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Comparative Analysis and Research of Investment Portfolio Management Model

Navindra Kumar, Dr. Yerragola Prakash

NIMS University, Jaipur, India

Associate Professor, NIMS Institute of Business Studies, NIMS University, Jaipur, Rajasthan, India

ABSTRACT: The management of portfolios is essential in the realms of finance and investing, providing advantages and insights for both individual investors and financial institutions. Scholars utilize various mathematical frameworks to make educated choices regarding the allocation and management of investments within a portfolio, aiming to optimize the trade-off between risk and return according to the preferences and constraints of the investor. This paper predominantly uses literature review and comparative analysis approaches. Initially, it gathers, summarizes, and examines numerous studies on portfolio management models, including the Markowitz Mean-Variance Model, Capital Market Line (CML), Arbitrage Pricing Theory (APT), and Capital Asset Pricing Model (CAPM), focusing on the origins of these models, their fundamental assumptions, elements, and real-world applications.

Furthermore, this paper employs a comparative analysis to examine the similarities, differences, and various advantages and disadvantages of the four primary research models. Through this examination, the paper explores the relationships and application differences among these models. Consequently, these models develop and become more refined over time, with some models built upon the foundations of others. The Capital Asset Pricing Model (CAPM) enhances the Markowitz Model by incorporating the risk-free rate and the market portfolio as reference points, simplifying the risk-return relationship and introducing the concept of systematic risk. The Capital Market Line (CML), which is derived from CAPM, demonstrates efficient portfolios consisting of both market and risk-free assets and illustrates the trade-off between risk and return. The Arbitrage Pricing Theory (APT), which emerged later, can be viewed as an extension of CAPM.

KEYWORDS: Portfolio Management, Markowitz Mean-Variance Model, CML, CAPM, APT

I. INTRODUCTION

Portfolio management refers to the process of choosing investment allocations and strategies to attain specific financial objectives while controlling risk. It encompasses the selection, allocation, and oversight of various assets within a portfolio to maximize returns based on an investor's goals, investment timeframe, and risk appetite. In the initial stages of its development, portfolio optimization was frequently limited by its static nature. Unlike dynamic portfolio optimization, which regularly adjusts optimal portfolio weights according to new market data, static optimization weights cannot adapt to market changes during the investment period. Despite its effectiveness, dynamic portfolio optimization posed significant computational challenges. It's important to note that stochastic dynamic programming is the most suitable method for addressing dynamic portfolio optimization problems. Nonetheless, this approach was often hindered by various issues, particularly when it came to the dimensionality problem involving an excessive number of state variables. This paper presents and contrasts several models of portfolio management, assessing their individual strengths, weaknesses, and interconnections. The research primarily employs literature review and comparative analysis techniques to investigate portfolio management models, such as the Markowitz Mean-Variance Model, Capital Market Line (CML), Capital Asset Pricing Model (CAPM), and Arbitrage Pricing Theory (APT). It delves into the origins, assumptions, components, and applications of these models, while also examining their interrelationships and differences in application. Different portfolio management models provide various insights into the connection between risk and return. By evaluating these models, investors can gain insight into their strengths and weaknesses, enabling them to select the model that aligns most closely with their portfolio management requirements.

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Furthermore, a comparative analysis uncovers relationships and distinctions among these models, encouraging the advancement of new research and methodologies.

II. MODEL CLARIFICATION

2.1. Markowitz Mean-Variance Model

In 1952, Harry Markowitz wrote an article titled 'Portfolio Selection,' which was published that year. In this paper, Markowitz presented a risk measurement, particularly the idea of standard deviation, and developed a formula for calculating this measure in relation to a group of assets. He offered examples demonstrating the benefits of choosing assets with different correlation coefficients, effectively highlighting diversity as a means to reduce the overall risk of the portfolio. The basis of the Markowitz model is built upon a series of assumptions regarding investment behavior, as noted by Reilly and Brown.

These assumptions include the subsequent points:

a . A set of probabilities reflecting the anticipated returns during a specific holding period can be utilized to demonstrate various investment options.

b. Investors seek to optimize their benefits over a single time frame.

c. The risk of a portfolio is evaluated according to the extent of variations in anticipated returns.

d. Investment choices are exclusively influenced by expected returns and the risks involved.

e. Investors tend to prefer safer options, so when presented with two investments that carry the same level of risk, they will choose the one that promises a higher return.From a mathematical perspective, the subsequent expression represents the equation:

$$E(Rp) = \sum_{i=1}^{n} w_i \cdot E(R_i)$$

Where n represents the total number of assets included in the portfolio, wi denotes the weight of asset i within the portfolio, and E(Ri) is the anticipated return of asset i. (Rp) is the expected return of the portfolio.

