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From Theory to Practice: Applying the Markowitz Model in Stock Portfolio Management under ESG

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ABSTRACT

The study consisted of a month-long simulated stock market operation focusing on the comprehensive analysis of equity portfolio creation and management. Against the backdrop of growing concern for environmental protection, the S&P 500 Net Zero 2050 Climate Transition ESG Index was deemed the appropriate benchmark for the portfolios due to the average level of risk tolerance of customers. The investigation began with an in-depth assessment of macroeconomic and sector conditions, followed by careful selection of securities using both fundamental and technical analysis techniques. The portfolio was then optimized using the Markowitz model and subsequently managed using a variety of strategies, including trading, monitoring, and rebalancing. The subsequent phase of the research involves a rigorous evaluation of performance utilizing various metrics including single-period returns and the Sharpe ratio. The study culminates in a reflective analysis of the overall investment project. Despite the portfolio's underperformance against the benchmark, the project provides invaluable insights into the intricacies of stock market investment and portfolio management, accentuating the impact of market volatility and the significance of strategic asset allocation.

KEYWORDS

Investment; Stock market analysis; ESG; Markowitz model; Portfolio Optimization; Performance evaluation

1. EXECUTIVE SUMMARY

It has been noted that global economic growth has slowed and that trade has been hindered. The US economy remains in high inflation while industries continue to change. However, environmental protection is increasingly being considered, and green industries have great potential. The implications of all of this are relevant to portfolio selection.

In order to combat climate change and global warming, the client instructed me to invest $100,000 in equities that meet a 1.5 ℃ climate scenario and contribute to a reduction in greenhouse gas emissions. The customer has an average level of risk tolerance, and the S&P 500 Net Zero 2050 Climate Transition ESG Index would be the appropriate benchmark for the portfolio. A return target is set equal to the benchmark's return over the duration of the investment. Stocks must be traded on the US stock market during the investment period of six weeks. All ten stocks must be included in the S&P 500 Net Zero 2050 Climate Transition ESG Index as of 30 September 2022. My top picks are Abbvie Inc, Eversource Energy, Keysight Technologies Inc, Coca-Cola Co, Motorola Solutions Inc, Netflix Inc, Starbucks Corp, S&P Global Inc, TransDigm Group Inc, and Tesla Inc.

As a result, the portfolio failed to achieve its return target. Portfolio holding period returns are -5.84%, while benchmark holding period returns are -4.87%. Despite rebalancing Tesla midway through the

period, the final portfolio profit was negatively impacted by the 30% loss in Tesla's share price. This shows that my portfolio still needs to be improved and upgraded.

2. MACROECONOMIC AND INDUSTRY CONDITIONS

It is essential to contextualize the overarching economic landscape. This preliminary understanding will facilitate a nuanced exploration of the determinants influencing current market dynamics and their consequential impacts across various industries. Subsequent analysis will dissect pivotal economic indicators and evolving trends that are sculpting the global economic environment.

2.1. Macroeconomic Analysis

There has been a broad-based and more severe slowdown in the world's economic activity. As reported by UNCTAD in its latest Global Trade Update, global trade is expected to reach a record $32 trillion by 2022. Global trade is expected to be constrained next year due to geopolitical tensions, high energy prices, rising interest rates, and persistent inflation [1]. See Figure 1.

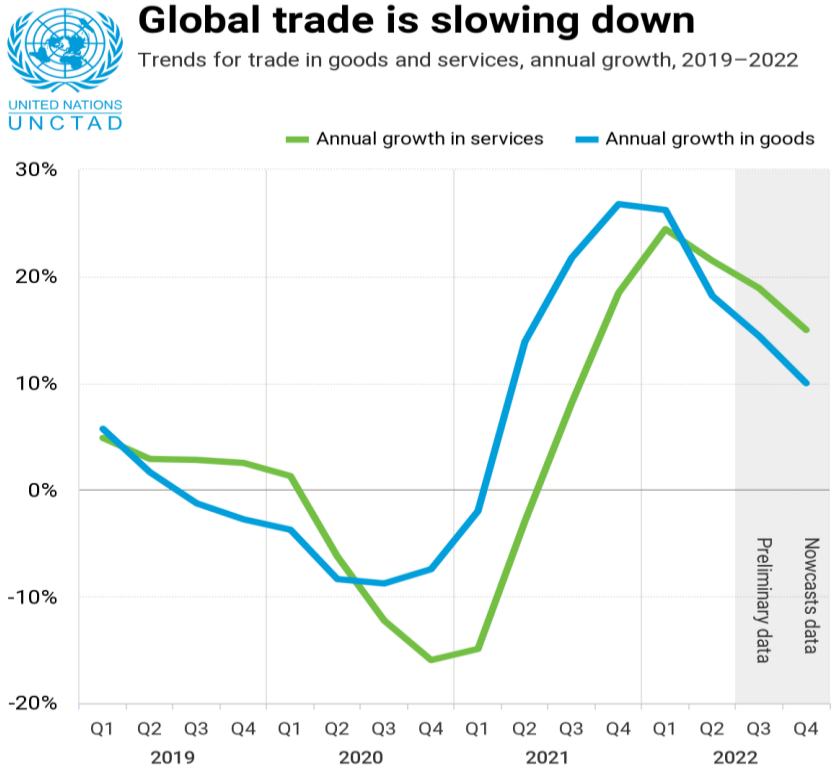

Figure 1. The annual growth in services and goods from 2019 to 2022

Source: UNCTAD calculations based on national statistics [1]

