Dean&Francis

ISSN 2959-6130

How to Improve Investment Portfolio of ESG Companies under Constrains

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Abstract:

This paper explores the construction of investment portfolios based on ESG (Environmental, Social, Governance) factors using Markowitz's portfolio theory. We selected 50 companies based on MSCI ESG ratings and used 2023 stock price data to construct portfolios of various sizes (10, 30, and 50 stocks). Through Excel tools, we calculated covariance matrices, simulated stock allocations, and analyzed weekly returns for each portfolio. We optimized risk-adjusted returns and employed the Sharpe ratio to identify the optimal portfolio. Our findings demonstrate the positive impact of ESG factors on long-term portfolio stability and highlight the importance of Markowitz's model in financial risk management. This study provides practical insights and a fresh perspective on optimizing ESG-based investment decisions in the current market environment.

Keywords: Markowitz model; exponential model; Excel Sharpe ratio; covariance; efficient frontier; optimal portfolio

1. Introduction

The construction of investment portfolios has long been a key area of research in finance. As global market conditions continue to evolve, investors face increasing challenges in balancing returns and risks. Achieving an optimal balance between risk and return has become one of the primary concerns for investors. Particularly with the rise of sustainability, ESG (Environmental, Social, and Governance) factors have emerged as crucial considerations in investment decision-making. The introduction of ESG standards has reshaped portfolio management, as investors seek long-term, risk-adjusted returns while addressing global challenges such as climate change.

1.1 Background

Markowitz, the founder of Modern Portfolio Theory, proposed the mean-variance model, which aims to diversify investment portfolios by optimizing the risk-return ratio. Within this theoretical framework, ESG factors have gradually become important indicators for assessing a company's long-term value, especially as the world faces challenges like climate change, energy shortages, and growing social responsibility.

Current research on portfolio construction mainly focuses on traditional risk-return optimization models. While there is extensive research on ESG investing, there remains a gap in understanding how to effectively construct optimal portfolios based on ESG ratings, and how the Markowitz Modern Portfolio Theory and Index Models perform when applied to ESG-based portfolios. Therefore, this paper aims to fill this research gap by using MSCI's ESG ratings and Markowitz's portfolio theory to study how to construct optimal portfolios in different market conditions. The paper focuses on covariance matrix calculations, stock weight allocation, and optimizing risk-adjusted returns, while also analyzing the market performance of these portfolios.

In this study, we used 2023 stock data from Macrotrends and selected 50 companies from MSCI with varying ESG performances. Using Excel tools, we conducted data analysis to construct portfolios of 10, 30, and 50 stocks, and evaluated them using financial indicators such as the Sharpe ratio. This research not only demonstrates the positive impact of ESG factors on long-term investment returns but also reinforces the core role of Modern Portfolio Theory in risk management.

2. Literature review

2.1 Development of Portfolio Theory

2.1.1 Early Theory

Early investment theory took shape as early as the beginning of the 20th century, but it focused mainly on the valuation of individual assets and lacked systematic analysis of multi-asset portfolios. Before the 1940s, investors relied primarily on intuitive experience when selecting investment projects, typically focusing on the return on a single asset and ignoring risk management. In the 1950s, a systematic theoretical framework was gradually established.

2.1.2 Harry Markowitz and modern portfolio theory

(1) Markowitz model

Markowitz (1952) proposed modern portfolio theory in his seminal paper "Portfolio Selection". The mean-variance model proposed therein laid the foundation for modern portfolio theory. This model proposes the concept of diversification by optimizing the risk-return ratio in an investment portfolio and reduces the overall risk by finding an effective frontier to achieve the optimal risk-return ratio.

(2) Main contributions:

a.

Expected Return:

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

- $E(R_p)$: Expected return of the portfolio
- w_i: Weight of asset i in the portfolio
- $E(R_i)$: Expected return of asset i

b.

Variance:

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

- σ_p^2: Variance of the portfolio
- w_i, w_j: Weights of assets i and j in the portfolio
- σ_{ij}: Covariance between assets i and j

c.

Standard Deviation:

$$\sigma_p = \sqrt{\sigma_p^2}$$

- σ_p: Standard deviation of the portfolio

d. Efficient frontier: The set of optimal investment portfolios that offer the maximum expected return for a given level of risk.

e. Minimum variance portfolio: The portfolio with the lowest risk of all possible portfolios.

f. Optimal portfolio: A portfolio that offers the optimal risk-return ratio based on the investor's risk tolerance.

g. Risk diversification: Investing in different assets reduces the overall risk of your investment portfolio.

h. Asset-Return Correlation: Use correlations between assets to construct investment portfolios with optimal risk-return ratios.

