

# **Analysing ESG Impact: Performance of NYSE and Nasdaq Stock Portfolios at Varying ESG Levels**

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## **Abstract**

This article compares the market risk and returns of portfolios characterized by varying levels of ESG (Environmental, Social, and Governance) criteria. Covering the period from 2016 to 2022, the analysis utilizes datasets from the NYSE and Nasdaq stock markets. The portfolio selection relies on ESG scores provided by LSEG (formerly Refinitiv), focusing on stocks with consistent ESG scores throughout the study period. The research examines the risk-return relationship, with risk measured by both volatility and the VIX index and returns measured using the Return Index (RI) from LSEG's dataset. Key findings indicate that portfolios with the strictest ESG criteria generally outperform other portfolios and the broader markets in terms of the risk-return trade-off. Additionally, high-ESG portfolios from Nasdaq perform better than those from NYSE, with no significant sector-based correlation. The final section conducts an efficient frontier analysis to identify optimal portfolios based on their risk-return profiles, highlighting the benefits of incorporating ESG criteria in portfolio construction for achieving a more favourable risk-return trade-off.

**Keywords:** ESG, Risk-Return, Portfolio Analysis

**JEL classification:** G11, G12, Q50

## Introduction

The surge in ESG investing underscores a growing investor interest in fostering a sustainable future. Motivated by social justice movements and catalyzed by the COVID-19 pandemic, investors are increasingly gravitating towards ESG funds. Despite a lower inflow of \$2.5 billion into U.S. sustainable funds in the last quarter of 2023 compared to previous years, nearly three-fourths of all new sustainable funds were actively managed, slightly above the average of the past decade.

Renowned figures like Larry Fink advocate for the integration of sustainability and climate considerations into investment portfolios, citing the potential for improved risk-adjusted returns. Asset management groups and the younger generation are embracing sustainable investing as the future paradigm. Businesses and investors are increasingly adopting an ESG lens in strategic decision-making, recognizing the correlation between sustainability initiatives and enhanced financial performance. Studies indicate that organizations with robust ESG frameworks tend to exhibit superior risk management practices and foster greater innovation. Moreover, the COVID-19 pandemic has highlighted the resilience of organizations with a strong ESG focus, positioning them advantageously during disruptions and uncertainties (Gao & Geng, 2024).

Empirical studies on ESG investing have yielded inconclusive and often contradictory findings regarding its financial performance. While some studies report zero or negative effects (Quinn, 2019; Gawęda & Złoty, 2023; López Prol et al., 2022), others suggest that ESG factors enhance investment performance (Yin et al., 2023; Gao & Geng, 2024). This divergence stems from various factors such as the specific focus of the study, sample periods, geographic regions, and methodologies employed.

A significant source of uncertainty in ESG investing lies in the lack of clear definitions and standardized metrics for assessing ESG responsibility. While the overarching categories of Environmental (E), Social (S), and Governance (G) remain consistent, evaluation criteria vary significantly across different rating platforms issuing ESG scores. Leading corporate rating agencies like MSCI ESG Research, Sustainalytics, S&P, Refinitiv, and Bloomberg ESG Data Services each have their own methodologies. This lack of uniformity poses challenges for investors and consumers in assessing the reliability of ESG ratings (Berg et al., 2022).

In this article, a different approach is adopted compared to previous studies (Brandon et al., 2021; Berg et al., 2022). Despite acknowledging the divergence in ESG ratings, Refinitiv data is chosen as the sole focus for analysis to facilitate simpler interpretation. While future research may explore aggregating data from multiple sources, this decision is motivated by the availability of the Refinitiv dataset and its comprehensive construction.

This article comprises four main parts. First part covers theoretical foundations of ESG, its structure, and definition by Refinitiv, along with a review of relevant literature. In the second there is an explanation of datasets used, construction of portfolios for analysis, and introduction of the theoretical framework employed. Then the third section presents the empirical results from the methodological strategy and includes the relationship between companies' ESG performance and stock returns, as well as portfolio performance analysis based on returns and volatility, covering both overall and sector-specific portfolios. The article concludes with a construction of the efficient frontier and optimal weight allocation of the best trade-off risk-return portfolios.