A rise in global inflation was predicted from 4.7% in 2021 to 8.8% in 2022. The rate will, however, decrease to 6.5% in 2023 and 4.1% in 2024 [2]. The Federal Reserve raises the federal funds rate to reduce inflation. Banks pay higher interest rates on loans to businesses and individuals due to increased interest rates. The economy will be cooled by reducing the money supply and lowering inflation [3]. By selling dollar-denominated Treasuries and recycling dollars into the market, the Fed decreases the flow of capital into the stock market, thereby lowering stock prices. The market was expecting only a 50 basis point rate increase following the latest inflation data release. As a result, the stock market surged due to less of a hike than the previously announced rate hike figures [4]. All of this information will influence the decision regarding my portfolio.

In view of the volatility of the stock market, I would probably prefer stocks related to durable goods. This is because the use of durable goods has increased due to the epidemic. My preferred sectors would be Automobiles & Components, and Technology Hardware & Equipment. Additionally, industries experiencing rapid growth as a result of the epidemic should also be considered. This is because explosive profit growth can increase profits, such as Media & Entertainment, Pharmaceuticals, and Biotechnology.

2.2. Industry Analysis

There has been a slowdown in the pace of economic activity, which has adversely affected the outlook for most sectors. Despite the global financial crisis and the acute phase of the COVID-19 pandemic, this is the weakest growth situation since 2001 [2]. Most of the industry is experiencing exhaustion at this time. Thus the comparison is based on return on equity and share price. ROE is an effective indicator of profitability since it measures the return on investment concerning shareholders' equity. Moreover, S&P 500 stock prices reflect broader market movements and may be helpful for making investment decisions to a certain extent.

A green financial system was built in the US with the Comprehensive Environmental Response, Compensation, and Liability Act. Various green financial products have been developed and innovated in the US, providing a wealth of investment channels. The US Environmental Protection Agency [5] points out that this has also significantly reduced the cost of financing sustainable projects in the US and facilitated project financing accessibility. ROE data for crucial sectors is presented in Table 1, and stock prices for the S&P 500 are shown in Table 2.

Table 1. The return on equity(ROE) of key industries in 2021

Industry Name	ROE (unadjusted)	ROE (adjusted for R&D)	Company Chosen
Entertainment	4.28%	4.37%	NFLX
Real Estate (Development)	-0.46%	-0.46%	
Automobiles	6.72%	6.01%	TSLA
Air Transport	-27.28%	-25.97%	
Consumer Services	13.67%	13.57%	SBUX
Engineering/Construction	6.48%	6.48%	
Beverages (Soft)	32.80%	31.60%	KO
Beverage (Alcoholic)	4.39%	4.39%	
Capital Markets/Financial Services (Non-bank & Insurance)	0.28%	0.28%	SPGI
Biotechnology	-0.76%	1.53%	ABBV
Software (Internet)	-11.29%	-4.12%	
Aerospace & Defense	9.09%	6.97%	TDG
Communications Equipment	24.93%	15.73%	MSI
Education	8.61%	8.67%	
Electronic Equipment, Instruments & Components	16.80%	14.65%	KEYS
Utilities (General)	8.44%	8.44%	ES

Sources: Pages.stern.nyu.edu, Return On Equity [6]

Table 2. The overall performance of S&P 500 stock prices in different sectors

INDEX NAME	YTD	1 YEAR	3 YEARS Annualized	5 YEARS Annualized	Company Chosen
Real Estate (Sector)	0.31%	-27.53%	-0.84%	2.82%	
Financials & Real Estate Index (USD) (Custom)	0.36%	-16.20%	2.87%	3.83%	
IT Services (Industry)	0.43%	-20.36%	0.47%	7.53%	
Communication Services & Information Technology Index	-0.48%	-32.80%	5.93%	10.37%	
Communication Services (Sector)	1.39%	-39.92%	-4.06%	-0.15%	NFLX
Consumer Discretionary (Sector)	-0.59%	-39.61%	0.30%	4.52%	TSLA, SBUX
Consumer Staples (Sector)	-0.24%	-3.39%	6.66%	5.89%	KO
Energy (Sector)	-3.63%	48.67%	12.20%	3.29%	
Financials (Sector)	0.38%	-13.11%	3.86%	4.17%	SPGI
Health Care (Sector)	-0.29%	-2.88%	10.23%	10.09%	ABBV
Industrials (Sector)	0.21%	-6.14%	6.01%	5.22%	TDG
Information Technology (Sector)	-1.01%	-30.34%	9.86%	13.65%	Keys, MSI
Materials (Sector)	-0.11%	-12.95%	9.27%	4.76%	
Utilities (Sector)	0.00%	-0.50%	3.41%	6.39%	ES

Sources: S&P Dow Jones Indices [7]

It is very critical to conduct an industry analysis when selecting a portfolio. The two tables above indicate that financials and industrials are performing well, which is why I selected these two sectors. The share price of Communication Services has been low for the year but is increasing year-to-date. Communication Services is so essential to people's lives today that NFLX is a worthwhile investment. Bodie, Kane, and Marcus [8] cited the low elasticity of demand for essential goods and low sensitivity to business conditions. Consumer essentials are always in demand, regardless of the environment. I selected Abbvie Inc (ABBV) and Coca-Cola Co (KO) in this regard.

