



Review of Asset Pricing Theory and Empirical Research Results

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Abstract

Capital asset pricing theory is one of the most popular issues in modern finance research. In the form of research review, this paper sorts out the research history of the four most famous capital asset pricing models, points out their advantages and disadvantages in combination with the relevant empirical analysis. Finally, we give an conclusion of the future research trend in this field.

Keywords: *asset pricing; CAPM model; asset portfolio*

1. Introduction

The rigorous theoretical research work on the direction of capital asset pricing began in 1952. Markowitz put forward the asset portfolio theory as a starting point, and took the CAPM model proposed by Sharp et al. in 1964 as a milestone. Since then, with the unremitting efforts of researchers, new asset pricing models have been put forward constantly, such as Fama- French three-factor model, Carhart four-factor model, Fama-French five-factor model and other asset pricing models. However, so far, no model can withstand the test of a large number of empirical studies. The factor model itself is limited to its theoretical basis or the background, and it must be continuously improved in empirical research. This article will review the well-known research results and empirical tests in this field since Sharp, and show some modern scholars' improvement work on factor models.

2. Literature Review

2.1 CAMP Model

2.1.1 The Background of the CAPM Model

Investment returns and investment risks have always been the issues that investors are most concerned about. Perold (2004) pointed out that although market investment behavior first appeared in the seventeenth century, it was not until after 1940s, represented by the results of Neumann and Morgenstern (1944), the strict

theories on investment decisions and financial risks began to appear. In 1952, Markowitz established the modern asset portfolio management theory, pointing out that investors can avoid risks and maximize returns through different financial investment portfolios. Modigliani and Miller (1958) laid the foundation for the valuation theory of companies and their stocks under uncertain conditions. They pointed out that the company's capital structure has no effect on the company's value or stocks. Tobin (1958) explained why investors are more willing to maintain sufficient diversification of their financial investment portfolios in terms of liquid assets and securities. In the early 1960s, Sharpe (1964) made diversified investments in accordance with the rationality of investors and strictly followed the rules of the Markowitz model, and the capital market was a completely efficient market, and the hypothesis that no friction hindered investment was put forward. The Capital Asset Pricing Model (CAPM), which has a pivotal position in the field of finance, provides an important theoretical basis for studying the quantitative relationship between the return of risky assets and the risk.[1][2]

2.1.2 Limitations of the Traditional CAPM Model

Many scholars have verified that the model has limitations both in theoretical research and practical applications. [3][4][5]

Firstly, CAPM is based on the efficient market hypothesis (EMH). The premise of its model

establishment actually implies three important assumptions, that is, traders are rational and their investment behaviors are arbitrary and satisfy the effective arbitrage. The requirements are too harsh for the actual market. And after the 1970s, with the continuous deepening of research, the correctness of EMH has also been questioned by many scholars.

Secondly, the β value of CAPM is difficult to determine. Due to the influence of various factors on the stocks in the securities market, their β values will also have certain changes. Fama and French (2004) studied past data and found that the results obtained by CAPM have a large deviation from the actual results. Tsong-Yue and Stohs [6] (2015) even pointed out bluntly that this model is not available.

Finally, CAPM is not suitable for China's market environment. Zhou Shenghang, Ma Xianxian[7] randomly selected 100 stocks from the Shanghai stock market during the three-year period from January 1, 2017 to December 31, 2019. The above does not support the effectiveness of the CAPM model in the Shanghai stock market in China.

2.1.3 Researchers' Improvement to the CAPM Model

Nowadays, the academic circles question the CAPM model mainly because it is almost impossible to meet all the assumptions set by the model in real market conditions. Therefore, the improvement work of researchers on the traditional CAPM model is mainly focused on gradually weakening the assumptions of the model[8]. Lintner (1969) extended CAPM to the level of heterogeneous beliefs. Mayers (1972) introduced the concept of background risk. Black (1972,1993) first studied CAPM under leverage constraints, and then introduced the concept of short selling constraints into it. Thorsten Hens & Fatemeh Naebi extended the CAPM model to the case where some investors are not mean-variance optimizers. Cui Jin, Yin Xia, and Huo Qiuju[9] conducted research on the improvement of CAPM in China's capital market based on the empirical analysis of scale premium, providing an important improvement area for the application of the CAPM model in practice. Zhang Peiwen, Wang Ruixuan, Jiang Haifeng [10] improved the CAPM model cluster that introduced the conditional heteroscedasticity effect, and provided a useful reference for the correct use of such models in empirical analysis.

