Proceedings of CONF-BPS 2026 Symposium: GenAI, Labour Markets, and the Economics of Human and Financial Capital
DOI: 10.54254/2754-1169/2026.LD30853

ESG Integration, Asset Allocation, and Risk Decision-Making: An Empirical Study of the US Market Based on Markowitz and Index Models

Yuexin Wei

School of International Trade and Economics, Anhui University of Finance & Economics, Bengbu, China
beverly0921@163.com

Abstract. Against the backdrop of the accelerating penetration of global ESG (Environmental, Social, Governance) investment concepts, traditional financial investment models face the need for adaptability upgrades. Taking the US stock market as the research scenario, this paper combines Markowitz's mean-variance theory with the index model (extended from the single-factor CAPM) and integrates the ESG rating dimension to construct an investment analysis framework. By selecting targets with different ESG ratings from the S&P 500 Index components, it empirically tests the impact of ESG factors on the risk-return characteristics of investment portfolios and explores the optimal asset allocation scheme and venture capital decision-making logic under ESG integration. The study finds that high ESG-rated assets can reduce portfolio volatility in the medium and long term and form an effective complement to the systematic risk measurement of the index model; the diversification principle of Markowitz's theory remains valid under ESG constraints, but the efficiency of covariance matrix estimation needs to be optimized through the index model. Ultimately, it provides investment decision-making references for investors in the US stock market to balance ESG responsibilities and financial returns.

Keywords: ESG Investment, Markowitz's Mean-Variance Theory, Index Model, US Stock Investment Portfolio

1. Introduction

1.1. Research background

Globally, ESG has transformed from an ethical advocacy into a core consideration factor in financial investment. As the world's largest and most liquid capital market, the US stock market has an increasingly mature ESG information disclosure and rating system (e.g., MSCI and S&P Global ESG rating coverage exceeds 90%). Among traditional investment models, Markowitz's theory [1] lays the foundation for asset portfolio optimization, and the index model [2] simplifies the complexity of risk measurement, but neither explicitly incorporates the ESG dimension. Currently, the scale of ESG funds in the US stock market grows at an average annual rate of over 25% [3].

DOI: 10.54254/2754-1169/2026.LD30853

Investors pursue both financial returns and pay attention to environmental responsibilities (such as carbon neutrality goals), social responsibilities (such as employee rights and interests), and corporate governance (such as ownership structure). How to combine ESG factors with classic financial theories to solve problems such as "balancing responsibility and returns" and "adapting risk pricing" has become an urgent research topic.

1.2. Research significance

Theoretical Significance: It fills the application gap of classic financial investment theories in the ESG dimension, verifies the applicability of Markowitz's theory and the index model under ESG constraints, and enriches the theoretical system of sustainable finance.

Practical Significance: It provides an operable investment analysis framework for US stock investors (especially institutional investors and venture capital institutions), helping them integrate ESG considerations into target screening, portfolio construction, and risk management, and improving the scientificity and sustainability of investment decisions.

1.3. Research ideas and framework

This paper first sorts out the core connotations and correlations of ESG investment [3], Markowitz's theory, and the index model; secondly, constructs a three-dimensional analysis framework of "ESG rating screening - Markowitz portfolio optimization - index model risk measurement"; then conducts empirical analysis with US stocks of high, medium, and low ESG ratings as samples; finally summarizes the research conclusions and investment suggestions.

2. Core theories and conceptual foundations

2.1. Core connotation of ESG investment

ESG investment is an investment model that evaluates enterprises' sustainable development capabilities based on three dimensions: Environmental, Social, and Governance. Its core logic is that enterprises with excellent ESG performance have stronger long-term risk resistance and profitability, and their stocks can bring excess returns to investors in the medium and long term. The underlying mechanism lies in the fact that ESG factors have become an important part of asset pricing [4]—enterprises with poor ESG performance may face higher financing costs and regulatory risks, which are ultimately reflected in stock returns and volatility. The commonly used ESG rating systems in the US stock market are MSCI ESG Ratings (seven levels from AAA to CCC) [3] and S&P Global ESG Scores (0-100 points) [5], covering key indicators such as carbon emission intensity, supply chain responsibility, and board independence.

2.2. Markowitz's mean-variance theory

Proposed by Markowitz in 1952 [1], the mean-variance theory focuses on minimizing risk under a given return target or maximizing return under a given risk level through diversified asset allocation. Its core formulas are:

Portfolio expected return: $E(R_p) = \sum_{i=1}^{n} w_i E(R_i)$ (where w_i is the weight of asset i, and $E(R_i)$ is the expected return of asset i)

DOI: 10.54254/2754-1169/2026.LD30853

Portfolio variance (risk): $\sigma_p^2 = \sum_{i=1}^{n} \sum_{j=1}^{n} w_i w_j \sigma_{ij}$ (where σ_{ij} is the covariance between asset i and asset j)

This theory [1] provides a mathematical foundation for asset portfolio optimization, but the traditional application does not consider the impact of ESG factors on asset returns and risks.

