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A Comparative Study of Markowitz, CAPM and Fama-French Models in Portfolio Return Forecasting

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Abstract: This paper aims to offer a deep comparative study of the financial markets by using three important portfolio theories: Markowitz Portfolio Theory, Capital Asset Pricing Model (CAPM), and Fama-French Multifactor Model. By analyzing the underlying assumptions, model construction, risk-capturing ability, and their efficacy in predicting portfolio returns, this paper endeavors to illuminate the application of these theories in modern portfolio management and their strengths, weaknesses, and differences from each other. It is found that while the Markowitz model emphasizes the core of diversification in risk management, the Fama-French model offers a more thorough framework for risk assessment by adding various risk variables, whereas the CAPM provides a more succinct approach through the concept of systematic risk. Each model has specific application scenarios and limitations, and its effectiveness relies on market conditions and investors' needs. The research in this paper provides theoretical guidance for scholars and investors specializing in finance and a practical reference for actual investment management.

Keywords: Markowitz portfolio theory, capital asset pricing model (CAPM), Fama-French multifactor model.

1. Introduction

In modern financial markets, constructing and managing investment portfolios is a key part of realizing asset appreciation [1]. An effective portfolio strategy can not only improve the expected return of assets but also control the risk at the same time, and realize the optimal allocation of assets. Moreover, a variety of portfolio models have emerged from financial theories in the 20th century, the most representative of which are Markowitz's portfolio theory [1], the CAPM [2], and the Fama-French's multi-factor model [3].

The model has become a cornerstone in the finance field and has significantly impacted both theory and practice. As the pioneering work of modern portfolio theory, the Markowitz model proposed a quantitative analysis of the risk and return of investment portfolios for the first time. It emphasizes that through rational allocation of assets and diversification of investments, the portfolio's overall risk can be effectively reduced without lowering the expected return. Then, the Capital Asset Pricing Model (CAPM) further develops this theory by providing a systematic method for assessing the relationship between risk and expected return of portfolio investments. On the other hand, the Fama-French multi-factor model introduces multiple risk factors to the CAPM to more comprehensively capture the various market and non-market factors that affect asset returns.

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The purpose of this paper is to explore in depth the role of these three models in predicting portfolio returns, and to compare their strengths and weaknesses, as well as their similarities and differences, in terms of underlying assumptions, model construction, risk capture, and return prediction. Through in-depth analysis and comparison of these models, their application in modern financial markets and their guiding role in investment strategies can be better understood. This is not only of great theoretical significance for scholars and students of finance but also provides a valuable reference for investment management in financial practice.

2. portfolio theory

2.1. Fundamentals of the theory and model construction

Markowitz portfolio theory, proposed by Harry Markowitz in 1952, marks the birth of modern portfolio theory [1]. The core of the theory lies in the idea of "diversification to reduce risk". By building the Efficient Frontier, it achieves the ideal balance between risk and return and presents the quantitative concepts of expected return and risk.

Markowitz suggests that to calculate a portfolio's expected return and risk, consider each asset's mean and variance and combine them with the covariance of assets.The cardinal objectives of investors revolve around two key facets: either elevating the expected return to its zenith for a pre - specified degree of risk, or diminishing the risk to its nadir for a predetermined level of expected return. By employing this analytical approach, investors are able to pinpoint the optimal position on the efficient frontier, which essentially represents the ideal investment portfolio.

2.2. Application of the Markowitz model to predicting portfolio returns

The asset allocation technique primarily reflects the use of Markowitz's model in portfolio management. In 1952, Markowitz put out the fundamental foundation of contemporary portfolio theory, highlighting the fact that asset diversification may lower a portfolio's total risk without lowering expected returns. According to Markowitz, an investor may create a "efficient frontier" that reduces risk for a certain return aim or maximizes return for a given degree of risk.[1] In 1959, he further elaborated the mathematical foundations and practical applications of portfolio selection, emphasizing the construction of optimal portfolios through the calculation of covariance matrices between assets. He proposed the mean-variance optimization framework, which provides a methodology for systematic asset allocation for both institutional and individual investors [4].In 1991 Markowitz reviewed the development and application of portfolio theory and emphasized the importance of portfolio theory for asset allocation decisions. He pointed out that although the theory assumes that markets are perfectly efficient and investors are perfectly rational, this does not always hold true in actual markets, yet portfolio theory still provides a solid theoretical foundation for modern asset allocation [5]. The model quantitatively analyzes the risk and return of various assets to help investors make a reasonable choice among diversified assets. In practice, the model can guide investors to choose an appropriate asset portfolio according to their own risk preferences, so as to achieve the purpose of risk control and return maximization. The Markowitz model emphasizes the reduction of overall portfolio risk through asset diversification. A quantitative approach is provided to assess and balance risk and return. The model assumes that markets are perfectly efficient and that investors are rational, which often does not hold true in real markets. Accurate estimation of returns, variances and covariances requires a large amount of historical data and the calculation process is relatively complex.

