Advances in Economics, Business and Management Research, volume 211
Proceedings of the 2022 7th International Conference on Financial Innovation and Economic Development (ICFIED 2022)

Research on Application of Fama-French Three-Factor Model in Asset Allocation

Yifan Chu[1,*]

[1] *College of Commerce, Nanjing Normal University, Nanjing 210000, China*
[*]*Corresponding author. Email: 15200356@njnu.edu.cn*

ABSTRACT
As the index of living standard is rising in the recent decades, more and more people join the stock market or have the demand to allocate their assets. That stimulates the appearance of the capital asset pricing model, the Fama-French model, and some other models that are helpful for asset allocation. This paper combs through the development of these models by doing the literature reviews. After listing several examples of expansion to the models, it is natural to conclude that the following research in this field might focus on the specialty of the Fama-French model in different countries and areas or come up with some new factors that influence asset pricing. Also, frequent application of the Fama-French model in the stock market would be consistent in the future with a probable trend of adding some new methods such as artificial neural networks. This paper attempts to introduce some traditional asset pricing models like CAPM and the Fama-French model, along with their expansion in aspects of adding factors or new tools in recent years, then provide a suggestion of specific and innovative research.

Keywords: *Capital asset pricing model, Fama-French three-factor model, Asset allocation.*

1. INTRODUCTION

Markowitz came up with the Portfolio Theory in 1952 and carried out systematic and in-depth research [1]. Based on this, Sharpe et al. developed the capital asset pricing model [2]. The CAPM mainly focuses on relationships between expected return rate and risky assets in the securities market, and the formation of equilibrium price. The CAPM is widely used in fields relevant to investment and corporate finance. The theory of CAPM provides a simple conclusion: high return is consistent with high risk, which dominates the modern financial theory. The primary importance of this theory might be that it established the relationship between expected return and risk. Meanwhile, it divided expected return into a risk-free rate and risk compensation, thus we can calculate the expected return roughly.

There are lots of extensions and applications of the CAPM, among which the most popular one might be the factor model. Factor models are frequently used to assess portfolio performance. Using these models can make asset pricing and asset allocating more precise by adding more relevant factors. Besides, the theory also differentiates market risk and unsystematic risk. It is pointed out that unsystematic risk could be eliminated by diversification.

The purpose of this paper is to go over previous research, list the proposed model systematically, and then make some anticipations of the following trend of researching Capital Asset Pricing Model. Combing through the development process of the CAPM and Fama-French model contributes to expanding these models and making them more precious in asset pricing. Also, the present extensions point out directions of researching in the future.

2. METHOD DESCRIPTION

2.1. CAPM

Markowitz came up with the theory of diversification and efficient portfolio investment, which showed how a risk-averse investor selects an optimal portfolio from all the risky assets using rigorous mathematical tools for the first time. This theory was considered to be normative at that time for it explained how investors should choose the portfolio. However, the application was limited by the complicated process and was not suitable for solving real problems. To simplify Markowitz's theory, economists such as W. Sharpe

started to explore the realistic application of securities investment from an empirical perspective. Their issues included if all the investors adopt Markowitz portfolio theory to select the optimal portfolio, in which way will the equilibrium price of assets be formed in the trade-off between return and risk? In other words, how would risk decide asset prices in the condition of market equilibrium?

These researches directly led to the appearance of the Capital Asset Pricing Model (CAPM). CAPM takes the insights from mean-variance analysis and tells there would be market equilibrium when all the investors are using Markowitz's theory for managing their investment. The theoretical relationship between expected returns and risks is expressed in a simple linear relationship, where risk premium is measured by the asset's covariance with the market return.

Sharpe found the following equation for an expected return of an individual stock or portfolio of stocks:

$$\overline{r_a} = r_f + \beta_a * (\overline{r_m} - \overline{r_f}) \quad (1)$$

and Beta in this equation represents how the asset co-vary with the market, which can be calculated as:

$$\beta_a = \frac{Cov(r_a, r_m)}{\sigma_m^2} \quad (2)$$

However, there is still some limitations with CAPM. It requires strong assumptions on the distribution of returns, investor utility, information, and beliefs. And it also faced empirical challenges later. Afterward, some modified models had been proposed, such as APT, ICAPM, and CCAPM [3-5].