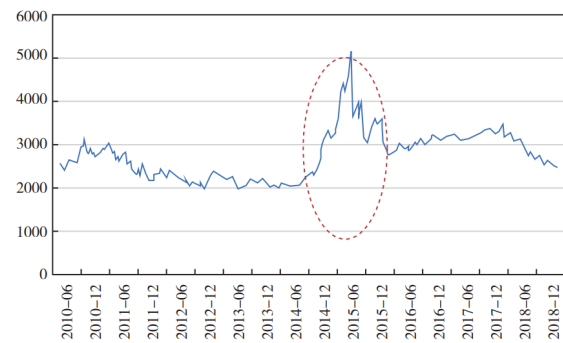


Fig.1. The closing price trend of Shanghai Composite Index in Literature [9]

2.2 Three-factor Model

2.2.1 The Background of the Fama-French Three-factor Model

Since the traditional capital asset pricing model (CAPM) was established by Sharpe (1964) and others on a series of overly rational and strict assumptions, the CAPM model is almost completely in some work (such as dealing with the market value effect, explaining the excess return of assets, etc.) invalidate. Based on this, many researchers have tried to improve the model by relaxing the assumptions of the traditional CAPM model. Merton (1973) rejected the restriction that investors can only invest in a single period in the CAPM, and proposed a more realistic intertemporal capital asset pricing model (ICAPM). Ross (1976) proposed the arbitrage pricing model (APT). Although some scholars agree that the arbitrage pricing model (APT) can be used as a substitute theory for CAPM, and compared with traditional CAPM, APT does not have so many strict assumptions, but because it does not give specific factors driving asset prices, it leads to a lot of tedious calculation in practical application, so the application universality of CAPM is still higher than that of APT. In addition, since the 1980s, many scholars have independently discovered that with the in-depth study of the financial market and its continuous development, many anomalies that cannot be explained by traditional finance have appeared in the financial market, such as, The phenomenon of herd effect, scale effect, noise and noise trading, etc. This makes it seem urgent to improve the traditional CAPM model, and the most classic of these improvements is the three-factor pricing model proposed by Fama and French (1993) based on the empirical analysis of US stock data.[11]~[14]

2.2.2 Empirical Test of the Three-factor Model in the Chinese Market

Chinese scholars have conducted a large number of empirical tests on the Fama-French three-factor model, and many scholars have generally affirmed the

performance of the model in the empirical prediction of the Chinese market. Ze-hong LI and Jun-jie PAN [15] fully considered the potential impact of changes in the industrial environment on FF3, using data from 2007-2013, they concluded that FF3 is more suitable than CAPM to predict the return rate of China's power industry stocks. Li Ziyi and Li Huanzhen [16] analyzed FF3's stocks in China's 5G sector and pointed out that the model has a certain practicability for predicting the excess return rate of the investment portfolio. S Xie and Q Qu [17] used the FF3 data on the Shanghai Stock Exchange's A-share market from January 2005 to December 2012, and believed that although the prediction results of commercial stocks are slightly different, the regression results of the three-factor model are still acceptable. It is considered to be in line with market conditions. Huang Juan[18] added a Weibo sentiment pricing factor to the three-factor model to better explain the phenomenon of excess returns in stocks. It not only verified the adaptability of FF3 in the Chinese market, but also studied the sentiment of self-media information disclosure.

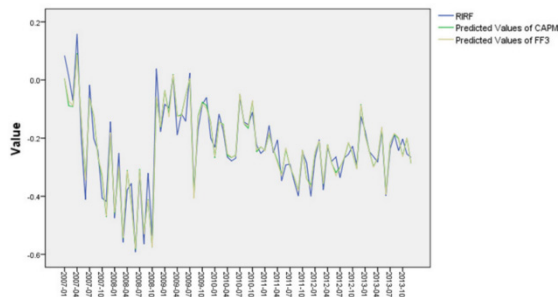


Fig.2. The fitting results of the two models in reference [15] from 2007 to 2013

2.2.3 The Research Trend of the Three-factor Model

Although the three-factor model is not based on strict assumptions like CAPM, and empirical analysis shows that the three-factor model does have better applicability than traditional CAPM, it lacks sound economic theoretical support. At present, the research results of this model are mostly based on the results of empirical tests. Therefore, researchers more often use the three-factor model to conduct empirical tests on the capital market[19]. Zhou Qi, Jiao Jian et al. [20] conducted regression analysis in different window periods based on the selected three factors, and showed that the model is invalid when the quarter is used as the data window to perform three-factor regression, and the FF three-factor only has explanatory power for long-term returns. . In addition, although FF3 does explain many financial anomalies that traditional CAPM cannot explain, recent studies have shown that the three-factor model still cannot explain the current hot issues of financial research such as excess returns, momentum

effects and reversal effects. It is a major research direction for improving three-factor model to introduce other reasonable constraint factors into three-factor model.

