Quantitative Portfolio Selection Based on Fama-French 3-Factor Model: An Empirical Research

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Abstract—This paper tries to take the monthly yield of 300 stocks in the CSI 300 Index in Chinese A shares market from January 2012 to December 2021 as the research object, making the stocks group through the size and book market value comparison. Fama-French three-factor model is used to perform regression analysis of the sample, and conduct stock selection strategy research based on the model. The study found that the three-factor model still has certain practicality in China's capital market, and investors can select stocks according to the three-factor model. Accordingly, this thesis believes that the fit of the three-factor model has dropped significantly compared with ten years ago, and the three-factor model will become less and less suitable for China's capital market in the future, which needs continuous optimization and improvement. The data comes from CSMAR database. This paper uses computer simulation to conduct stock selection by Stata. The study found that the three-factor model still has certain practicality in China's capital market, and investors can select stocks according to the three-factor model. According to simulation results, this paper believes that the fit of the three-factor model has dropped significantly compared with ten years ago, and the three-factor model will become less and less suitable for China's capital market in the future, which needs continuous optimization and improvement. The findings of this paper are a very important signal for investors to further optimize the model.

Keywords- Three-factor model; A-share market; Book-to-market ratio; Asset premium factor; Scale factor

1 INTRODUCTION

The study of capital asset pricing theory is one of the hot spots in the field of modern finance, and this type of model gives predictions about the connection between asset risk and expected return. Among them, the Fama-French three-factor model believes that the "market capitalization

factor" and "book capitalization ratio" can account the excess yield of the portfolio and compensate for the risks that the β fails to reflect.

In previous studies, it was found that the theory of capital asset pricing in Western countries dominated by the United States has been relatively mature, investors mainly belong to institutional investors, during the period of 2017, the ratio of individual investor shareholding was 21.17% in China's securities market investor structure, the proportion of professional institutional investor shareholding and general legal person investor shareholding was 16.13% and 61.53% respectively. The total market value of institutional investors is still lower than that of individual investors which were approximately 5%, nevertheless, the proportion of institutional investors holding more than 33% of individual investors in the US securities market as early as 2010 [1], hence the Fama-French three-factor model has a certain predictive power for its stock returns, which can better interpret its capital market. However, whether the classic three-factor model of the West can be applied to China's A-share market with very different systems and different investment groups has not yet been unanimously concluded by scholars.

Western stock exchanges first appeared in the Netherlands in 1611, And Britain and France also established stock exchanges immediately, and in retrospect, the evolution of China's capital market, Chinese capital markets has gone through four stages from scratch, from regional to national. The embryonic stage (1978-1990) was promoted by the state, the shareholding system began to be tried, and the issuance of stocks brought about the trading demand of stocks, therefore, a stock trading counter was established. During this period, not only stocks but also bond issuance and trading markets also began to sprout. The Shanghai Stock Exchange and the Shenzhen Stock Exchange were officially opened with the support and promotion of the government, marking the official entry of Chinese securities market on the historical stage. In the establishment and exploration stage of the capital market (1990-1998), during this period, the supply of stocks exceeded demand due to the high market sentiment of domestic participation in stock investment, not only the emergence of internal private transactions and the interception of subscription lottery forms promoted the birth of securities regulators and the introduction of capital market laws and regulations. In addition to the construction of the legal system, various types of domestic financial institutions also began to emerge. The Securities Law was officially promulgated in the stage of capital market standardization and system construction (1998-2006), which drew back a new chapter in the reform and innovation of the domestic capital market, nevertheless, the stock market ushered in the reform of equity splitting due to the small and medium-sized board proposed by the control of market risks, The equity split reform was officially launched in 2005, and "Sany Heavy Industry" was the first share of the stock reform [2]. In the stage of deepening reform and innovation (2007-2021), the report of the Eighteenth National Congress of the Communist Party of China raised to deepen the innovation of the financial system, improving and promoting macroeconomic stability, accelerating the progression of multi-level capital markets, playing the role of the market to relax the control of the securities market, improving the market supervision system, changing China's current financing system that relies on bank credit excessively, and promoting the construction of a credit financial system[3]. Compare with the Western capital market, China's capital market was established 367 years later, with its relative lack of stability and maturity. It is not comprehensive enough to use the CAPM model to study its investment returns, because it is difficult to explain the vision outside of systemic risk. Therefore, this paper uses the Fama-French 3-factor model to test the effectiveness of China's A-

share market in the international situation, and study whether the model can be effectively applied to China's A-share market and effectively price capital assets simultaneously.