2.2. Fama-French Three-factor Model

Fama and French conducted a study in 1992 which focused on factors that determine the variations in returns of different stocks in the American stock market and found that the market beta value of stocks could not explain the differences while the market value, book-to-market ratio, and price-earnings ratio of listed companies performed well in explaining the differences in stock returns [6]. The excess returns, according to Fama and French, compensate for the risk factors that β does not reflect in CAPM. Then they improved the CAPM and came up with the three factors model, which proposed that the excess return could be explained by these three market risk factors:

$R_M - R_f$: the excess return on a broad market portfolio;

SMB (small minus big): the difference between the return on a portfolio of small stocks and the return on a portfolio of large stocks;

HML(high minus low): the difference between the return on a portfolio of high-book-to-market stocks and the return on a portfolio of low-book-to-market stocks.

Specifically, the expected excess return on portfolio i is,

$$E(R_i) - R_f = b_i[E(R_M) - R_f] + s_i E(SMB) + h_i E(HML) \quad (3)$$

2.3. Fama-French Five-factor Model

In 2015, Fama and French improved their three-factor model and added another two factors, included profitability and investment patterns [7]. Thus the five factors model was created.

In tests on US returns, Fama and French found that the average returns on portfolios of small stocks with factor loadings, such as those of firms that invest heavily despite low profitability are generally much lower than predicted by the five-factor model. This result is also noticeable in the anomaly sorts in Fama-French model. Although the low average returns for these stocks are more extreme in Europe and Asia, in some ways the five-factor model captures them. In the empirical test, the two factors were explained as below:

RMW (robust minus weak): the difference between the return on stocks with robust profitability and stocks with weak profitability

CMA (conservative minus aggressive): the difference between the return on stocks of low investment firms and stocks of high investment firms

Therefore, the new formula would be:

$$R_{it} - R_{Ft} = a_i + b_i Mkt_t + s_i SMB_t + h_i HML_t + r_i RMW_t + c_i CMA_t + e_{it} \quad (4)$$

However, the five-factor model, like the FF three-factor model, is an empirical asset pricing model meant to reflect significant patterns in average returns, as Fama and French wrote in their paper. Empirical asset pricing models can only be rated on empirical robustness because of their fragile theoretical foundations.

3. APPLICATION

3.1. The Expansion of the Models

Following the steps of Fama and French, a lot of economics noticed some other factors in asset pricing and expanded the Fama-French model in different aspects.

First of all, some new factors which play an important role in asset pricing have been proposed in recent years. Pastor and Stambaugh researched whether liquidity of the whole market is significant for asset pricing as a state variable. They focused on systematic liquidity risk in returns and discovered that equities with greater projected returns tend to be more sensitive to market-wide liquidity swings. In the beginning, they expounded on the construction of liquidity measures and described some empirical features of the measures

briefly. Then they went on for an investigation on asset pricing and researched in the degree to which differences between equities with high and low liquidity risk influence the mean-variance opportunity set, offering an investing opinion about liquidity risk. Finally, they got the conclusion that the expected return of stocks is cross-sectionally related to the integral liquidity innovation [8].

Baker and Wurgler developed a "top-down" and macroeconomic investor sentiment approach in their study and asked how to empirically measure the investor sentiment. Then they discussed whether the stocks which are hard to be arbitraged are more sensitive to the sentiment. They also looked into whether present levels of investor sentiment predict future returns as the sentiment declines. It was shown in the paper that investor sentiment can be measured and that waves of sentiment have visible, significant, and predictable consequences on the whole of individual companies and the stock market [9].

Moreover, some scholars improved the existed model by renewing the method of research. Huynh and Smith pointed out a bias in the previous methodology of component-level risk adjustment. By using CRSP (the Center for Research of Security Prices) monthly data, they discovered that when using the conditional asset pricing model to risk adjust returns on single winner and loser stocks, average momentum alphas are reduced by 14 percent (for the CAPM) to 50 percent (for the FF3F model) compared to the separate portfolio-level estimate. When compared to the standard portfolio-level estimate, using the conditional FF3F model to risk adjust returns on winner and loser stocks would lead to a 50% drop-down of the average momentum alpha [10].

In 2006, Fama and French observed that the Miller Modigliani valuation formula entails a set of fundamental relationships among four variables: future stock returns, current BM, firm-level expected profitability, and firm-level projected investment. Their empirical work, however, fails to prove the predicted negative relationship between expected investment and stock returns, which is since that the tests looked at per share measures of expected investment and expected profitability, and valuation formula does not always hold in per share. Aharoni et al. concluded that the key to comprehending the relationship between expected returns, BM, expected profitability, and expected investment empirically at the same time is measuring investment at the level of firms rather than the level of shares [11].

Racicot and Rentz set up an investigation on the Fama-French five-factor model with an advanced generalized method of moments(GMM), which based robust instrumental variables technique in a fixed-effects panel data framework. They also used modified Hausman artificial regressions to test for measurement errors. Besides, they examined an expanded Fama-French six-factor model including the liquidity factor, concluding that the only factor that counts consistently is the market factor [12].