3. SECURITY SELECTION

Subsequent to the evaluation of macroeconomic and industry conditions, we now transition to the meticulous process of security selection. The forthcoming section will commence with an in-depth exploration of fundamental analysis, emphasizing its role in assessing the intrinsic value of securities based on financial metrics and market data. Additionally, we will delve into technical analysis, underscoring its importance in identifying market trends and timing investment decisions effectively, thereby complementing the insights gained from fundamental analysis.

3.1. Fundamental Analysis

Equity valuation theory suggests that stock prices represent a company's future income ability. Stock market analysts identify mispriced securities using stock valuation models [8]. Using the same metrics, relative valuation compares a company to similar companies to determine its value [9]. According to equity valuation models, intrinsic value refers to a company's 'true' value. A company's intrinsic value is derived from its investment fundamentals and characteristics [10]. For example, the

cost approach and the dividend discount models. Unlike these models, the comparable models will try to find a relative value [11].

According to the comparables models, KEYS was chosen for comparison with the industry average. (See Appendix B)

Table 3. The ratios comparison between KEYS and industry in 2022

	KEYS	Industry average
Forward Price/Earnings Ratio (TTM)	20.12	20.98
Price/Book Ratio (MRQ)	7.35	7.36
Price/Sales Ratio (TTM)	5.74	4.85
PEG ratio (5 yrs expected)	2.2	1.8

Source: Yahoo! Finance & S&P Dow Jones Indices [12, 13]

According to the Table 3, the Forward Price/Earnings Ratio and Price/Book Ratio of Keysight Technologies Inc (KEYS.N) are below the industry average. It is likely that Keysight Technologies Inc shares are undervalued or underpriced, which indicates potential. Moreover, another ratio is called the price to earnings growth ratio (PEG), which is the ratio of price to earnings growth. The PEG ratio of Keysight Technologies Inc is 2.2, compared to an industry average of 1.8. Generally speaking, a high PEG ratio indicates a high company's potential. Therefore, 2.2 is a good ratio compared to 1.8, which proves our previous conclusion that Keysight Technologies stock is underpriced or undervalued. My choice is Keysight Technologies Inc.

It is also worth noting that different valuation methods produce different results. For example, the discounted cash flow method ignores market factors and competitor information and focuses only on the company being valued. However, equity markets can be overvalued at times, which makes comparisons more difficult, especially if the company is overvalued. The most reliable results are usually obtained by combining various methods [14].

Moreover, fundamental analysis is primarily concerned with analysing financial reporting data and market expectations in order to determine the market capitalisation and fair value of a company's shares. A fundamental valuation method includes the analysis of financial statements, including balance sheets and income statements, as one of its critical tasks. Forecasting future profitability is therefore a vital component of the valuation of a company. As part of the valuation process of business companies, financial statement information is often used, as it provides some critical information such as the company's assets, debt ratios, and cash flow data [15]. As a result of financial statement analysis, we are able to gain an understanding of a company's assets, liabilities, and cash flow.

The Table 4 is a fundamental analysis using Tesla as an example, comparing the second and third quarters of 2022. (See Appendix B)

Table 4. The comparison of Tesla's keys financial ratios across time

	Q2-2022	Q3-2022	Change %
Leverage			
Interest coverage(times interest earned)	57.23	69.60	21.63%
Interest burden	0.98	0.99	0.32%
Liquidity			
Current ratio	1.43	1.46	2.20%
Quick ratio	0.96	0.95	-1.61%
Profitability			
Return on equity	6.41%	8.64%	34.70%
Operating margin	14.60%	17.20%	17.81%

Source: Investor Relations in Tesla Official Website [16]

The interest coverage ratio measures a company's ability to generate pre-tax profits to cover current interest payments [17]. As shown in the table above, the ratio in Tesla's third quarter increased by 21.63 %, indicating that the company was able to pay interest without having to service its debt. Furthermore, the interest burden ratio represents the percentage of EBIT remaining after interest expense. As a result of the significant increase in EBIT being greater than the increase in interest expense in the third quarter, this ratio increased from 0.98 to 0.99. It indicates Tesla's profits have increased, but interest expenses also need to be controlled.

Furthermore, liquidity refers to the ease with which an asset or security can be converted to cash without affecting its market value. Since the inventory was higher than the current assets, the current ratio increased by 2.2%, and the quick ratio decreased by 1.61%. It is more typical to have a current ratio of 2 and a quick ratio of 1. Thus Tesla ratio fluctuation is normal, and solvency is still guaranteed. In addition, industry-specific criteria for the current and quick ratios differ.

Lastly, profitability is significant because it reflects the efficiency with which a company generates profits through its core businesses [18]. ROE increased by 34.7% in the third quarter, indicating a higher rate of return on investment than in the second quarter. 17.81% increase in the operating margin shows that both sales revenue and operating profit increased simultaneously. As a result, Tesla's profitability has the potential to improve.

Tesla is a good investment as the customer seeks to reduce greenhouse gas emissions. Additionally, Tesla's indicators prove the company's potential.