2.3 Four-factor Model

2.3.1 Background of the Four-factor Model

Asset pricing theory has always been a hot issue in finance research. Although the traditional CAPM model has studied the relationship between the expected rate of return of assets in the securities market and risky assets, and occupies a dominant position in modern finance. However, its assumptions are so strict that it is almost impossible to achieve them in the real market, so the traditional CAPM single factor model performs poorly in many empirical studies. Since then, many scholars have tried to obtain new models by weakening the constraints of CAPM or adding new factors, the most famous of which is the FF three-factor model based on the CAPM model and the APT model. The model adds scale factor SMB and book market value factor HML on the basis of CAPM. Although compared with the single-factor model, the model has been widely verified in empirical research, but the FF three-factor model itself cannot explain financial anomalies such as momentum effects. Carhart (1997) [21], on the basis of the FF three-factor model, by studying the returns of the American securities market, using the JT method to construct the momentum factor WML, the four-factor model was obtained. After empirical analysis, it is concluded that the four-factor model, compared with the three-factor model, more comprehensively reflects the impact of various factors on fund performance, so it can better evaluate portfolio returns. At the same time, the four-factor model also verifies the effectiveness of the momentum factor.

2.3.2 Empirical Study of the Four-factor Model in the Chinese Market

As the academic circles still dispute whether there is a significant momentum effect in the Chinese market, researchers have different opinions on whether the empirical performance of the four-factor model in the Chinese market is better than the three-factor model. Cao Binjie [22] tested the data of all A-shares listed on the Shanghai Stock Exchange from July 2005 to June 2018 respectively with the three-factor model and the four-factor model, and found that compared with the three-factor model, the fitting results of the four-factor model were not significantly improved, and the performance of the newly added momentum factor was not significant. Zeng Hui [23] divided the weekly return rate data of Shanghai A-shares from May 2009 to April 2013 into 9 groups of portfolios, and made an empirical analysis with the Carhart four-factor model, believing

that the momentum factor MD3 of the four-factor model significantly improved the explanatory ability of the model. Cheng Gang and Zhang Xiaoyan [24] evaluated the performance of hybrid funds in China's fund industry, and believed that the fund performance evaluation system based on the four-factor model is better than the ranking based on absolute returns, but the four-factor model itself is not applicable in China. Xu Hongyu and Xiong Chang [25] took A-share listed companies from 2004 to 2005 as samples and believed that the explanatory power of the four-factor model with momentum factor was improved to a certain extent, but the model still could not fully explain the stock return and there were still influencing factors that had not been taken into account. Zhao Dongjun [26] studied the investment performance of open-end stock funds from January 2013 to June 2018 and believed that the four-factor model fitted the overall data of open-end stock funds in China well and could be used as a powerful tool to analyze the performance of open-end stock funds in China.

2.3.3 The Improvement of the Four-factor Model by Chinese Researchers

As the Chinese market is an emerging and rapidly developing market, Chinese researchers have done a lot of improvements to the four-factor model to make it more suitable for market analysis in China. Wang Wei [27] added the performance comparison benchmark of the fund to the traditional Carhart four-factor model. The improved model has significantly improved the interpretation of the excess return of the fund, and the evaluation of the performance of China's equity open-end funds is more reliable. In view of the fact that domestic scholars generally believe that the reversal effect rather than the momentum effect exists in the Chinese market, Ouyang Zhigang and Li Fei [28] proposed a momentum factor through the reversal effect, which effectively improved the explanatory power of the FF three-factor model. However, it still shows that the four-factor pricing model cannot fully explain the changes in the average stock return. Zhong Qiu [29] creatively added a price factor to the traditional Carhart four-factor model in view of the financial anomalies existing in China's capital market, such as small-cap effect and book-to-market ratio effect, and conducted an empirical test by using the relevant data of LOF fund from July 2013 to June 2018.