(Sharp ratio)

2.1.3 Efficient market hypothesis (EMH)

In the 1960s, Eugene Fama put forward the efficient mar-

ISSN 2959-6130

ket hypothesis. This hypothesis supports Markowitz's theory that in efficient markets, analyzing asset prices does not produce excess returns and market prices reflect all available information, so a proper allocation of assets is as follows: The key to risk management and pricing is always fair, which further expands the application of portfolio theory.

2.1.4 Pricing model for capital investments

In the 1960s, William Sharp and colleagues developed the Capital Asset Pricing Model (CAPM) . This model measures the risk of an asset to the overall market using its beta (β) value and provides a method for estimating the expected return of an asset.

Core formula: $R\ i = Rf + \beta\ i\ (Rm - Rf)$

R i: Expected return on investment

R f: risk-free return

β i : Beta value of the asset

Rm : Market expected return

2.1.5 Further development and expansion

(1) Multi-element model

Based on the CAPM, financial scholars such as Fama and France have proposed multifactor models that take into account the influence of other market factors on asset returns. These models provide more sophisticated methods for assessing risk, such as the Fama-France three-factor model and a five-factor model.

(2) Behavioral Finance

In the 1980s, traditional portfolio theory was questioned and more attention was paid to the influence of investor behavior on market prices.

2.2 Exponential model

Index models are regression models based on market indices that are intended to simplify the risk analysis of investment portfolios. A study by Elton and Gruber (1973) shows that index models have a high application value in large-scale portfolio management.

2.3 Application of the beta coefficient

The beta coefficient is often used as a measure of the volatility of an individual stock relative to the market. Fama and French (1993) combined beta coefficients with market, size, value, and other three-factor model factors to further develop the market's understanding of asset pricing. This study calculates the beta coefficient based on the closing price. This better reflects the investor's risk exposure at the end of the trading day.

2.4 Influence of ESG factors

In recent years, faced with serious challenges such as global warming, increasingly scarce energy supplies and frequent public health incidents, the international community has realized that the traditional economic growth model is no longer sustainable and urgently needs a new economic growth model. There is general agreement on the need for a migration. A more environmentally friendly, inclusive and sustainable model. Continuous transformation of development paths. In this context, the rise of environmental (E), social (S), corporate governance (G) or ESG information disclosure systems will not only bring major changes in the understanding of corporate responsibility, but will also contribute to the creation of a sustainable society. The evolution of the world economic system is advancing towards its goals.

The ESG Disclosure Framework encourages companies to proactively disclose their actual results and achievements in the areas of environmental protection, fulfillment of social responsibility and internal governance, thereby significantly increasing corporate transparency and enhancing trust in corporate behavior. More importantly, ESG factors go beyond traditional financial performance metrics and examine the significant impact that corporate activities have on the long-term well-being of humanity and the development of society as a whole, from reducing carbon emissions to promoting labor rights and transparency in supply chains, as well as strengthening anti-corruption mechanisms and other aspects.

Today, ESG has become an important measure of corporate value and potential in capital markets and has a significant impact on investors' decision-making processes. More and more investors are beginning to incorporate ESG performance into their investment decisions, and companies with good ESG practices achieve stable long-term growth, effectively resist external risks, and make greater contributions to society. We believe that we can create value. Therefore, disclosing ESG information is not only an expression of corporate social responsibility, but also a key to attracting capital and increasing competitiveness.

3. Research content

To explain the Markowitz portfolio theory based on ESG ratings. The Excel language provides an intuitive and powerful tool for portfolio research. Easily perform covariance calculations, model building and portfolio optimization, and quickly solve complex problems using built-in functions and solver tools. In addition, Excel 's visualization capabilities and flexibility support the intuitive display and adjustment of portfolio parameters and make risk and return analysis clearer.