3.2. Technical Analysis

Technical analysis is based on the assumption that markets are not efficient. It is the use of past patterns of stock price movement to determine upward or downward signals that can be used to predict short-term and medium-term changes in stock prices [19]. There is no doubt that the concept of trend is one of the oldest concepts in technical analysis, and it is probably the most influential part of technical analysis to determine the trend in stock prices as it is the starting point for many other techniques [8].

Figure 2. The changes in historical data for TDG stock

Source: Yahoo! Finance [20]

Based on the Figure 2, TransDigm Group Inc (TDG) experienced a significant decline from December 1, 2022, to December 6, 2022. Historically, a significant decline in TDG is typically followed by a substantial increase. December 6 appears to be a good time to invest. At the end of December 6, I purchased shares at a lower price, which resulted in a potential profit.

4. PORTFOLIO OPTIMIZATION

According to Markowitz and G Peter Todd [21], the Markowitz model can be described as a mathematical model with a straightforward objective: to identify a global risk-neutral portfolio that will achieve optimal risk-adjusted returns. Many new investors use this technique in the capital markets because the model facilitates practical application. Markowitz's model of selection emphasizes the importance of portfolio diversification. Equities are categorized according to their risk levels [22]. It is common for investors to allocate a portion of their capital to this portfolio of investments based on how risk-averse they are.

According to Commerce Mates [23], there are three advantages. Firstly, it can make portfolios more efficient. An investor's objectives may be met if the right mix of stocks, bonds, and other securities is chosen. Developing a balanced portfolio requires avoiding high-risk assets, which risk-averse investors can spot. By doing so, investors can achieve higher returns with less risk.

Secondly, the portfolio is resistant to systematic risk since market securities are evaluated efficiently. Due to its diversification strategy, the model invests in various assets or securities. If any asset causes a loss, the overall portfolio held by the investor will not be significantly adversely affected by the loss.

Lastly, the Markowitz model underpins modern portfolio theory. An ideal portfolio can be created using modern portfolio theory. It may be difficult for investors to identify an ideal portfolio independently. Profitable portfolios can be built using MBT theory for amateur investors.

Wallstreetmojo [22] claims that the Markowitz model has two drawbacks. Firstly, it is based on historic data and does not guarantee high returns. In order to construct an effective frontier for risky assets, the model is unable to provide any guidance for predicting the risk premium associated with a security. Returns from the past are not a reliable indicator of future returns. Secondly, some of the assumptions made in the model are not in accord with reality. Commissions, taxes and other fees, for example, are not accounted for. In addition, there are taxes and transaction costs associated with financial products in the real world. Further, it is assumed that investors are risk-averse and perfectly

rational. Unfortunately, this is not possible, and emotions are the driving force behind irrational behaviour.

It is more challenging to create a Treynor-Black portfolio than a Markowitz portfolio. Kane, Kim, and White [24] argue that the model is not popular because picking stocks accurately is difficult and restrictions on short selling limit the ability to exploit market efficiency and generate alpha. The Markowitz model would therefore be more suitable for me since it is easier to work with.

The Markowitz Portfolio Optimization Model involves three steps. The first step is to identify the risk-return portfolio from a pool of risky assets. It is then determined what the optimal risky portfolio is. Lastly, a complete portfolio is selected based on the investor's needs (Appendix C).

Table 5. The application of the Markowitz model

Panel A: Return and Risk Parameters of the Investable Universe (annualized)

Mean Return Forecast Adjustment Factor	0.2
	Mean Return	Standard Deviation
SBUX	0.0283	0.2614
TSLA	0.1333	0.7273
TDG	0.0444	0.3522
SPGI	0.0357	0.2462
ES	0.0123	0.1888
KO	0.0160	0.1875
ABBV	0.0287	0.2914
MSI	0.0483	0.2580
NFLX	0.0381	0.4495
KEYS	0.0534	0.2949
Index	0.0214	0.1996

Panel B: Estimate of Expected Risk Free Rate

Risk Free Rate	0.01267723

Panel C: Correlation Matrix

	SBUX	TSLA	TDG	SPGI	ES	KO	ABBV	MSI	NFLX	KEYS	Index
SBUX	1.0000	0.1946	0.5528	0.4923	0.2761	0.4567	0.2411	0.5135	0.2632	0.5007	-0.1739
TSLA	0.1946	1.0000	0.3435	0.4387	0.1915	0.2207	0.1456	0.3299	0.3378	0.1744	-0.0581
TDG	0.5528	0.3435	1.0000	0.5444	0.3630	0.6536	0.3304	0.6158	0.3491	0.5101	-0.0516
SPGI	0.4923	0.4387	0.5444	1.0000	0.4092	0.4177	0.2265	0.5965	0.4734	0.5452	-0.1414
ES	0.2761	0.1915	0.3630	0.4092	1.0000	0.5343	0.1014	0.3985	-0.0022	0.2882	-0.1400
KO	0.4567	0.2207	0.6536	0.4177	0.5343	1.0000	0.2664	0.3668	-0.0510	0.1427	-0.0453
ABBV	0.2411	0.1456	0.3304	0.2265	0.1014	0.2664	1.0000	0.2393	0.1548	0.2639	-0.0686
MSI	0.5135	0.3299	0.6158	0.5965	0.3985	0.3668	0.2393	1.0000	0.4626	0.5388	-0.1161
NFLX	0.2632	0.3378	0.3491	0.4734	-0.0022	-0.0510	0.1548	0.4626	1.0000	0.5830	-0.2311
KEYS	0.5007	0.1744	0.5101	0.5452	0.2882	0.1427	0.2639	0.5388	0.5830	1.0000	-0.2746
Index	-0.1739	-0.0581	-0.0516	-0.1414	-0.1400	-0.0453	-0.0686	-0.1161	-0.2311	-0.2746	1.0000