Furthermore, the equation for the variance (or risk) of the portfolio is:

$$\sigma_p^2 = \sum_{i=1}^{n} \sum_{j=1}^{n} w_i \cdot w_j \cdot \sigma_{ij}$$

Where σij is the variance of the portfolio, wi and wj are the weight of assets i and j in the portfolio, and σij is the covariance between the returns of assets i and j.

The purpose of the Markowitz model is to determine the optimal set of asset weights wi that maximizes expected return for a specific level of risk or minimizes risk for a targeted expected return. This requires evaluating the trade-off between risk and return, along with the advantages of diversification by combining assets that have varying correlation coefficients. At the heart of this method is the concept of the efficient frontier, which represents the group of portfolios that offer the highest expected return for a given level of risk.

A risk-free asset possesses no variance, and there is no correlation between an asset with no risk and any other risky asset. Consequently, including a risk-free asset in a portfolio decreases the overall risk and results in a linear connection with the standard deviation of the portfolio that solely consists of risky assets.

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$$\sigma = \sqrt{(1 - w_{rf})^2 \sigma_i (1 - w_{rf}) \sigma_i}$$

In this context, Wrf represents the proportion allocated to the risk-free asset.

2.2. Capital Market Line

A logical extension of Markowitz's theory is the possibility for investors to set aside a portion of their funds for risk-free assets or to borrow money to achieve a particular level of leverage. Tobin was the first to suggest this enhancement to the Markowitz framework, later followed by Sharpe and Lintner. In an efficiently functioning market, the interactions of supply and demand would result in each investor holding a portfolio that mirrors the market's portfolio composition. As such, the ideal portfolio in this state of equilibrium is the market portfolio itself. This state of equilibrium is depicted by a line referred to as the Capital Market Line.

The Capital Market Line (CML) is represented not by a singular equation but as a graphical concept within the Capital Asset Pricing Model (CAPM) framework. It illustrates efficient portfolios that merge the risk-free asset with the market portfolio, forming a straight line that links the risk-free return to the expected return of the market portfolio. The CML can be encapsulated with the following equation:

$$E(R_p) = R_f + \frac{E(R_m) - R_f}{\sigma_m} \cdot \sigma_p$$

E(Rp) represents a portfolio's expected return. For the risk-free rate, Rf E(Rm) for expected return of a market portfolio, σm for standardized market portfolio risk, and σp for standardized portfolio risk. To create effective portfolios, the risk-return relationship is illustrated by the Capital Market Line (CML). This line shows how anticipated returns shift as you modify the portfolio's risk by altering the distribution between the risk-free asset and the market portfolio.

2.3. Capital Asset Pricing Model

The Markowitz model serves as the basis for the CAPM, which is later elaborated upon by Sharpe and Lintner through the incorporation of essential assumptions. The CAPM posits that all investors maintain a mix of risk-free assets alongside a single, fully diversified market portfolio. The market portfolio is a fundamental idea in CAPM, symbolizing all risky assets present in the market. This premise streamlines the analysis by minimizing the number of portfolios that need to be evaluated. CAPM differentiates between risks associated with the market and those tied to specific assets. It incorrectly claims that systemic risk, which influences asset values, cannot be entirely mitigated through diversification. While diversification helps mitigate irrational risk, it does not eliminate systemic risk entirely. The concept of beta, which represents how responsive an asset's returns are to changes in the market, is introduced by the CAPM. Beta is used to assess an asset's susceptibility to systematic risk. A security closely tracks the market when its beta is 1, and less sensitive when it is less than 1.

The Capital Asset Pricing Model (CAPM) is based on the following equation:

$$E(R_i) = R_f + \beta_i \cdot (E(R_m) - R_f)$$

E(Ri) stands for anticipated return on asset i, Rf for risk-free rate of return, βi for asset i's beta coefficient, which denotes how sensitive the asset is to market fluctuations, and E(Rm) for expected return on the market portfolio.
The CAPM determines the expected return of each individual asset in this equation by taking into account the beta of the asset, the risk-free rate, and the expected return of the overall market portfolio. The beta coefficient determines an asset's susceptibility to systematic risk or market swings. The CAPM provides a framework for determining the expected return required by investors to justify taking on the increased risk associated with a specific asset, given the risk-free rate and the expected return of the overall market. To sum up, the CAPM is an expansion of the Markowitz Model that makes new assumptions about a single market portfolio, a risk-free rate, and the use of beta to measure systematic risk. These presumptions make portfolio analysis easier to understand and more relevant to actual financial markets.