4. Research method

4.1 Data collection

We selected 50 MSCI companies with varying levels of environmental, social and governance performance and priority based on ESG ratings as sample companies to build our investment portfolio. We then obtained the 2023 stock price data for these 50 companies from Macrotrends, which mainly includes weekly closing price data.
Using this data, we calculated weekly return rates for each company and used them as a basis for subsequent analysis. Calculate your weekly sales using the formula in Excel: = (Closing price this week - Closing price last week) / Closing price last week.
(Excel table)

4.2 Build an investment portfolio

4.2.1 Group Composition

These 50 stocks were organized into three investment portfolios of different sizes (10 stocks, 30 stocks and 50 stocks). This grouping allows you to analyze the impact of portfolio size on risk and return.
(50 ompanies)

4.2.2 Calculate Return

Calculate the return for each portfolio on a weekly basis. We first calculate the weekly return for each stock and then calculate the weekly return for the entire portfolio based on the weight of each stock in the different portfolios. Use the Excel function =AVERAGE(range) to calculate the average return for each stock.
(Excel screenshot)

4.2.3 Markowitz Model

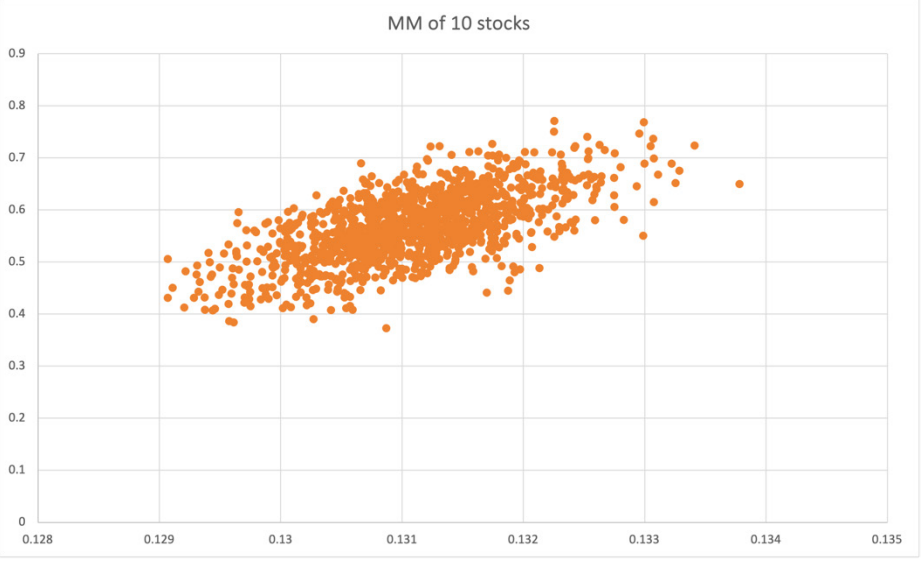
An optimal investment portfolio was constructed using the mean-variance optimization method (Markowitz model). This model optimizes the risk and return of an investment portfolio by calculating the covariance matrix. Use the Excel function =COVARIANCE.P(range1, range2) to calculate the covariance between stocks. Organize the results of the covariance calculation for all stocks into a covariance matrix.
(Excel screenshot)

4.2.4 Index Model

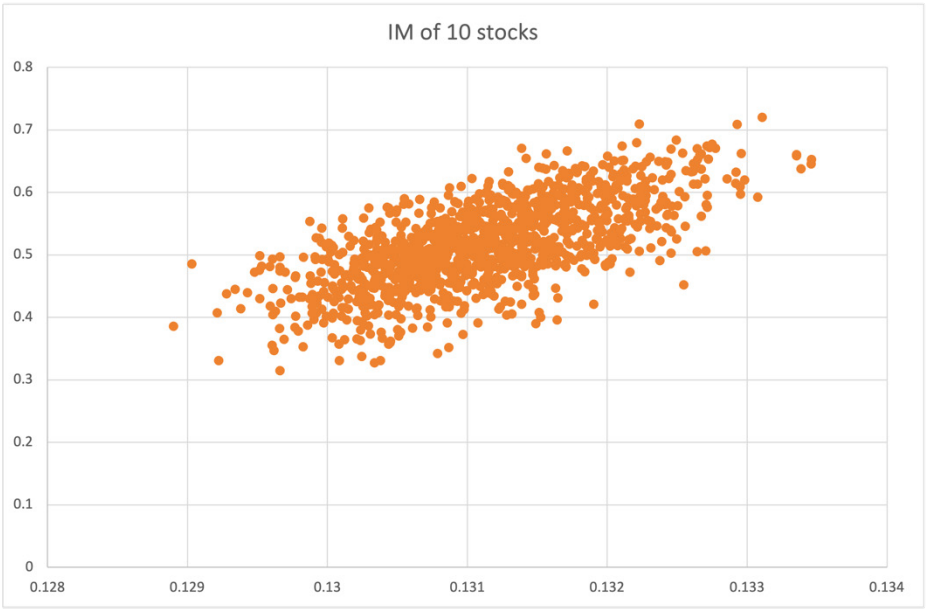
Using an index model uses a market index as a benchmark for a regression model to analyze the relationship between each stock and the market. Simplify your portfolio risk assessment by performing regression analysis on each stock's beta coefficient.
(Excel screenshot)