Panel D: Covariance Matrix

		SBUX	TSLA	TDG	SPGI	ES	KO	ABBV	MSI	NFLX	KEYS	Index
	Std Dev	0.2614	0.7273	0.3522	0.2462	0.1888	0.1875	0.2914	0.2580	0.4495	0.2949	0.1996
SBUX	0.2614	0.0683	0.0370	0.0509	0.0317	0.0136	0.0224	0.0184	0.0346	0.0309	0.0386	-0.0091
TSLA	0.7273	0.0370	0.5290	0.0880	0.0786	0.0263	0.0301	0.0308	0.0619	0.1104	0.0374	-0.0084
TDG	0.3522	0.0509	0.0880	0.1241	0.0472	0.0241	0.0432	0.0339	0.0560	0.0553	0.0530	-0.0036
SPGI	0.2462	0.0317	0.0786	0.0472	0.0606	0.0190	0.0193	0.0162	0.0379	0.0524	0.0396	-0.0069
ES	0.1888	0.0136	0.0263	0.0241	0.0190	0.0356	0.0189	0.0056	0.0194	-0.0002	0.0161	-0.0053
KO	0.1875	0.0224	0.0301	0.0432	0.0193	0.0189	0.0352	0.0146	0.0177	-0.0043	0.0079	-0.0017
ABBV	0.2914	0.0184	0.0308	0.0339	0.0162	0.0056	0.0146	0.0849	0.0180	0.0203	0.0227	-0.0040
MSI	0.2580	0.0346	0.0619	0.0560	0.0379	0.0194	0.0177	0.0180	0.0666	0.0536	0.0410	-0.0060
NFLX	0.4495	0.0309	0.1104	0.0553	0.0524	-0.0002	-0.0043	0.0203	0.0536	0.2021	0.0773	-0.0207
KEYS	0.2949	0.0386	0.0374	0.0530	0.0396	0.0161	0.0079	0.0227	0.0410	0.0773	0.0870	-0.0162
Index	0.1996	-0.0091	-0.0084	-0.0036	-0.0069	-0.0053	-0.0017	-0.0040	-0.0060	-0.0207	-0.0162	0.0398

Panel E: Bordered Covariance Matrix for Optimal Portfolio

		SBUX	TSLA	TDG	SPGI	ES	KO	ABBV	MSI	NFLX	KEYS	Index
	Weights	0.0500	0.0742	0.0500	0.0500	0.0500	0.0500	0.0500	0.1750	0.0500	0.1837	0.2170
SBUX	0.0500	0.0002	0.0001	0.0001	0.0001	0.0000	0.0001	0.0000	0.0003	0.0001	0.0004	-0.0001
TSLA	0.0742	0.0001	0.0029	0.0003	0.0003	0.0001	0.0001	0.0001	0.0008	0.0004	0.0005	-0.0001
TDG	0.0500	0.0001	0.0003	0.0003	0.0001	0.0001	0.0001	0.0001	0.0005	0.0001	0.0005	0.0000
SPGI	0.0500	0.0001	0.0003	0.0001	0.0002	0.0000	0.0000	0.0000	0.0003	0.0001	0.0004	-0.0001
ES	0.0500	0.0000	0.0001	0.0001	0.0000	0.0001	0.0000	0.0000	0.0002	0.0000	0.0001	-0.0001
KO	0.0500	0.0001	0.0001	0.0001	0.0000	0.0000	0.0001	0.0000	0.0002	0.0000	0.0001	0.0000
ABBV	0.0500	0.0000	0.0001	0.0001	0.0000	0.0000	0.0000	0.0002	0.0002	0.0001	0.0002	0.0000
MSI	0.1750	0.0003	0.0008	0.0005	0.0003	0.0002	0.0002	0.0002	0.0020	0.0005	0.0013	-0.0002
NFLX	0.0500	0.0001	0.0004	0.0001	0.0001	0.0000	0.0000	0.0001	0.0005	0.0005	0.0007	-0.0002
KEYS	0.1837	0.0004	0.0005	0.0005	0.0004	0.0001	0.0001	0.0002	0.0013	0.0007	0.0029	-0.0006
Index	0.2170	-0.0001	-0.0001	0.0000	-0.0001	-0.0001	0.0000	0.0000	-0.0002	-0.0002	-0.0006	0.0019
	1.0000	0.0013	0.0056	0.0022	0.0015	0.0006	0.0007	0.0009	0.0060	0.0023	0.0065	0.0003

Portfolio Variance	0.0279
Portfolio Standard Deviation	0.1671
Portfolio Mean Return	0.0430
Sharpe Ratio	0.1813