The results show that the improved four-factor model is significantly better than other models in evaluating the overall performance of China's LOF fund. Gao Xian [30] found that investor sentiment is an important asset pricing factor of China's stock market, and built a new four-factor model based on it. Through empirical analysis, he concluded that asset pricing

factor with investor sentiment can better explain China's stock market.

2.4 Five-factor Model

2.4.1 The Background of the Five-factor Model

Fama-French (1993) [31] based on the traditional CAPM model and APT arbitrage theory, introduced the scale factor (SMB) and book-to-market ratio factor (HML) into the factor model, and proposed the FF three-factor model. Although the explanatory power of the FF three-factor model is significantly improved compared to the CAPM model and does not include the strict assumptions of CAPM, the FF three-factor model lacks a rigorous theoretical basis and cannot explain financial anomalies such as momentum effects. Carhart (1997) [21] constructed a four-factor model by adding momentum factors to the three-factor model, which not only verified the effectiveness of the momentum factor, but also significantly improved the model's ability to interpret portfolio returns. In the global financial market, Fama-French (2012) [32] selected the stock market data of Europe and the United States, Japan and the Asia-Pacific region as samples, and found that the value premium phenomenon was prevalent in the returns of these four regions, and except Japan, the stock returns of the other three regions showed strong momentum effect. The above work has contributed to the revision and improvement of the factor model. Fama-French (2014) [33] proposed a five-factor model by adding corporate profitability factor (RWM) and corporate investment level factor (CMA) into the previously proposed three-factor model in order to better explain the difference in return rate of the stock market.

2.4.2 Empirical Research on the Five-factor Model in the Domestic Capital Market

Cui Lifang and Chen Xiqiang [34] studied the stock market of China's home appliance industry based on the Fama-French five-factor model, and found that the effect of size factor and investment factor was not significant, and in the FF five-factor model, book-to-market ratio factor and profit factor showed mutual "attraction". Liu Lili and Liu Yu [35] tested whether the five-factor model is applicable to the stock analysis of listed companies in China's commercial circulation industry. The results show that the five-factor model has good explanatory power, and the five-factor model can provide an accurate analysis of the return rate for the stock market of listed companies in China's commercial circulation. Guo Zhuxi [36] used the Fama-French three-factor model and five-factor model to carry out an in-depth study on the iron and steel enterprises listed on the A-share market. Through empirical test, it is concluded that the Fama-French five-factor model is not effective in the steel sector of China's stock market, and

the regression effect is worse than that of the Fama-French three-factor model. The profitability factor and investment style factor of the Fama-French five-factor model are redundant. Shen Boren[37] combined the Fama-French five-factor model with the residual self-help method, and through the autonomous simulation sampling with replacement of the residual sequence of regression results, he concluded that the Fama-French five-factor model had good applicability for the performance analysis of public offering funds in China.

2.4.3 Empirical Research on the Five-factor Model in the Foreign Capital Market

Because different countries and regions have different market.... Bert AK, Uyar U, and Uyar SK[38] tested the relationship between average return and risk factors in the FF five-factor model through wavelet multiscale analysis, and the results showed that all risk factors in the five-factor model were not redundant. Fama and French[39] tested the applicability of the five-factor model in the global stock market, and the results showed that the five-factor model performed well in the European, North American and Asia-Pacific markets, except for the lack of effectiveness in the Japanese market. Mosoeu Selebogo and Kodongo Odeno [40] used the Fama-French five-factor model and generalized moment regression to analyze the data from January 2010 to December 2015, and the results showed that the factor of profitability was the most effective factor to explain the cross-section of stock returns in emerging markets. But the five-factor model does poorly for country-specific portfolios and geographically diversified portfolios. Li Shuai and Zhang Qiang [41] used the Fama-French five-factor model to study the stocks of the pharmaceutical industry in the United States before and after the COVID-19, and the results showed that the epidemic did not have a significant impact on the pharmaceutical industry in the United States, and the explanatory power of the Fama-French five-factor model on the industry was strengthened after the end of the epidemic. Jose Luis Miralles-Quiros, Maria Mar Miralles-Quiros, Jose Manuel Nogueira[42] A selection of ETFs (exchange-traded funds) that are traded on the Nasdaq. Using the Fama-French five-factor model, this paper studies the latest content of the framework of socially responsible investment -- SDG assets. The results show that investors in this field should focus on the SDG such as health, industry, innovation and infrastructure.

