the model regression coefficients of 60 time series data, so as to analyze the stability of the regression coefficients. The stability of the regression coefficients can be investigated in this way. On the other hand, higher frequency data such as weekly or daily data can be considered to explore the robustness and adaptability of the model under different time scales, in addition, other factors can be considered, such as the turnover rate, etc., but researchers need to pay attention to the problem of multicollinearity between the factors. Finally, in future research, scholars can continue to verify the adaptability of the Fama-French model in specific areas. At present, some scholars in China have tried to use the Fama-French model in the field of real estate, and researchers can continue to apply it to other fields, such as medicine, green economy and even funds to verify and expand.

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