Panel F: Calculating Allocations of Optimal Risky Portfolio

Stock	Optimal Allocation	Dollar Allocation	Stock Price	Number of Stocks
SBUX	0.0639	5984.06	103.00	58.10
TSLA	0.0948	8883.34	123.15	72.13
TDG	0.0639	5984.06	610.00	9.81
SPGI	0.0639	5984.13	352.00	17.00
ES	0.0639	5984.05	82.00	72.98
KO	0.0639	5984.06	62.00	96.52
ABBV	0.0639	5984.06	158.00	37.87
MSI	0.2236	20948.98	268.00	78.17
NFLX	0.0639	5984.03	310.00	19.30
KEYS	0.2346	21986.26	176.00	124.92
Portfolio	1.0000	93707.03		

According to the Table 5, optimal portfolio allocations were obtained. These are KEYS (24%), SBUX (6%), TSLA (10%), TDG (6%), SPGI (7%), ES (6%), KO (7%), ABBV (6%), MSI (22%), NFLX (6%). (See Appendix D)

5. PORTFOLIO MANAGEMENT

Following the formulation of the investment portfolio, the subsequent discussion centers on portfolio management strategies. We will begin by examining equity portfolio management and then delve into specific techniques such as trading, rebalancing, and monitoring of the portfolio, which are essential for maintaining and optimizing its performance over time.

5.1. Equity Portfolio Management

There are three types of equity portfolio management: passive, active, and semi-active. The objective is to outperform the benchmark index without excessive risk [25]. Compared with active managers,

semi-active portfolio managers are more concerned about tracking risk and tend to construct a portfolio with a minimal level of volatility around benchmark returns. However, the enhanced indexer thinks the incremental return more than compensates for the slight risk increase. As a result, there is strict control over risk tracking, and the information ratio tends to be higher [26].

With semi-active management, the target return is higher than that of passive management, and the risk is lower than that of active management. Risk tolerance was assessed as average for the client. The S&P 500 Net Zero 2050 Climate Transition EGS Index returns are set to the holding period return. Semi-active management is appropriate for a client who does not have a primary objective of profit but does need to achieve benchmark profit. To achieve a target return greater than the benchmark, I have selected TESLA, along with TDG and SPGI, as stocks for adjustment.

5.2. Trading, Rebalancing And Monitoring Of Portfolio

5.2.1. Trading

Limit orders were used in purchasing the stocks, which require an investor to set a price and ask the broker to purchase or sell the stock at a price that is less than or equal to a specific number [27]. When purchasing stocks, I discovered that the prices of the selected portfolios were higher than in the previous portfolios. As a result, I believe they would fall in the near future. Thus, I placed limit orders on all of my stocks, and all of them were bought at a much lower price in the end.

5.2.2. Monitoring and Rebalancing

It is essential that a portfolio manager keeps track of all factors that affect the portfolio, including tax circumstances, market cycles, and the portfolio itself. The term 'rebalancing' refers to the process of adjusting the portfolio periodically or according to certain circumstances in order to return it to its original target allocation [28]. The purpose of this step is to control risk. If market conditions change and the prices of different assets rise or fall, the proportions of original portfolio will become imbalanced. By selling assets that are rising and purchasing assets that are falling, the investor maintains the ideal asset allocation for rebalancing. Furthermore, the imbalance is certain to persist and result in a completely different allocation of equity and debt. As well as maintaining the desired systematic risk exposures, rebalancing enhances the effectiveness of a portfolio.

There are two ways to rebalance a portfolio. One approach is calendar rebalancing, in which rebalancing is done at regular intervals in order to achieve the target weighting, for example, every month, quarterly, and annually. Unfortunately, this method cannot be applied to this investment project due to its short duration. A second type of rebalancing is percentage-of-portfolio rebalancing, implemented by setting rebalancing triggers such as 1%, 5%, and 10% [29]. The portfolio is rebalanced when an asset class's weight exceeds one of the rebalancing thresholds for the first time. Given the short investment period of 6 weeks, I think 10% is appropriate. The formula is, therefore, Target Allocation +/- (Target Allocation * 10%).

Table 6. The results of percentage-of-portfolio rebalancing

Company	Association with the formula	Results(minimum)	Results(maximum)
SBUX	6%+/-(6% * 10%)	5.40%	6.60%
TSLA	10%+/-(10% * 10%)	9.00%	11.00%
TDG	6%+/-(6% * 10%)	5.40%	6.60%
SPGI	7%+/- (7% *10%)	6.30%	7.70%
ES	6%+/-(6% * 10%)	5.40%	6.60%
KO	7%+/- (7% *10%)	6.30%	7.70%
ABBV	6%+/-(6% * 10%)	5.40%	6.60%
MSI	22%+/-(22% * 10%)	19.80%	24.20%
NFLX	6%+/-(6% * 10%)	5.40%	6.60%
KEYS	24%+/-(24% * 10%)	21.60%	26.40%

Table 7. the stock information on 15 December, 2022

Company	Shares	Holdings %	Value
SBUX	62	6.20%	$6,199.38
TSLA	48	7.57%	$7,568.16
TDG	10	6.12%	$6,121.50
SPGI	18	6.37%	$6,369.12
ES	75	6.31%	$6,309.75
KO	101	6.37%	$6,374.11
ABBV	39	6.36%	$6,360.90
MSI	83	21.34%	$21,342.62
NFLX	20	5.81%	$5,808.20
KEYS	133	23.43%	$23,431.94

According to Table 6 and Table 7, TSLA is the only stock that requires rebalancing, according to the two tables above. This is because on 15 December, the holding percentage of TSLA was 7.57%. In accordance with Table 6, TSLA's percentage should range between 9% and 11%, but TSLA does not comply with this requirement. Therefore, I have rebalanced the TSLA percentage to the original percentage optimised according to the Markowitz model.