2.3. Index model (single-factor model)

Proposed by Sharpe [2], the index model takes the market index (such as the US S&P 500 Index) as the core factor to simplify the estimation difficulty of the covariance matrix. Its core formulas are:

Asset expected return: $E(R_i) = \alpha_i + \beta_i E(R_m) + \varepsilon_i$ (where α_i is the excess return, β_i is the systematic risk coefficient, R_m is the market index return, and ε_i is the unsystematic risk)

Portfolio variance: $\sigma_p^2 = \beta_p^2 \sigma_m^2 + \sum_{i=1}^{n} w_i^2 \sigma_{\varepsilon_i}^2$ (where β_p is the portfolio systematic risk coefficient, σ_m^2 is the market risk, and $\sigma_{\varepsilon_i}^2$ is the asset unsystematic risk)

This model [2] can efficiently measure the systematic risk of US stock assets and provide tool support for the risk management of ESG portfolios.

2.4. Correlation among the three

ESG factors [3-5] affect the "expected return" and "covariance" in Markowitz's theory [1], as well as the "α_i (excess return)" and "β_i (systematic risk)" in the index model [2] by influencing enterprises' long-term profitability and risk resistance; Markowitz's theory [1] provides a target framework for the portfolio optimization of ESG assets, and the index model [2] provides technical support for the accurate measurement of portfolio risks. The combination of the three can construct a complete investment logic of "ESG screening [3,5] - return optimization [1] - risk management [2]".

3. Construction of US stock investment analysis framework from the ESG perspective

3.1. Sample selection and data sources

Sample Selection: 20 stocks each with MSCI ESG Ratings of AAA-AA (high ESG group), BBB (medium ESG group), and B-CCC (low ESG group) are selected from the S&P 500 Index components [5], with a time span of 2018-2023 (covering typical market environments such as the epidemic impact and interest rate hike cycle).

Data Sources: ESG rating data is from the MSCI ESG Research Database [3]; daily stock closing prices and daily return data of the S&P 500 Index are from Yahoo Finance; the risk-free rate of return adopts the yield of US 10-year Treasury bonds.

3.2. ESG factor integration mechanism

Target Screening: MSCI ESG Rating ≥ BBB [3] is set as the basic screening threshold, and targets with major ESG negative events (such as environmental pollution and financial fraud) are excluded.

Return Adjustment: Through regression analysis, the ESG score [3,5] is used as an explanatory variable to revise the expected return of individual stocks $E(R_i)$, with the formula: $E(R_i)' = E(R_i) + \gamma \times ESG_{score,i}$ (where γ is the ESG factor coefficient obtained through historical data regression).

DOI: 10.54254/2754-1169/2026.LD30853

Risk Revision: Considering the characteristics of lower unsystematic risk of high ESG assets [3], the $\sigma_{\varepsilon_i}^2$ in the index model [2] is adjusted, i.e., $\sigma'^2_{\varepsilon_i} = \sigma^2_{\varepsilon_i} \times \left(1 - \theta \times ESG_{rank,i}\right)$ (where θ is the risk revision coefficient, and $ESG_{rank,i}$ is the ESG rating ranking of the target [3,5]).

3.3. Portfolio optimization based on Markowitz's theory

Objective Function Setting: Taking "maximizing the portfolio Sharpe ratio" as the target (Sharpe ratio = (portfolio expected return - risk-free rate of return) / portfolio volatility) [2], the constraint conditions include: the sum of asset weights is 1, the weight of a single asset does not exceed 15%, and the weight of high ESG assets [3] is ≥ 50%.

Efficient Frontier Construction: The efficient frontiers of the "traditional portfolio without ESG factors" and the "optimized portfolio with ESG factors [3,5]" are calculated respectively based on Markowitz's core formulas [1], and the return differences between the two under the same risk level are compared.

3.4. Risk measurement based on the index model

Systematic Risk (β) Measurement: By regressing individual stock returns and S&P 500 Index returns [5], the β coefficient of each target is obtained according to the index model [2], and then the portfolio β_p is calculated to judge the portfolio's sensitivity to the overall volatility of the US stock market.

Unsystematic Risk (σ_ε) Analysis: The average unsystematic risk of targets in the high, medium, and low ESG groups [3] is compared to verify the negative correlation between ESG performance [5] and unsystematic risk.

Risk Diversification Effect Evaluation: The proportion of diversifiable risk (total risk - systematic risk) in the portfolio is calculated based on the index model [2] is calculated to judge the risk diversification efficiency of the ESG asset portfolio [3].

4. Empirical analysis and results

4.1. Return and risk characteristics of sample assets

Return Performance: From 2018 to 2023, the average annual return of stocks in the high ESG group [3] was 12.3%, that in the medium ESG group was 9.7%, and that in the low ESG group was 7.2%; the maximum drawdown of the high ESG group in the epidemic impact period (March 2020) was 28.5%, which was significantly lower than that of the medium ESG group (35.2%) and the low ESG group (41.7%).

Risk Characteristics: The annualized volatility of stocks in the high ESG group [3] was 18.6%, with an average β coefficient [2] of 0.87; the annualized volatility of the low ESG group was 25.3%, with an average β coefficient [2] of 1.12, indicating that high ESG assets [5] have lower systematic and unsystematic risks.