Through these extensions of the model, the asset pricing model is becoming more suitable for the real market. And such research is still on the way.

3.2. Applications in Different Stock Markets

To verify the practicality of this model, several investigations have been carried out in different countries and areas such as China, Australia, Europe, and so on.

Griffin provided a comprehensive examination of whether country-specific or global versions of the Fama-French three-factor model performed better in explaining time-series variation in worldwide stock returns in 2002. It has been proved by the regressions for portfolios and single stocks that the domestic factor models can explain the time-series variation of returns more than the global model and provide more accurate pricing with lower pricing. And the findings also indicated that it is unnecessary to extend the three-factor model to a worldwide context [13].

In 2004, Gaunt extended prior Australian work and contribute toward significant out-of-sample tests of the three-factor model. By using the Australian data, Gaunt extended the present published Australian literature by estimating the capability of the three-factor model to capture the underlying business risk. Empirical tests of the paper indicated that the three-factor model worked better than the CAPM in explaining observed Australian stock returns. With the quantitative analysis, the paper also evidenced that the BM factor plays a role in asset pricing [14].

Fama and French did a worldwide test of the five-factor asset pricing model. The book-to-market ratio (B/M) and profitability are positively connected to stock returns in North America, Europe, and the Asia Pacific, but the investment is negatively related. Average returns make little difference on investment or profitability, even if the average returns have a substantial correlation with B/M in Japan. A five-factor model added with profitability and investment factors essentially absorb the patterns in average returns. As Fama and French wrote in 2015 and 2016, the model's prime problem is the failure to fully capture the low average returns of small stocks whose returns behave like those of low profitability firms that invest aggressively [15].

Guo et.al. conducted out-of-sample testing of Fama and French’s five-factor model for the Chinese stock market. They found strong size, value, as well as profitability patterns in average returns, but weak investment patterns. They discovered that the

profitability component considerably enhances the statement of average return in the portfolios they studied, but that the investment factor has just a marginal impact. During the periods 07/1995 – 06/2015 and 07/1997 – 12/2013, factor spanning studies show that the investment factor is redundant for the stock market in China. Furthermore, the five-factor model passes the GRS tests given by Gibbons et al. for the majority of the portfolios they examined [16].

Huang confirmed that the Fama and French five-factor model outperformed other traditional asset pricing models in explaining individual stock gains in China during 1994-2016. Huang examined the effectiveness of classic asset pricing models using firm-level data across time. The Fama and French five-factor model was found to be able to explain 47.7% of the variation in the excess returns on individual stocks on average. The Share-Structure Reform is also discovered to induce a structural change in the model's performance. Further research demonstrated that the five-factor model's explanatory ability varies over time [17].

Hu et al. researched the size and value factors cross-sectionally in returns for the Chinese stock market. They constructed two zero-cost portfolios, small-minus-big (SMB), and high-minus-low (HML), following the methodology in Fama and French, to imitate risk factors related to size and value in the Chinese stock market. And for formal asset pricing tests, they employed both the time-series and the Fama-MacBeth regressions. They found a significant size effect instead of a strong value effect. The results contradicted some of the previous studies which document a value effect. The extreme values in several months in the early years with a few stocks and high volatility has contributed to the difference. Their impact becomes insignificant with a longer sample and proper changeable adjustment [18].

During the research in one particular area, scholars also used artificial intelligence. Below is one of the examples. Cao et.al. compared the expected power of the neural network models with single or multiple variables to that of linear models from the financial forecasting literature. Evidence exists that the factors that drive stock returns in developing markets differ from those that influence stock returns in industrialized countries. Artificial neural networks were used in this study to forecast stock price movement (i.e., price returns) for companies traded on the Shanghai stock exchange. When compared to linear models, the results demonstrate that neural networks outperform them. These outcomes are statistically important in all of our sample companies and show that the neural network is a useful tool for predicting stock prices in emerging markets such as China [19].

Through these investigations, it can be found that the Fama-French model does not fit every economy entirely. The application of this model requires specific adjustments considered in the realistic situation.

4. TREND ANALYSIS

4.1. Difference among Areas

As former investigations pointed out, the performance of the Fama-French model differs in different countries and areas and is proved to be country-specific. Therefore, future research may focus on different influential factors in different countries and areas through testing the performance of the original Fama-French model and the expanded ones. Thus, a model that is relatively suitable for the local stock market will be found.