6. PERFORMANCE EVALUATION

Subsequent to the execution of portfolio management strategies, the focus shifts to a rigorous evaluation of performance outcomes. The ensuing analysis encompasses performance measurement, attribution, and appraisal, systematically assessing the efficacy of the implemented investment

strategies and their alignment with predefined objectives. This multifaceted evaluation provides a critical review of both quantitative results and strategic decision-making processes.

6.1. Performance Evaluation

Investment management decisions are measured and evaluated in terms of performance. In order to understand how well this portfolio is performing against the objectives and constraints of the client, we need to evaluate the outcome of the investment decisions made to manage it. In order to understand whether this performance meets or is consistent with a client's objectives and constraints, it is pertinent to assess performance from the sponsor's or client's perspective.

In contrast, performance evaluation is vital for investment portfolio managers. The portfolio manager will be able to assess the portfolio's performance and whether investment decisions are being made in accordance with expectations since it will act as a feedback or control loop [30]. Three parts make up a performance appraisal: performance measurement, performance attribution, and performance appraisal.

6.2. Performance Measurement

Performance measures are included in the evaluation of equity portfolios. Bodie, Kane and Marcus [8] describe three methods of measuring performance: single-period return, time-weighted return, and internal rate of return. A single-period return approach is adopted due to the short duration of the investment project. This formula is as follows:

$$R = \frac{Total\ proceeds}{Initial\ Investment} = \frac{Dividend\ Income\ +\ Capital\ gains}{Initial\ Investment}$$

$$= \frac{D_1 + (P_1 - P_0)}{P_0}$$

According to the HOW THE MARKET WORKS website [31], the Net Worth of my portfolio is $94,153.7 on 30 December 2022 and the initial investment is $100,000. Therefore R=($94,153.7-$100,000)/$100,000= -0.058463 ≈ -5.85%. See Table 8.

Table 8. Performance Measurement

Portfolio Holding Period Return	-5.85%
Benchmark Holding Period Return	-4.87%
Portfolio Return Objective (Benchmark + 0%)	-4.87%
Has the portfolio achieved the return objective?	NO

My portfolio produced a single-period investment return of -5.85%, while the benchmark generated a return of -4.87%. Therefore, my portfolio did not meet the client's return target since the benchmark return is the target return. My portfolio suffered significantly during the short investment cycle as Tesla's share price declined rapidly.

6.3. Performance Attribution

According to Menchero [32], performance attribution has the purpose of explaining portfolio performance relative to a benchmark, identifying the sources of excess returns, and relating those returns back to actively managed portfolios.

The performance attribution system includes allocation choices across broad asset classes, industry or sector choices within each market and security choice within each sector. Here is a table that

compares my portfolio's returns with those of a benchmark portfolio to give an indication of our performance and the source of the data.

Table 9. Performance Attribution

	(1)	(2)	(3)	(4)	(5) = (1) - (2)	(6) = (5) * (4)	(7) = (3) - (4)	(8) = (7) * (1)	(9) = (6) + (8)
Economic Sectors	Portfolio Sector Weight (%)	Benchmark Sector Weight (%)	Portfolio Sector Return (%)	Benchmark Sector Return (%)	Active/Excess Weight	Sector Allocation	Active/Excess Return	Within- Sector Selection	Total Value-Added
Information Technology	45.62	28.40	-3.25	-6.98	17.22	-1.20	3.73	1.70	0.50
Health Care	6.35	15.50	-0.68	-0.76	-9.15	0.07	0.08	0.01	0.08
Financials	6.33	11.80	-4.68	-4.94	-5.47	0.27	0.26	0.02	0.29
Consumer Discretionary	18.62	10.10	-19.33	-9.72	8.52	-0.83	-9.61	-1.79	-2.62
Communication Services	6.20	8.30	-4.86	-5.14	-2.10	0.11	0.29	0.02	0.13
Industrials	6.10	8.30	3.23	-2.74	-2.20	0.06	5.98	0.36	0.42
Consumer Staples	6.36	6.70	0.97	-2.01	-0.34	0.01	2.98	0.19	0.20
Energy	0.00	3.90	0.00	-4.19	-3.90	0.16	4.19	0.00	0.16
Utilities	6.30	1.80	-0.20	-0.16	4.50	-0.01	-0.04	0.00	-0.01
Real Estate	0.00	2.80	0.00	-4.36	-2.80	0.12	4.36	0.00	0.12
Materials	0.00	2.40	0.00	-5.35	-2.40	0.13	5.35	0.00	0.13
Cash	-1.88	0.00	19.80	0.00	-1.88	0.00	19.80	-0.37	-0.37
Total	100.00	100.00	-5.85	-4.87	0.00	-1.11		0.13	-0.97

Table 9 shows that my portfolio has a total value added of -0.97%, which indicates that my portfolio has a relatively low return compared to the benchmark. Among these sectors, IT is the one in which I am most heavily invested, with total value added of 0.5% and the best business performance. The poorest performing sector is consumer discretionary, probably because Tesla has lost almost 30% of its value. Moreover, utilities are also negative, but perform slightly better than consumer discretionary. (See Appendix E)

6.4. Performance Appraisal

Performance appraisals are designed to provide quantitative evidence that can be used by fund sponsors to determine whether portions of their investment portfolio should be retained or modified [33]. While risk-adjusted performance measures are the most widely used performance assessment methods, these include Jensen's Alpha, Sharpe ratio, Treynor metric, M2 measure and information ratio.