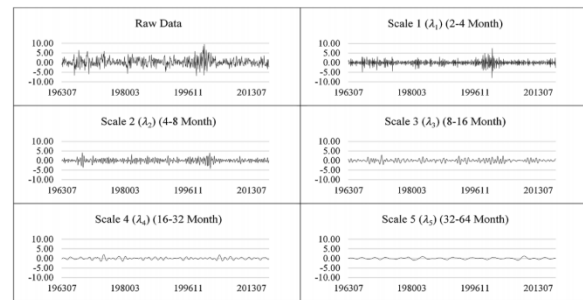


Fig.3. The ME1BM1 portfolio graph based on different time scales and original time series in Literature [38].

2.4.4 Research on the Improved Factor Model

Because different countries and regions have different market environments, and investors' mentality under different market environments are also different, no matter what kind of factor model, when it is specifically applied to predict a certain market trend or investment return, it may fail. For this reason, many researchers try to apply improved factor models that add new factors according to the market environment or investor mentality to predict investment returns. Jiao Jianyu [44] studied the applicability of the five-factor improved model with liquidity factor in the Chinese market, and the results showed that the explanatory ability of the modified model was slightly better than that of the five-factor model, but it only had limited explanatory ability for the fluctuation of stock return rate in the GEM market. Fu Yimo [45] first built a six-factor model by adding emotional factors to the FF five-factor model, and found that some factors and emotional factors of the five-factor model can be applied to the Chinese A-share market, and then removed the investment factor from the six-factor model, and found that the new multi-factor model can better explain the stock returns in China's A-share market. Yin Yuqiao [46] added a pricing factor to the FF five-factor model to obtain a six-factor model, which better explained the five patterns existing in China's A-share market. Liu Jingyi [47] studied a six-factor model adjusted by liquidity and price-earnings ratio, and the results showed that the improved model has significantly improved explanatory power for China's stock market compared with the FF five-factor model.

3. Conclusion and Future Research Outlook

This article mainly sorts out the main research results in the field of capital asset pricing theory and the empirical research of related models in the domestic and foreign securities markets, and shows the latest improvement results of a small number of researchers on the factor model. By analyzing the existing research results, we can see that, whether in domestic or foreign capital markets, the explanatory power of each factor

model shows different performance depending on the research object, region, time and other factors. The applicability in this market is inconsistent. Literature [6], [7] show that the classic single-factor CAPM model has not shown applicability in domestic and foreign markets. Although the Fama-French three-factor model and its improved model proposed later have generally shown accuracy in many empirical tests in the Chinese market[16][17][18], It still fails to explain many of the financial anomalies that are widely studied in academia today. Afterwards, Carhart (1997) [21] used the JT method on the three-factor model to construct a four-factor model obtained by the momentum factor WML, but the model did not show better explanatory power in many studies by Chinese scholars [22][23][24], only after adding new factors according to the actual market conditions, its explanatory power can be improved, but it still cannot explain problems such as changes in the average return rate of stocks[24]. Fama-French (2014) [33] proposed a five-factor model. Although this model takes into account more constraints in the real market than the previous three-factor model, however, the five-factor model still performs poorly in many empirical studies of financial markets at home and abroad [37][46]. In addition, in the immature and fast-developing Chinese market, the explanatory power of the factor model is quite different from that of the major western developed countries. Therefore, the construction of the factor model suitable for the Chinese market is a hot research topic in China's financial academia [43][44][45][46]. So far, every factor model has been questioned because of its own theoretical foundation flaws, or has performed poorly in the forecast of the securities market, and is no longer suitable for the current fast-developing capital market. This is all because in the real intricate market environment, we cannot construct an asset model that includes all possible impact factors.

Because the biggest reason for the deviation between the explanatory effect of the factor model and the actual market results is that the factor model fails to fully consider the various possible influencing factors in the actual market conditions, the current research on asset pricing factor models is mainly focused on constructing new on the impact factor. In addition, due to the continuous development of the modern capital financial market, traditional finance based on the rational economic man hypothesis and the efficient market hypothesis has been questioned and challenged. Accompanied this, behavioral finance that takes irrational factors into consideration has emerged. The construction of a new asset pricing model has become a hot topic of current research. In addition, for the relatively short and immature Chinese market, the research on asset pricing models suitable for Chinese market conditions is a current research hotspot for Chinese researchers.

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