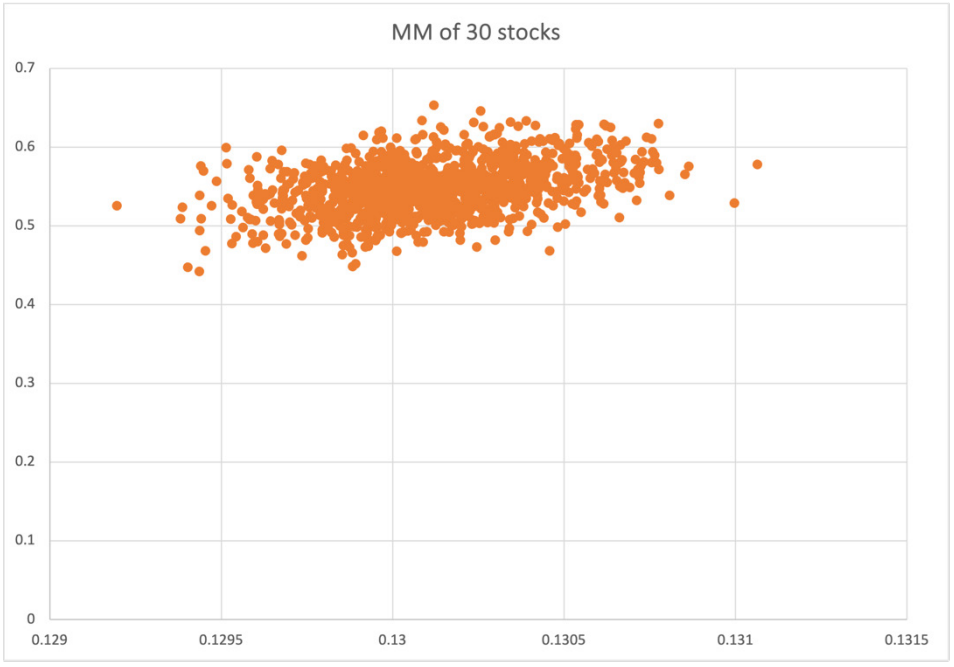
4.2.5 Calculating the Beta Coefficient

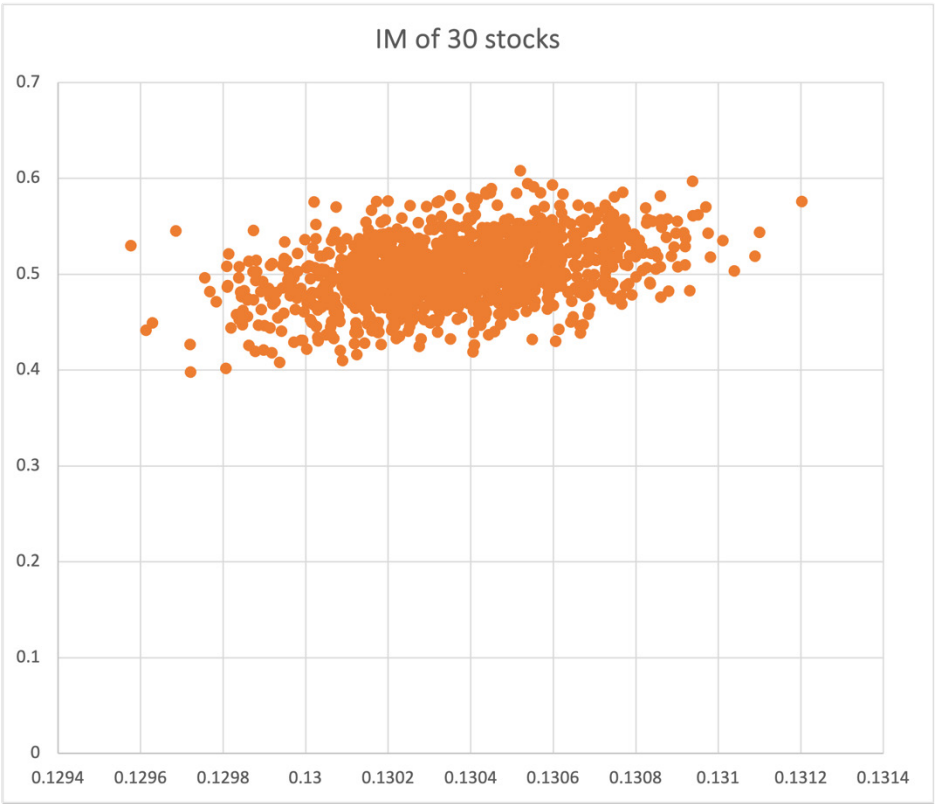
The beta coefficient is calculated based on the past closing price of each stock. Specifically, we derived the respective beta coefficients by performing a linear regression between the return of each stock and the return of the market index. These beta coefficients are then multiplied by the weight of each stock in the portfolio and aggregated to