## 1. Theoretical aspect and literature review

Environmental sustainability is pivotal for evaluating a company's operations. This pillar examines efforts to reduce environmental impact through renewable energy usage, waste management programs, and addressing issues like pollution and deforestation. Dawkins and Fraas (2010) found a positive relationship between environmental performance and voluntary climate change disclosure, showing that company visibility and issue visibility (climate change) interact to influence disclosure levels.

The relationship between climate change and financial systemic risk is well-studied. Curcio et al. (2023) emphasize the importance of adopting appropriate policies to counteract the increasing frequency and severity of climate disasters. Their findings highlight the potential exposure of financial firms to green or brown companies due to climate policies, with implications for risk management models and procedures. Companies are strategically positioning themselves to address climate change sensitivity, acknowledging sustainability's effect on financial performance (KPMG, 2022).

Social responsibility within a company encompasses various aspects, from fair employee treatment to community engagement. Evaluating this pillar involves assessing factors like employee compensation, diversity and inclusion policies, and human rights protections. Potharla et al. (2024) highlight the importance of workforce and supply chain diversity, fair workplace practices, human rights compliance, and product integrity in informed investment decision-making. They confirm the economic benefits that social sustainability bestows on companies and their investors. Additionally, Gonçalves et al. (2023) find that the social component of ESG significantly shapes financial performance for Europe's largest publicly listed firms.

Effective governance ensures accountability and transparency in business operations. This pillar evaluates board independence, financial reporting transparency, and measures to prevent conflicts of interest. It also examines executive compensation structures and their alignment with overall company performance. Xie et al. (2019) found that corporate transparency regarding ESG information positively correlates with corporate efficiency, with governance information disclosure showing the strongest positive linkage, followed by social and environmental information disclosure. Pedersen et al. (2021) tested empirical predictions using various ESG proxies, finding that good governance predicts strong future fundamentals and attracts modest investor demand, while environmental and social aspects have weaker predictive power for profits, potentially explaining the higher valuations of socially responsible stocks.

The divergence in ESG ratings underscores a critical limitation of relying solely on a single source for measurement. Halbritter and Dorfleitner (2015) emphasize that the interpretation and direction of outcomes are influenced by the specific ESG rating provider. The lack of a universally agreed-upon ESG definition means rating agencies may incorporate subjective biases in their metrics, potentially skewing results. This study's findings are contingent upon Refinitiv's definition. Berg et al. (2022) reveal substantial disparities among ESG ratings from different agencies, with correlations ranging from 0.38 to 0.71. This variability complicates ESG performance assessment, diminishes companies' incentives to improve ESG practices, hinders accurate valuation of firms' ESG performance, and challenges linking CEO compensation to ESG performance. Future work should consider the diverse perspectives and methodologies employed by different rating agencies when evaluating ESG performance.

Empirical studies on ESG investing over the past decades have yielded inconclusive and often contradictory findings regarding its financial performance.

Gawęda and Złoty (2023) found that ESG disclosure and scoring had a negative impact on the rate of return, while individual ESG scores did not affect the return rate. Sector leaders were less negatively impacted by the COVID-19 crisis, but their leadership status was not statistically significant. López Prol et al. (2022) systematically found that high ESG portfolios have lower volatility and returns, resulting in lower Sharpe ratios. Agliardi et al. (2023) demonstrated that environmentally low-rated companies had better financial performance, while environmental leaders were less risky and more resilient. Quinn (2019) found little significant evidence of a relationship between ESG scores and stock valuation, but significant evidence for governance and social scores.