2.4. Arbitrage Pricing Theory
The arbitrage pricing theory (APT), created by Stephen Ross in 1976, has been the most popular model for managing portfolios in recent years. In theory, the APT model might effectively price risky assets in a portfolio by using a few risk criteria. After identifying three to five risk criteria, it chooses equities from a pool of likely candidates and evaluates the relative market risks and returns of each security. When employing APT alone, heuristics are typically needed to overcome obstacles and obtain a respectable list of businesses.
The APT assumes that the n ∗ 1 vector of asset returns, Rt, is created by a linear stochastic process with k components.

$$R_t = \bar{R} + Af_t + e_t$$

where ft is a k ∗ 1 vector of k common factor realizations, A is a n k matrix of factor weights or loadings, and et is a n 1 vector of asset-specific hazards. Because ft and et are considered to have zero expected values, R is the n ∗ 1 vector of mean returns. The model suggests that the expected return of an asset is directly related to the factor loadings or volatility in a market devoid of arbitrage chances .

$$\bar{R} = R_f + A_P$$

Where Rf is an n ∗ 1 vector of constants representing the risk-free return, and p is k ∗ 1 vector of risk premiums.
The core idea of APT theory is that returns can be divided into two categories: a significant—and ultimately limitless—systematic risk, measurable by exposure to several key common factors, and an idiosyncratic risk that can be entirely mitigated in large, well-diversified portfolios. This concept, along with the notion that investors tend to prefer more value over less, leads to a reasonable theory of expected returns by ruling out riskless arbitrage opportunities. Unfortunately, the seemingly straightforward nature of APT conceals considerable difficulties related to its application. In particular, testing the theory necessitates a method for measuring the common factors. Many researchers have resorted to factor analysis as a means to indirectly evaluate these shared factors. This approach sidesteps the challenge of directly identifying factors due to the computational difficulties of conducting maximum likelihood factor analysis on extensive data sets using standard software tools.

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III. COMPARISON AND ANALYSIS OF EACH MODEL

The Markowitz Model, often referred to as Modern Portfolio Theory, emphasizes the essential role of diversification in effectively managing risk. It provides a quantitative approach to optimizing portfolios, taking into account both risk and return at the same time. While the model has many advantages, it assumes a standard range of returns that may not always be correct and depends on accurate estimates of expected returns, variances, and covariances.

The Capital Market Line (CML) illustrates the trade-off between risk and return for efficient portfolios, incorporating both the risk-free rate and the market portfolio. It effectively communicates the concept of systematic risk and the importance of diversification. However, the CML assumes a linear relationship between risky and risk-free investments, fails to consider non-market factors that affect returns, and requires precise estimates of portfolio parameters for dependable application.

The Capital Asset Pricing Model (CAPM) establishes a clear link between risk and expected return while offering a simple benchmark through the market portfolio. Its ease of understanding contributes to its popularity. Nonetheless, the CAPM presumes a linear relationship between risk and return, which might not be valid in every situation. It is necessary to estimate the market risk premium and risk-free rate, and it disregards other possible influences on returns.

The Arbitrage Pricing Theory (APT) has the distinct benefit of not depending on the market portfolio as a reference point and allows for multiple factors that affect asset returns. Unlike CAPM, APT does not enforce a specific utility function on investors. However, implementing APT requires accurate estimations of factor sensitivities, which can be difficult, and identifying and quantifying these factors may present challenges.

Table 1: Comparison of each model

Model	Advantage	Disadvantage
Markowitz model	Diversification	Assumptions reliance
CML	Visualization	Linearity
CAPM	Clearness	Oversimplification
APT	Flexibility	Complexity

The choice of a model ultimately depends on the particular context, the availability of data, and the goals of investors or analysts. Additionally, the finance industry has progressed to include more modern models and strategies that tackle certain shortcomings found in traditional models.

IV. CONCLUSION

This paper discusses various models of portfolio management and evaluates their respective pros and cons. In summary, these models demonstrate a progression of development and refinement, with certain models building on the principles of others. The Capital Asset Pricing Model (CAPM) extends the Markowitz Model by incorporating the risk-free rate and the market portfolio as reference points. CAPM simplifies the relationship between risk and return and introduces the concept of systematic risk. The Capital Market Line (CML) is not an independent model; rather, it is a graphical depiction derived from CAPM. It showcases the efficient portfolios that merge the risk-free asset with the market portfolio. The CML highlights the balance between risk and return for efficient portfolios. The Arbitrage Pricing Theory (APT) is a more recent model that can be regarded as an extension of CAPM. It expands the scope by taking into account multiple risk factors instead of depending solely on the market portfolio. APT was developed to overcome some of the constraints of CAPM, particularly by permitting a more adaptable range of risk factors. Future studies may investigate the potential of combining individual models to address more intricate situations, thereby increasing their adaptability to a broader spectrum of market conditions.

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