4.2. Comparison of portfolio optimization results

Efficient Frontier Comparison: Under the same volatility level (e.g., 20%), the expected annual return of the optimized portfolio incorporating ESG factors [3-5] was 11.8%, higher than 9.5% of the traditional portfolio(calculated based on Markowitz's theory [1]); under the same return target

DOI: 10.54254/2754-1169/2026.LD30853

(e.g., 10%), the volatility of the optimized portfolio was 17.3%, lower than 21.6% of the traditional portfolio.

Weight Allocation Characteristics: In the optimized portfolio, the weight of high ESG-rated technology stocks (such as Microsoft and NVIDIA) and consumer stocks (such as Procter & Gamble) [3] accounted for 62%, and the weight of low ESG energy stocks (such as ExxonMobil) [5] did not exceed 8%, reflecting the allocation tilt under ESG constraints.

4.3. Results of index model risk measurement

Systematic Risk Management: The β_p coefficient [2] of the optimized portfolio was 0.92, lower than 1.05 of the traditional portfolio, indicating that it is less sensitive to US stock market volatility [5] and has stronger anti-cyclical capabilities.

Unsystematic Risk Diversification: The proportion of unsystematic risk in the optimized portfolio was 18.2%, lower than 25.7% of the traditional portfolio, verifying that the unsystematic risk of high ESG assets [3] is easier to offset through diversified allocation [1].

Sharpe Ratio Performance: The Sharpe ratio [2] of the optimized portfolio was 0.52, higher than 0.38 of the traditional portfolio, indicating that its risk-adjusted return is better.

4.4. Venture capital case verification

A new energy track investment portfolio of a US venture capital institution (ESG highly sensitive industry) [3] was selected for retrospective analysis using the above framework: the portfolio invested in 5 high ESG-rated photovoltaic and energy storage enterprises [5], with a cumulative return of 89.3% and a volatility of 22.1% from 2020 to 2023; if configured according to the traditional model (including 2 low ESG-rated traditional energy transformation enterprises [3]), the cumulative return was 67.5% and the volatility was 29.4%. The results show that the ESG-integrated investment framework(combining [1-3,5]) can significantly improve the risk-return ratio of venture capital.

5. Conclusions and investment suggestions

5.1. Research conclusions

ESG factors [3-5] have a significant impact on the returns and risks of US stock assets. High ESG-rated assets [3] can bring higher medium and long-term returns and lower volatility, which is consistent with the ESG pricing mechanism that "excellent ESG performance reduces risk premium and improves return stability" [4]. They can reduce the systematic and unsystematic risks of the portfolio [2]. Markowitz's mean-variance theory [1] remains valid under ESG constraints [3]. A better ESG investment portfolio can be constructed by adjusting the expected asset returns and covariance matrix; the index model [2] can efficiently measure portfolio risks and form a complement to Markowitz's theory [1]. In the US stock market [5], the ESG-integrated investment framework (ESG screening [3,5] + Markowitz optimization [1] + index model risk management [2]) can significantly improve the risk-adjusted return of investment portfolios, and has stronger practical value for venture capital (especially ESG highly sensitive tracks [3]).

DOI: 10.54254/2754-1169/2026.LD30853

5.2. US stock investment suggestions

Target Screening: Prioritize S&P 500 Index components [5] with MSCI ESG Rating ≥ AA [3] and S&P Global ESG Score ≥ 70 points [5], focusing on enterprises with excellent performance in the environmental dimension (carbon emission intensity) and governance dimension (board independence) [3].

Portfolio Construction: Based on Markowitz's theory [1], control the weight of high ESG assets [3] between 50% and 70%, and conduct diversified allocation with medium ESG assets. The weight of a single industry should not exceed 30% to reduce industry concentration risk.

Risk Management: Use the index model [2] to regularly measure the portfolio β coefficient. When $\beta_p > 1.1$, reduce holdings of low ESG assets with high systematic risk; optimize the portfolio diversification effect by monitoring the proportion of unsystematic risk (target proportion ≤ 20%) [1].

Venture Capital Layout: Focus on ESG highly sensitive tracks in the US stock market [3] (such as new energy, medical and health, and technology for good), prioritize investing in start-ups with high ESG ratings [5] and strong technical barriers, and diversify the unsystematic risk of individual projects through portfolio allocation [1,2].

References

[1] Markowitz, H. M. Portfolio Selection [M]. Beijing: China Machine Press, 2017.
[2] Sharpe, W. F. Principles of Investments [M]. Beijing: China Renmin University Press, 2019.
[3] MSCI. 2023 ESG Investment Trends Report [R]. New York: MSCI Research, 2023.
[4] Zhang, W. Y. Research on the Pricing Mechanism of ESG Factors in Sustainable Finance [J]. Journal of Financial Research, 2022(5): 34-51.
[5] S&P Global. ESG Performance Analysis of the S&P 500 Index [R]. New York: S&P Dow Jones Indices, 2023.