The rest of this article is arranged as follows: the second part is a literature review; the third part is the study design, including information sources and research methods; the fourth part is the analysis of empirical results, using data statistics and factor regression respectively; the fifth part is a discussion, based on the analysis results to derive a stock selection strategy.

2 LITERATURE REVIEW

In the early 1960s, in order to reduce the cumbersomeness and cost of Markowitz's research theory, Sharpe, Linter, and Mossin conducted a study based on Markowitz's theory of pluralism and efficient portfolio investment to simplify the application of Markowitz's theory, which led to the emergence of the CAPM model directly. This model explained the "vision" of capital market stocks that could not be explained by the one-way model [4]. With the solution of the "vision" brought about by the one-factor model, a new "vision" also follows. Fama and French discover that the market capitalization factor and the book capitalization ratio can better explain the expected return of a stock, and built a three-factor model on account of this, improving the ability to interpret and predict the yield.[5]

In recent years, most scholars have studied the Fama-French three-factor model based on the CAPM model, and a lot of scholars have researched whether the three-factor model born in the Western capital market is equally applicable in the Chinese capital market. At present, scholars have not reached an agreement on whether the three-factor model is suitable for China's capital market. Zhao Shengmin believes that China's stock market's maturity is lower than that of the US stock market. As opposed to the US stock market, the information asymmetry phenomenon is more serious, not just that the regression coefficient of RMW and CMA is not remarkable, while the regression coefficient of HML is significant, therefore, the three-factor model is more fit for the Chinese stock market[4]; Wang Ruoying trusts that the Fama-French three-factor model is universally applicable in China's Shanghai and Shenzhen A-shares[6]; Jiang Meihong believes that most of the stocks in the SSE 50 constituent stocks are suitable for the three-factor model. However, compared with Shanghai and Shenzhen index, the effect of this model is better than that in SSE 50.[7]; Zhang Zhaoqin et al. pointed out that the three-factor model of market factors, scale factors, and profit factors has the best explanatory ability in China's A-share market through the study of the profit effect of the A-share market[8]; Yang Zunhan believes that the Fama-French three-factor model may be effective for some industries in the A-share market and ineffective for some industries [9].

Through the existing literature, it is not hardness to find that the research of Chinese scholars on the significance of China's capital market based on the Fama-French three-factor model has been relatively perfect in the early 21st century. But after entering the second decade of the 21st century, scholars are more inclined to research the three-factor model as a salient test in various sectors of China's capital market. In particular, China's capital market has matured over the past decade, and environmental factors have become more complex. As one of the most famous models of quantitative investment, the three-factor model still needs further research in the study of the significance of China's current capital market, and this paper will discuss the quantitative

investment and stock selection strategy of Chinese capital market over the saliency test of the three-factor model on the 300 stocks of Shanghai and Shenzhen index.

3 RESEARCH DESIGN

3.1 Data sources

The data of this paper comes from the wind database, and the data of China's A-share market CSI 300 index between 2012 and 2021 are selected for regression analysis.

Risk-free interest rate R_f uses the one-year yield of the national debt, which is taken from the Guotaian database. In the ten years from 2012 to 2021, the one-year yield of treasury bonds has not changed much, and the overall change is relatively flat, floating around 2.52%.

Depending on the grouping way of Fama-French in the article, the stocks of each month are divided into six groups according to stock size and book to market ratio (book to market ratio =1/ price to book ratio).

First of all, depending on the size of the stock circulation market value, 2×3, divide the stocks into small-cap stocks (s) and large-cap stocks (b) and then divide the small-cap stocks and large-cap stocks into six combinations (SH, SM, SL, BH, BM, and BL) at the ratio of 30%, 40% and 30% according to the book value ratio (table 1). In addition, the stock performance of listed companies is constantly changing. Therefore, we need to deal with delisted stocks and stocks with abnormal financial or other conditions [10].