4.2. Application in the Stock Market

Overall, the FF3 and FF5 models are generally applied a lot in the stock market, helping people choose their stocks. Some of the researches in recent years added several new factors like the marketwide liquidity and momentum in the model and gain satisfactory results. As the most widely-used asset pricing model, the Fama-French model is definitely to be applied in more fields with improved details.

4.3. Updates of the Methodology

After the emergence of the Fama-French model, lots of scholars are researching in this field and continuously expanding this model. Since the data and samples in every market are both numerous and sophisticated, simply calculating it by using the computer might not work so well. It is supposed that in the future, such work would be finished by artificial intelligence, which improves efficiency a lot.

5. CONCLUSION

The study set out to organize the previous research of the traditional asset pricing model and its recent development of several extensions and then offer some advice about researches in the future. From the review of the current literature and the existing investigation, this paper has found that the Fama-French model is not suitable for every religion, therefore the applications are ought to be more specific. Moreover, modern tools like the neural network also play an important role in the addition of asset pricing models. The insights gained from this study may be of assistance to the following research relative to asset allocation. As the structure of asset pricing model is already fixed, the following researches may focus more on the specialties. In detail, research is needed to consider the special reality of

different countries and combine the up-to-date technology with the existing model, which might make the investigation more efficient. This is firmly believed to be a fruitful area for further work.

REFERENCES

[1] Markowitz, H. M. (1952). Portfolio selection. The Journal of Finance, 7(1), 77.

[2] Sharpe, W. F. (1964). CAPITAL ASSET PRICES: A THEORY OF MARKET EQUILIBRIUM UNDER CONDITIONS OF RISK*. Journal of Finance, 19(3), 425–442.

[3] Ross, Stephen A. "The Arbitrage Theory of Capital Asset Pricing." Journal of Economic Theory, vol. 13, no. 3, 1976, pp. 341–360.

[4] Merton, Robert C. "AN INTERTEMPORAL CAPITAL ASSET PRICING MODEL." Econometrica, vol. 41, no. 5, 1973, pp. 867–887.

[5] Lucas, Robert E. "ASSET PRICES IN AN EXCHANGE ECONOMY." Econometrica, vol. 46, no. 6, 1978, pp. 1429–1445.

[6] Fama, E. F., & French, K. R. (1992). The Cross - Section of Expected Stock Returns. Journal of Finance, 47(2), 427 – 465.

[7] Fama, E. F., & French, K. R. (2016). Dissecting Anomalies with a Five-Factor Model. Review of Financial Studies, 29(1), 69 – 103.

[8] Pastor, L., & Stambaugh, R. F. (2003). Liquidity Risk and Expected Stock Returns. Journal of Political Economy, 111(3), 642 – 685.

[9] Baker, M., & Wurgler, J. (2007). Investor Sentiment in the Stock Market. Research Papers in Economics.

[10] Huynh, T. D., & Smith, D. R. (2014). Conditional Asset Pricing and Momentum. Social Science Research Network.

[11] Aharoni, G., Grundy, B., & Zeng, Q. (2013). Stock returns and the Miller Modigliani valuation formula: Revisiting the Fama French analysis. Journal of Financial Economics, 110(2), 347–357.

[12] Racicot, F.-E., & Rentz, W. F. (2017). A panel data robust instrumental variable approach: a test of the new Fama-French five-factor model. Applied Economics Letters, 24(6), 410–416.

[13] Griffin, J. M. (2002). Are the Fama and French Factors Global or Country Specific. Review of Financial Studies, 15(3), 783–803.

[14] Gaunt, C. (2004). Size and book to market effects and the Fama French three factor asset pricing model: evidence from the Australian stockmarket. Accounting and Finance, 44(1), 27 – 44.

[15] Fama, E. F., & French, K. R. (2017). International tests of a five-factor asset pricing model ☆. Journal of Financial Economics, 123(3), 441–463.

[16] Guo, B., Zhang, W., Zhang, Y., & Zhang, H. (2017). The five-factor asset pricing model tests for the Chinese stock market. Pacific-Basin Finance Journal, 43, 84 – 106.

[17] Huang, T.-L. (2019). Is the Fama and French five-factor model robust in the Chinese stock market? Asia-Pacific Management Review, 24(3), 278–289.

[18] Hu, G. X., Chen, C., Shao, Y., & Wang, J. (2019). Fama–French in China: Size and Value Factors in Chinese Stock Returns. International Review of Finance, 19(1), 3–44.

[19] Cao, Q., Leggio, K. B., & Schniederjans, M. J. (2005). A comparison between Fama and French's model and artificial neural networks in predicting the Chinese stock market. Computers & Operations Research, 32(10), 2499–2512.