Despite some of its limitations, the Markowitz model remains the cornerstone of understanding and practicing modern portfolio theory and has had a profound impact on subsequent investment theory and practice.

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3. Fama-French Multifactor model

3.1. Fundamentals of the theory and model construction for different versions (FF3F/FF4F/FF5F)

In the early 1990s, Eugene F. Fama and Kenneth R. French put forward the Fama - French multifactor model with the aim of offering a more comprehensive explanation for the expected returns on securities. The fundamental premise of this model lies in expanding the traditional Capital Asset Pricing Model (CAPM). It achieves this by incorporating multiple risk factors, thereby enabling the capture of multidimensional risks present in the market.

Among the various iterations of the model, the widely - recognized three - factor model, also known as the FF3F model, has demonstrated its explanatory power. It posits that the market risk premium (the market factor), the size premium (the size factor), and the value premium (the book - to - market ratio factor) are the key drivers that account for the majority of the cross - sectional variance in stock returns. Empirical research indicates that firms characterized by high book - to - market ratios and relatively small market capitalizations are likely to generate a risk premium that cannot be adequately explained by a single market - related factor alone [3].

Building upon the three - factor model, the FF4F model introduces the momentum factor, thus evolving into a four - factor framework. Research findings suggest that the inclusion of the momentum factor enhances the model's ability to elucidate the persistence of mutual fund performance. This implies that the short - term momentum effect plays a crucial role in determining stock returns, and it cannot be fully encapsulated by the original three factors [6].

Further extending the model, the FF5F model incorporates two additional factors: profitability and investment mode, resulting in a five - factor model. Studies have revealed that companies boasting high profitability and low investment tendencies generally exhibit higher returns.Moreover, the five - factor model significantly enhances the capacity to explain the disparities in stock returns [7].

In summary, by integrating multiple risk factors, these Fama - French multifactor models offer a more nuanced and holistic perspective for analyzing and forecasting asset returns.

3.2. Application of the FF model in predicting portfolio returns

The primary application of the Fama-French model in portfolio management is to help investors identify and capitalize on risk factors in the market to improve asset allocation and enhance portfolio performance. By identifying the key factors that affect the expected return of assets, investors can adjust their investment strategies more precisely to market changes. Compared with the traditional CAPM, the FF model is able to explain and predict stock returns more comprehensively by introducing multiple factors.

In 1993 Fama published a paper in which he constructed the famous three-factor model, followed by a further study in 1996, which extended the three-factor model and proved that the model could explain many market anomalies that could not be explained by the single-factor CAPM, such as the long-run inversion effect[8],In 1998 he published a paper in which he formally applied the three-factor model to the international market, and found that value premiums are globally, confirming the universality of the three-factor model and showing that market risk premium, size premium and value premium are risk factors that are prevalent in the global capital market [9]. And the research has been continuously extended and further evolved into the FF4F, FF5F model. The validity of the FF model in multiple markets. As the number of factors increases, the model becomes more complex and difficult to operationalize and interpret. Accurately estimating the parameters of multiple factors requires a large amount of historical data and complex calculations. The performance of FF models may not be consistent across markets and time periods.

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Overall, the Fama-French model has an important place in both financial theory and practice, and its multi-factor framework provides a more nuanced and comprehensive tool for understanding and predicting asset returns.

4. Capital Asset Pricing Model (CAPM)

4.1. Fundamentals of the theory and model construction

William Sharpe's 1964 proposal of the Capital Asset Pricing Model (CAPM) marks a significant turning point in contemporary finance theory [2]. The approach, which was based on Markowitz's portfolio theory, made investing easier by introducing the ideas of market portfolios and risk-free assets. The fundamental tenet of the CAPM is that diversification may remove unsystematic risks and that investors are only rewarded for taking systematic risks. A linear equation serves as the model's representation. $E(Ri) = Rf + \beta i[E(Rm) - Rf]$, where the beta coefficient, a crucial metric for evaluating systematic risk, gauges how sensitive an asset is to market volatility. The CAPM makes the following assumptions: that markets are frictionless, that all investors have the same expectations, and that investors are logical and risk averse. Even if these presumptions are not entirely accurate in practice, the CAPM still offers a basic framework for risk management and asset pricing and paves the path for further advancements in financial theory.

4.2. Application of the CAPM model in predicting portfolio returns

Its straightforward depiction of the link between risk and return reflects the use of the CAPM model in portfolio return forecasting. The securities market line (SML), which gives theoretical support for asset valuation and investment decisions, is used in the model to illustrate the linear relationship between expected return and systematic risk [2]. In real-world applications, the CAPM is frequently used to determine the cost of equity capital, evaluate portfolio performance, and spot mispriced securities. The alpha coefficient, which Jensen created in 1968 using the CAPM, is now a crucial indicator of a fund manager's capacity to assess if a portfolio is beating a benchmark in the market. [10].Roll famously criticized the CAPM in 1977, stating that market portfolios can be measured by the CAPM [11]. criticism of the CAPM in 1977, pointing out the measurability problem of market portfolios, but did not dismiss the theoretical significance of the model [11]. At the same time, the CAPM model provides a framework for corporate financial decision making and helps firms to assess the cost and value of capital for new projects. Although CAPM faces challenges in empirical research, such as the difficulty of accurately estimating Beta and risk premium, its simplicity and intuition make it still maintain an important position in investment practice, providing a fundamental tool for portfolio construction and performance evaluation.