Table 1 Stock by types

	H (30%)	M (40%)	L (30%)
S (small-cap)	SH	SM	SL
B (large-cap)	BH	BM	ML

3.2 Fama-French 3-factor model

In 1992, the Fama-French three-factor model was obtained by Fama and French. They studied the factors that determine the difference in stock returns in the U.S. stock market. Depending on the model, the excess return of a portfolio can be explained by the exposure of three factors: market portfolio (Rm-Rf), market value factor (SMB), and book-to-market ratio factor (HML) [11].

$$E\left[R_t\right] - R_f = \beta_i \left(E\left[R_{mt}\right] - R_f\right) + s_i SMB_t + h_i HML_t + \varepsilon i \qquad (1)$$

In this model, R_{it} represents the yield of I stock at t; R_f is the risk-free rate of return; Rmt represents the market return rate in period T; HML_t t is the book to market ratio factor return at time t; SMB_t is the simulated portfolio yield of the market value factor (also known as the scale factor) of time t; $E[R_{mt} - R_f]$ is the market risk premium. β_i, s_i, h_i are $E[R_{mt}] - R_f$, SMB_t, HML_t Coefficient. εi is regression residual.

The Fama-French three-factor model confirms the specific factors, which can better explain the factors affecting the yield and promote the development of the capital asset pricing model.

According to the grouping situation, the market value of each group of data is weighted, and the product of the closing price of each group of shares last month and the market value is divided by the sum of the market worth of the group of shares. According to the grouping of stocks and the market capitalization-weighted return, the book to market ratio factor HML and market capitalization factor SMB are calculated by using the following formula:

$$SMB_t = (SL_t + SM_t + SH_t)/3 - (BL_t + BM_t + BH_t)/3 \qquad (2)$$

$$HML_t = (SH_t + BH_t)/2 - (SL_t + BL_t)/2 \qquad (3)$$

In addition to the market value factor and the book to market ratio factor, the average market return is obtained by summing the return rates of the six groups, and the market premium factor is obtained by subtracting the risk-free return rate.

4 EMPIRICAL RESULTS

4.1 Summary statistics analysis

This paper first reports the descriptive statistical analysis of six portfolio return rates, which are as follows.

Table 2 Summary statistics

Portfolio	Mean	The standard deviation	maximum	minimum
SL	0.0204	0.2479	1.7093	-0.2586
SM	0.0054	0.1131	0.5666	-0.2832
SH	-0.0140	0.1391	0.1974	-0.9336
BL	0.0210	0.0763	0.2628	-0.1723
BM	0.0231	0.1629	1.0931	-0.3726
BH	0.0201	0.2210	1.5153	-0.5512

As can be seen from this table, the average return rate of stocks with small market value and a high book-to-market ratio is negative. Indicating that such stocks have poor returns and are more possible to have financial crises. From the perspective of standard deviation, SL and BH groups have large standard deviations, we can consider that the investment risk of these stocks is high. In addition, except for stocks with large market value and high book-to-market ratio, the average portfolio return rate decreases with the increase in book-to-market ratio.

4.2 Regression analysis

The Stata was used for regression analysis of the data in this paper, and the results are as follows.

Table 3 Regression results

portfolio	ε_i	β_i	α_i	γ_i	F	adj-R-sq
SL	0.0042	1.4405	0.1630	-0.7378	132.2	0.7679
	p=0.651	p=0.000	p=0.149	p=0.000		
SM	0.0019	1.0035	0.1586	-0.0984	121.92	0.7530
	p=0.691	p=0.000	p=0.008	p=0.060		
SH	0.0126	0.8125	0.7685	0.9287	183.32	0.8213
	p=0.008	p=0.000	p=0.000	p=0.000		
BL	0.0109	0.7991	-0.2568	-0.0891	73.69	0.6470
	p=0.011	p=0.000	p=0.000	p=0.050		
BM	0.0073	1.2837	-0.6786	0.0696	188.77	0.8256
	p=0.167	p=0.000	p=0.000	p=0.218		
BH	0.0002	1.1753	-0.9738	0.1126	94.09	0.7012
	p=0.978	p=0.000	p=0.000	p=0.251		

Note: This paper considered the factor that can significantly reflect the excess return rate of the portfolio when the p-value is less than 0.05. Computer simulation by Stata.

According to the data obtained by Stata regression analysis. All of the portfolios pass the F test. It fully shows that Fama-French three-factor model is still a relatively market return prediction model. MKT, SMB, and HML can better explain the changes in the portfolio.