Sharpe ratios are used to compare excess investment returns with their risks, which means that over time, excess returns may indicate more volatility and risk than investment skills. An investor's Sharpe ratio should be used when selecting or evaluating a portfolio of risky investments or focusing on total volatility rather than systematic risk [33]. A higher Sharpe ratio generally indicates a more attractive risk-adjusted return. Here is the formula:

$$S_p = \frac{(\overline{r_p} - \overline{r_f})}{\sigma_p}$$

Table 10. Performance Appraisal

Portfolio Average Daily return	-0.17%
Portfolio Daily Standard Deviation	0.84%
Average Daily Risk Free Rate	0.0120%
Benchmark Average Daily Return	-0.14%
Average Daily Active Return (Alpha)	-0.03%
Active Risk (St. Dev. of Daily Active Return)	0.79%
Sharpe Ratio	-0.22
Information Ratio	-0.04

The Sharpe ratio as shown in Table 10 is -0.22. The negative Sharpe ratio indicates that the return is outweighed by the risk, meaning that the investment objective has not been achieved and portfolio adjustment is necessary.

In the Information Ratio (IR), active returns are divided by active risk as a measure of the volatility of a portfolio's returns relative to benchmark returns (typically an index such as the S&P 500). An information ratio indicates the return generated by deviations from benchmark holdings by the portfolio manager for each incremental unit of risk. When selecting or evaluating a portfolio for addition to a benchmark portfolio, we need to consider the information ratio [34].

$$IR = \frac{\alpha_P}{\sigma(e_P)}$$

Risk is explained by the information ratio using tracking error. Generally, the greater the information ratio, the greater the excess return resulting from tracking error. Based on the table above, the information ratio is -0.04, indicating that the excess return is underperforming and the portfolio returns less than the benchmark. In light of this, it is apparent that my portfolio is not performing well and does not assist clients in achieving their objectives and needs to be actively managed for improvement.

7. CONCLUSION

This study, through a month-long simulation using the Markowitz model within stock market operations, has elucidated the challenges and intricacies of portfolio management under risk-return constraints. Despite the portfolio's underperformance against the S&P 500 Net Zero 2050 Climate Transition ESG Index, it effectively showcased the complex dynamics between risk management and investment strategies, while incorporating elements of sustainability.

The research emphasized the critical role of macroeconomic and sector analysis in guiding the selection and optimization of portfolios, highlighting the application of theoretical models to real-world scenarios. This approach not only navigated the volatility of the stock market but also addressed the complexities introduced by integrating sustainability objectives, which subtly influence the risk-return profile.

The findings suggest a need for further development of financial models that more adeptly balance risk and return, advocating for continuous innovation in investment practices to better meet diverse investment goals. This sets a foundation for a reflective analysis, providing deeper insights into the practical applications of investment theories and the challenges faced in real-time financial decision-making.

8. REFLECTION ON THE INVESTMENT PROJECT

The investment project was based on a simulation of the actual stock market. Since it was my first time dealing with stocks, it was challenging. It was a valuable opportunity to apply my textbook knowledge to practice and gain some in-depth knowledge. In this investment project, I analyzed macro and sector data and applied various theories and models to determine which stocks to include in my portfolio. It was a crucial step that formed the basis for subsequent operations. Throughout a six-week period, I managed and optimized my portfolio. To maintain the existing balance of shares and bonds, which could withstand a certain level of volatility, I implemented a rebalancing exercise, which ensured that the asset allocation targets were on the right track. Unfortunately, the client's profit objectives were not met. Reflecting on this failure, I have taken stock.

Furthermore, it shows how volatile the stock market is and how complex investment operations are. As part of the project, I would write a report about portfolio management and thinking, and I would receive feedback on my report, which I believe that would help me a lot and helpe me understand my weaknesses in future stock market operations. It would have been better if I had spent more time on the investment project. Otherwise, I could have gained a better understanding of how to trade stocks.

I found this investment project very useful because it has real-world applications. Firstly, I learned how to prepare a portfolio report for a client. In addition, the project broadened my mindset and, to some extent, helped me develop a working mindset that matches reality. Moreover, I strengthened my knowledge of the stock market as e I have used various theories and models in my investment projects and applied what I have learned from books. This has developed my skills in the subject matter of the module and has stimulated my interest and potential. This is crucial to my professional development.

Additionally, it broadens my knowledge and allows me to search and collect information. My learning ability will also be improved through the process, which will increase my competitiveness at work and improve my learning ability. However, this investment project does not include a collaborative component, even though learning how to cooperate and communicate is also critical for society.

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