calculate the beta coefficient for the entire portfolio. Use Excel's =RAND() function to generate random stock weights so that these weights sum to 1. Calculate the expected return and risk (standard deviation) of a portfolio.
(Excel screenshot)



ISSN 2959-6130



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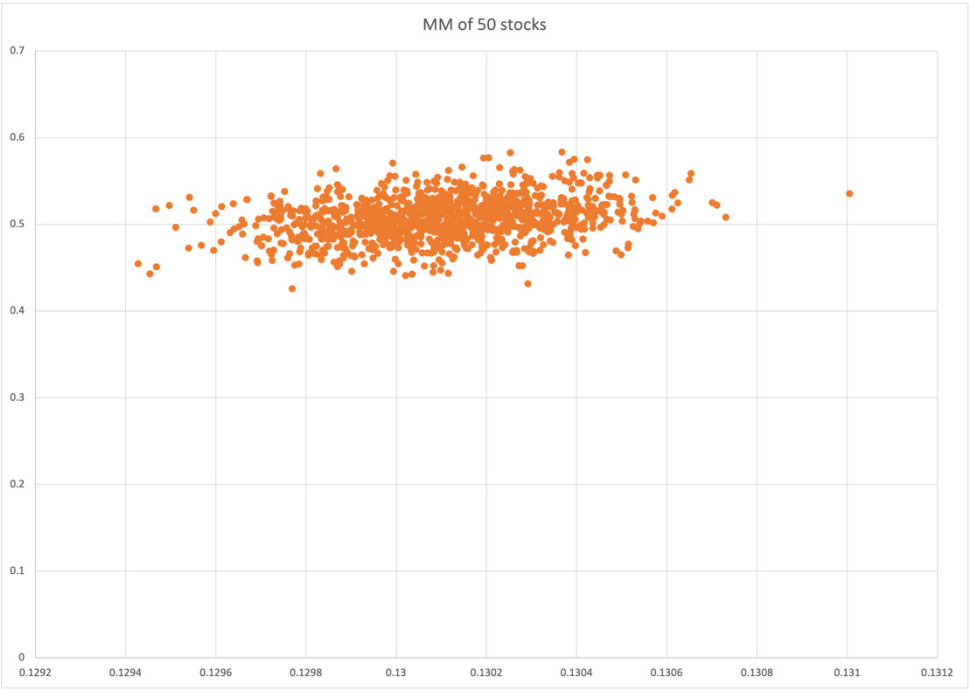
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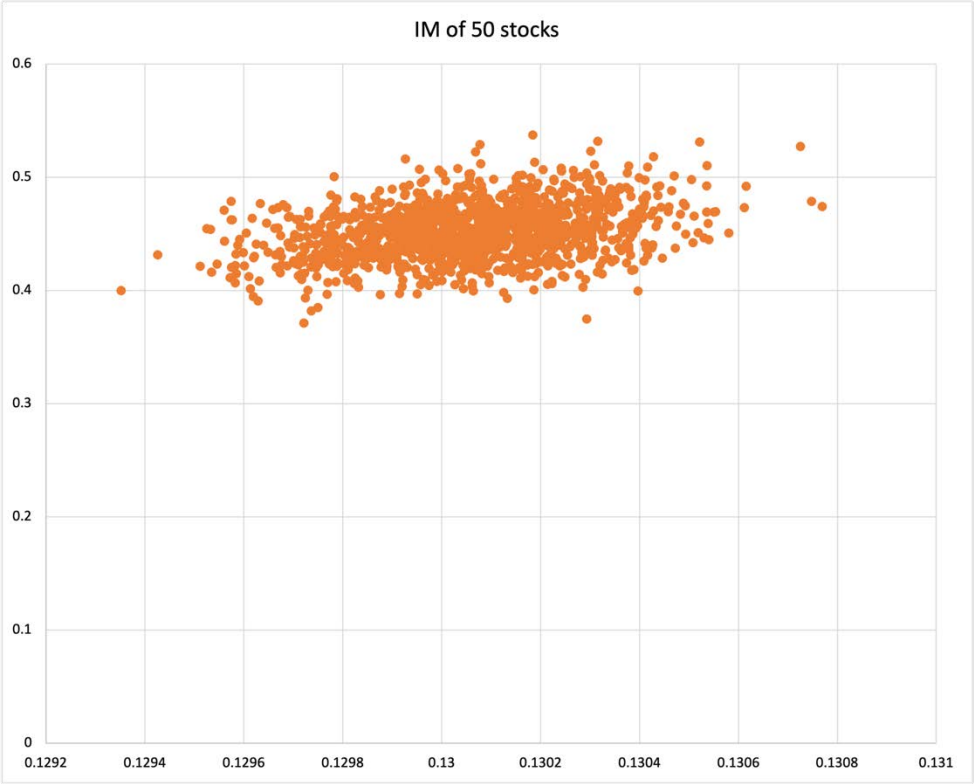
ISSN 2959-6130