For the intercept, the p-value was all greater than 0.05 except SH and BL groups. Indicating that the t-test had not been past in the rest of the 4 groups. It shows that with the outbreak of COVID-19 and the impact of the international situation as well as the development of the Chinese capital market, there are still many other factors that can greatly impact the return rate of the other four investment portfolios. Meanwhile, the p values of SH and BL are less than 0.05, which also proves that other factors have little influence on the excess return of these two portfolios.

For the coefficient of market premium factor (MKT), the p values of all the six portfolios were 0, and except for BL and BM groups, the values were all positive numbers greater than 1. In other words, the market premium factor can significantly predict the excess return of all portfolios, the excess return range of stocks with a small market value which has a low and middle book-to-market ratio, and a large market value which has a middle and high book-to-market ratio is greater than the excess return of the market.

For the regression coefficient of size factor (SMB), the p values of the other five groups are 0, except the p-value of SL's coefficient is higher than 0.05, which does not significantly reflect the excess return rate of this portfolio. The coefficients of portfolios with small market values are positive and the portfolios with big market values are negative. It shows that in the stocks with a small market value which have a middle and high book-to-market ratio, there is a positive connection between the excess return of the portfolio and the size factor. For stocks with big market value, there is a negative connection between the excess return rate of portfolios and the size factor. In addition, for stocks with a bigger book-to-market ratio under the same market value group, the fluctuation range of the portfolio's excess return is closer to the fluctuation range of the size factor.

As for the regression coefficient of the book-to-market ratio factor (HML), except for SL, SH, and BL groups, p values are all large than 0.05, that is, the book-to-market ratio factor cannot significantly reflect the excess return rate of the portfolio in the other three groups. In the stocks with small market capitalization, low book-to-market ratio, and big market capitalization, with low book-to-market ratio, this coefficient is negative. Indicating that in the stocks with low book-to-market ratio, the excess return of the portfolio is negatively correlated with the book-to-market ratio factor. However, for stocks with small market value and high book-to-market ratio, this relationship turns into a positive correlation.

For the adj-R-sq analysis, the adj-R-sq of each group is greater than 0.5. It can indicate that the Fama-French three-factor model has a high fitting degree for the Chinese capital market, and the adj-R-sq of small-market stocks is generally greater than that of large-market stocks. Therefore, this model has a greater impact on the excess return of small-market stocks in China's capital market.

5 DISCUSSION

At present, China is in a special period of the capital market, and the market is impacted by various risks. In the past decade, economy of China has changed from high-speed growth to high-quality steady growth. In such a volatile capital market, investors need to invest rationally and not blindly follow the trend.

As for the book-to-book-to-market ratio, among the stocks with small market value, the lower book-to-book-to-market ratio may indicate that there is a problem in the internal capital flow of the enterprise. Due to the scale restrictions of small market value enterprises, there is a greater possibility of the financial crisis. Therefore, investors should not blindly follow the "small-cap stock effect" and invest in some stocks with small market value, expecting to get greater returns. Investors should have a clear understanding that the stock price is not equal to the value of the company. In the capital market, stocks with large market value and high book-to-book-to-market ratios are generally regarded as having poor prospects. Such enterprises have relatively large fixed assets and cash, but the company's value valuation is low, showing a high book-to-book-to-market ratio. When selecting such stocks, they will bear large systematic and individual risks.

Even today, there is still an obvious "small-cap stock effect" in China's capital market. From the scale factor regression analysis, it can be seen that the portfolio size factor of small market value has a active relationship with the excess return of investors. On the contrary, the regression coefficient of the portfolio with a large market value is negative, and the excess return of the portfolio is negatively correlated with the size of the company. Therefore, in China's capital market, investors can give priority to smaller stock investments after weighing other conditions.

6 CONCLUSION

In general, the three-factor model is still significant and practical for China's capital market. Investors can study stock selection strategies according to the three-factor model. And the market premium factor is the most significant factor, which has a good ability to reflect the excess return

of investors, followed by the scale factor, and then the book to market ratio factor. Although the significance of the book-to-market ratio factor is poor, it does not mean that its prediction effect on excess return can be ignored. However, the market is still progressing. It is obvious that the goodness of fit of the three-factor model has decreased signally compared with the research ten years ago. This means that the basic three-factor model will not apply to China's capital market in the future. Investors need to change the factors and improve the model in time so that they can effectively price the capital assets of China's A-share market.

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