4.3. Empirical tests and extensions of CAPM models

Since its introduction, the Capital Asset Pricing Model (CAPM) has been subjected to a multitude of empirical examinations, yielding findings that paint a rather intricate scenario.

An early investigation conducted by Black, Jensen, and Scholes lent support to the linear risk - return relationship that lies at the heart of the CAPM. However, their study also uncovered an anomaly. They observed that the return generated by a zero - beta portfolio exceeded the risk - free rate. This outcome represents a departure from the fundamental tenets of the original CAPM formulation [12].

Building on this, subsequent research efforts by Fama and MacBeth further solidified the positive association between an asset's beta and its average returns. Their work provided additional empirical backing for one of the key predictions of the CAPM, while the earlier finding by Black et al. continued to highlight areas where the model's real - world performance diverged from its theoretical

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underpinnings.[13]. However, empirical studies after the 1980s gradually found many "market anomalies" that could not be explained by the CAPM, such as the scale effect, the value effect, etc., which prompted scholars to develop various extended versions of the CAPM. The Interperiod Capital Asset Pricing Model (ICAPM) was proposed by Merton, which takes into account the factor of investment opportunities over time; while the Consumer Capital Asset Pricing Model (CCAPM) takes the consumption growth rate as a risk measure [14]. The international CAPM takes into account systematic and exchange rate risks across different countries and provides a more comprehensive pricing framework for global investors. Despite the limitations of CAPM, its theoretical structure lays the foundation for modern financial theories, especially multi-factor models, such as the Fama-French three-factor model, which is an important development on the basis of CAPM, reflecting the important evolution of financial theories from single-factor to multi-factor models.

5. Comparative analysis of three models

5.1. Comparison of underlying assumptions and model construction

Markowitz model: based on mean-variance optimization, assumes that investors are risk averse and maximize expected returns and minimize risk by diversifying their portfolios.

CAPM model: based on the Markowitz model, the concept of market portfolios was introduced and assumed that all investors hold market portfolios, thus deriving the concept of systematic risk (Beta).

Several elements are added to the CAPM by the Fama-French model.Such as size of company, value and growth, and profitability, providing a more complex and comprehensive risk assessment framework.

5.2. Comparing effectiveness in risk capture and return forecasting

Markowitz model: effective for asset diversification, but its application in real markets is limited by its reliance on historical data and covariance matrices.

CAPM model: widely used to assess the risk premium of individual assets relative to market portfolios, but insufficient consideration of factors outside the market.

Fama-French model: provides a more comprehensive risk assessment and return prediction by introducing multiple risk factors, but the complexity of the model increases the difficulty of practical application.

5.3. Discuss the similarities and differences in the application of models to real financial markets

Applications: the Markowitz model focuses more on asset allocation and risk management, the CAPM is more commonly used in securities pricing and cost of capital assessment, while the Fama-French model is more widely used in investment strategy and risk assessment.

Data and computational requirements: the Markowitz and CAPM are relatively simple, but the Fama-French model requires more data and more complex computations.

Market Adaptability: Each of the three models has its limitations and strengths in specific market environments, and understanding the conditions and limitations of each model's applicability is critical to its effective application in real markets.

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6. Conclusion

This paper provides an in-depth discussion and comparison of the application of Markowitz's portfolio theory, the Capital Asset Pricing Model (CAPM), and the Fama-French multifactor model to portfolio return forecasting. Through comprehensive analysis, we draw the following conclusions:

Continuity in theoretical evolution: the Markowitz, CAPM and Fama-French models demonstrate the evolution of modern portfolio theory. From the basic framework of the Markowitz model to the CAPM's understanding of market risk to the multi-factor extension of the Fama-French model, these theories continue to deepen and enrich our understanding of market risk.

Characteristics and applicability of the models: Each model has unique strengths and limitations. The Markowitz model emphasizes the importance of asset diversification; the CAPM introduces Beta coefficients to assess and price systematic risk; and the Fama-French model provides a more comprehensive assessment of market risk by introducing multiple risk factors.

Challenges in practical applications: Despite the theoretical importance of these models, they face data and computational challenges in practical applications, as well as adaptability issues arising from changing market conditions.

Implications for investment practice: In order to build and manage their investment portfolios, investors must comprehend the foundations and constraints of these models. To create effective investment strategies, investors should integrate the benefits of several models based on their personal risk tolerance and investing goals.

Overall, the Markowitz, CAPM, and Fama-French models all provide investors with powerful tools for understanding and forecasting portfolio returns. Future research should continue to explore the applicability and validity of these models in different market environments and how they can be better integrated into actual investment decisions.

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