5. Result analysis

5.1 Ten stock data & Stock Market Analysis and Investment Strategies

5.1.1 Overall Market Performance Analysis

- Apple (APPLE) Stock Price Fluctuations: During the observation period, Apple's stock price showed fluctuating growth, increasing from $631.0354 in early 2023 to $858.4576 by the end of April, reflecting strong market confidence.
- Meta Platforms (META) Stock Trend: META's stock price also showed an upward trend, especially from March to May, when the stock price rose from around $538 to over $1,200, reflecting the continued popularity of the metaverse concept.
- Tesla (TSLA) Stock Dynamics: Tesla's stock price showed significant fluctuations throughout the observation period, but the overall trend was upward, increasing from $564.91 to $886.28, reflecting the market's optimistic attitude towards electric vehicles and their technology.

5.1.2 Industry Sector Differences

- Tech Stocks Stand Out: Tech stocks, represented by APPLE, META, and TSLA, performed strongly throughout the observation period, with significant increases in stock prices, reflecting the continued growth momentum of the tech industry.
- Energy Stocks Show Larger Fluctuations: Energy stocks, such as Exxon Mobil (XOM), showed larger fluctuations in stock price during the observation period, but limited overall gains, reflecting the energy industry's sensitivity to global economic conditions and geopolitical factors.
- Healthcare Stocks Show Steady Growth: Healthcare stocks, such as AbbVie (ABBV), showed some fluctuations, but overall maintained steady growth, reflecting the stability and long-term growth potential of the healthcare industry.

5.1.3 Key Time Period Analysis

- Market Recovers after Chinese New Year: During the first week of the Chinese New Year holiday (January 10-16, 2023), the market experienced a correction, but stock prices gradually recovered in the following weeks, reflecting the market's positive outlook for the future.
- Market Volatility in March: Market volatility was significant in March, affected by various factors, but tech stocks still showed This period's stock market price data shows strong growth momentum for tech stocks and a solid growth trend for healthcare stocks, while energy stocks show greater volatility.

When formulating investment strategies, investors should consider industry trends, corporate fundamentals, and market risks to achieve asset preservation and capital ap-

preciation.

5.2 10 Stocks MM

First, from the Excel document "10-MM.xlsx", we can see several key data points, including weekly return rates, covariance matrices, standard deviations, and Sharpe ratios for several companies such as APPLE, META, and TSLA. These data provide a foundation for analyzing the market performance, risks, and relative performance of these stocks.