Aydoğmuş et al. (2022) suggested that the overall ESG combined score is positively associated with firm value. Individual Social and Governance scores had a positive relationship with firm value, while the Environment score did not. Yin et al. (2023) found that ESG performance of listed companies in China positively impacted stock returns, particularly for non-state-owned companies and those in the eastern region. Gao and Geng (2024) indicated that companies with good ESG performance are more resilient in crises, referring to Chinese companies.

A key study by Whelan et al. (2020) analyzed over 1,000 research papers since 2015, finding a growing consensus that effective ESG management typically leads to improved operational metrics like Return on Equity (ROE), Return on Assets (ROA), and stock prices. ESG strategies appear to yield market-rate or excess returns compared to conventional strategies, offering downside protection during crises. Few studies found definitive negative correlations between ESG factors and financial performance. This research highlights the tangible benefits of integrating ESG considerations into investment decision-making, emphasizing the potential for ESG strategies to contribute to financial performance and mitigate risks during market volatility and uncertainty.

## **2. Methodology**

ESG score data, collected annually for the Environmental (E), Social (S), and Governance (G) aspects, forms the foundation of this study. This paper deliberately chooses to utilize yearly data for these scores, a decision aimed at enhancing the precision of portfolio construction in the period that is considered. Additionally, the decision to consider them separately was made to evaluate the differences between each score. Lastly, to ensure data integrity, any instances of missing values NA or #DIV/0! occurrences for each year are substituted with the respective year's average.

The ESG data utilized in this study is sourced from Thomson Reuters Eikon, providing comprehensive insights into a firm's ESG performance, including its environmental, social, and governance dimensions. This dataset comprises annual time series spanning from 2016 to 2022, aligning with the availability of ESG data for approximately 70% of firms listed on the NYSE during that timeframe (Refinitiv, 2022).

The ESG score serves as an indicator of a firm's dedication, proficiency, and impact concerning Environmental, Social, and Governance considerations, drawing from publicly disclosed information. It is derived from the aggregation of 10 category scores across the three pillars, each weighted differently based on industry standards. These scores are standardized to range from 0 to 100, with

higher values indicating superior performance. Furthermore, scores within each industry are categorized into four percentiles and graded accordingly, as depicted in Table 1 (Refinitiv, 2022).

| Score Range      | Description                        |                                                                                                                                                       |
|------------------|------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>0 to 25</b>   | <b>First Quartile<br/>GRADE D</b>  | Scores within this range indicates poor relative ESG performance and insufficient degree of transparency in reporting material ESG data publicly.     |
| <b>25 to 50</b>  | <b>Second Quartile<br/>GRADE C</b> | Scores within this range indicates satisfactory relative ESG performance and moderate degree of transparency in reporting material ESG data publicly. |
| <b>50 to 75</b>  | <b>Third Quartile<br/>GRADE B</b>  | Scores within this range indicates good relative ESG performance and above average degree of transparency in reporting material ESG data publicly.    |
| <b>75 to 100</b> | <b>Fourth Quartile<br/>GRADE A</b> | Scores within this range indicates excellent relative ESG performance and high degree of transparency in reporting material ESG data publicly.        |

Table 1. ESG Quartile Range

Source: (Refinitiv, 2022)

The tables below illustrate that, on average, the Nyse Index (our sample) exhibits the highest score within the governance pillar, boasting a substantial mean score above 55 (Table 2a), corresponding to a grade of B. Furthermore, it reveals a left-skewed distribution, indicating that most stocks in the Nyse index possess values greater than 58-65. Across all pillars, the average scores suggest at least a grade of C, signifying satisfactory ESG performance according to the Refinitiv (2022) grading system outlined in table 1.

Specifically, Figure 5a highlights a right-skewed distribution in the E Scores of the NYSE index, with only a few firms achieving a grade A (an ESG score of 75 or higher, as shown in Table 2b). This skew is likely connected to the large number of firms that do not provide an E score. Similarly, the S scores also exhibit a right skew, albeit less pronounced compared to the E scores.