5.3 Weekly Return Rate Analysis

From the weekly return rate data, we can see the fluctuations in the stock prices of different companies over different time periods. For example, in the first few months of 2023, the market experienced several notable up and down movements. TSLA and META, This Excel file contains multiple data on financial markets and portfolio performance, including risk-free interest rate, weekly return rate, beta value of portfolios, standard deviation, expected return rate, etc. Below is a detailed analysis and summary of these data.

6. Data Analysis

6.1 Risk-free interest rate

The file mentions the risk-free interest rate (risk-free rate) multiple times, which is always 0.001025. The risk-free interest rate is the benchmark interest rate in the financial market, used to measure the return rate of risk-free investments such as government bonds.

6.2 Weekly return rate

The file shows the weekly return rates of multiple assets (such as APPLE, META, TSLA, etc.) at different time periods. These return rates are positive or negative, reflecting market price fluctuations. For example, the expected weekly return rates of most assets are not directly listed in the table during the period from January 3, 2023 to January 9, 2023, but the weekly return rate data of each asset is detailed listed in the following time period.

6.3 Portfolio performance

The file also includes key indicators such as beta value, standard deviation, and expected return rate of portfolios. For example:
a. Beta value: Measures the volatility of a portfolio relative to the market. A beta value greater than 1 indicates that the volatility of the portfolio is greater than the market, while a beta value less than 1 indicates that the volatility of the portfolio is less than the market.
b. Standard deviation: Measures the volatility of portfolio returns. The larger the standard deviation, the greater the uncertainty of returns.
c. Expected return rate: The average return rate that an investment portfolio is expected to achieve based on historical data or model predictions.

6.4 Market analysis

The file analyzes the performance of the market under different circumstances through data from different time periods. For example, the weekly return rate data of different assets during the period from January 2023 to December 2023 shows the dynamic changes of the market. These data can help investors understand market trends and formulate investment strategies.

7. Conclusion

7.1 Conclusion1

7.1.1 Market volatility

The weekly return rate data shows that financial markets exhibit significant volatility in different time periods. This volatility Sheet1

7.2 Data Analysis

7.2.1 Overview of Data

The document records the stock prices of several tech companies such as APPLE, MSFT, and NVDA from January 3, 2023, to December 31, 2023. The data is recorded weekly and includes 54 weeks of stock price information.

7.2.2 Price Trend Analysis

a. Overall Trend:
The stock prices of most tech companies have shown an upward trend during this period, especially in the second half of the year, with some companies experiencing significant price increases.
b. Abnormal Fluctuations:
There have been periods of significant price drops for several companies (e.g., early April 2023, mid-June 2023) which may be related to market adjustments or specific company events.
c. Individual Company Performance:
NVDA (NVIDIA): The stock price has shown a strong upward trend, especially in the second half of the year, driven by the AI wave.
META (Facebook): The stock price has fluctuated significantly, with an overall upward trend but several periods of

ISSN 2959-6130

correction.
AAPL (Apple): The stock price has been relatively stable, with some fluctuations but an overall upward trend.
MSFT (Microsoft): The stock price has steadily increased, especially reaching a peak at the end of the year.

7.3 Industry Comparison

The tech industry as a whole has performed well, especially companies related to AI, cloud computing, and semiconductors.
Compared to traditional industries, the tech industry has shown stronger growth potential and market appeal.

7.4 Market Environment Analysis

7.4.1 Macroeconomic Factors

The global economic recovery and the drive towards digital transformation have provided a favorable environment for the tech industry.

7.4.2 Policy Environment

Governments' supportive policies for technological innovation have provided vast development opportunities for tech enterprises.

7.4.3 Market Sentiment

Investors' confidence in the tech industry has been gradually increasing, especially high investment enthusiasm in emerging technologies.

7.5 Conclusion2

The tech industry has a bright outlook: Based on the data analysis in the document, MM

7.5.1 One, Data Analysis

a. Data Set Overview
The data set records the weekly returns of several major US stocks, such as Apple, Microsoft, and Nvidia, from January 3, 2023, to December 31, 2023. The data set includes the weekly returns of these stocks and several market indices.
b. Volatility Analysis
Standard Deviation: By calculating the standard deviation of each stock's weekly return, we can evaluate its volatility. For example, from the data in the document, NVIDIA (NVDA) has the highest standard deviation (0.1389331889824

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