It is noteworthy that each quartile in the tables below represents a span of 1.75 years within the period. For instance, the first quartile spans from January 2016 to September 2017, and so forth until December 2022.

Table 2. Assessment of ESG pillars the NYSE Index

(a) E-pillar

| COMPONENT | QUARTILE | MIN   | MEAN   | MAX    | SD     |
|-----------|----------|-------|--------|--------|--------|
| <b>E</b>  | 1        | 0.130 | 38.607 | 98.220 | 28.815 |
|           | 2        | 0.140 | 41.362 | 99.130 | 28.878 |
|           | 3        | 0.110 | 45.259 | 98.450 | 28.448 |
|           | 4        | 0.380 | 46.149 | 97.720 | 28.363 |

(b) S-pillar

| COMPONENT | QUARTILE | MIN   | MEAN   | MAX    | SD     |
|-----------|----------|-------|--------|--------|--------|
| <b>S</b>  | 1        | 1.960 | 48.060 | 98.200 | 22.607 |
|           | 2        | 4.640 | 51.573 | 97.710 | 22.462 |
|           | 3        | 0.310 | 56.357 | 97.470 | 21.744 |
|           | 4        | 8.700 | 59.036 | 97.490 | 20.626 |

(c) G-pillar

| COMPONENT | QUARTILE | MIN   | MEAN   | MAX    | SD     |
|-----------|----------|-------|--------|--------|--------|
| <b>G</b>  | 1        | 1.360 | 54.891 | 98.810 | 21.654 |
|           | 2        | 0.910 | 57.777 | 98.620 | 21.096 |
|           | 3        | 1.730 | 59.493 | 99.460 | 20.860 |
|           | 4        | 0.840 | 61.055 | 99.080 | 20.679 |

Portfolio construction based on characteristics such as ESG scores is a well-established method for investigating the relationship between firms' social and financial performance. These portfolios often yield returns that standard asset pricing models cannot always explain, thereby representing empirical anomalies to some extent (Hjalmarsson, 2009).

Initially, firms from the NYSE are sorted into twelve portfolios based on their ESG scores. For each ESG category (E, S, and G), four different portfolios are constructed using distinct criteria:

For the E score:

- Selected portfolio based on 5 years with an E value > 80.
- Selected portfolio based on 6 years with an E value > 80.
- Selected portfolio based on 7 years with an E value > 80.
- Selected portfolio based on 7 years with an E value > 85.

The same procedure is followed for Nasdaq portfolios:

- Selected portfolio based on 5 years with an E value > 70.
- Selected portfolio based on 6 years with an E value > 70.
- Selected portfolio based on 7 years with an E value > 70.
- Selected portfolio based on 7 years with an E value > 75.

The selection criteria utilize the overall ESG score for each category annually, without considering the mean. For example, if a company in the NYSE index maintains an ESG score above 80 for 5 years, it falls into the first criterion; if it does so for 6 or 7 years (the entire period), it falls into the second and third criteria, respectively. A score above 85 for the entire period qualifies for the fourth criterion.

The portfolio groups remain consistent throughout the 2016-2022 period to facilitate long-term investment analysis and benchmark comparison. Additionally, all companies are reevaluated annually, allowing for changes in scores across the pillars. Furthermore, all stocks in the portfolio are equally weighted, and stock purchases from the beginning (2016) to the end of the period (2022) are considered without any adjustments to weights or other factors. The interest lies in comparing portfolios with high scores against the market benchmark.

One advantage of this approach is that it mitigates concerns regarding the relative nature of scores, ensuring they are not misleading or elusive for investors. A high pillar ESG score in a portfolio implies that all assets or firms within it hold similarly high ranks across that pillar alone, rather than a high overall ESG score. This methodology considers each pillar individually, enabling more specific analysis of score determinants.

Our work introduced two significant methodological differences. Firstly, we assumed equal weights for each stock in the portfolio. Secondly, we used a simplified formula due to the larger number of stocks included in our portfolio. This methodology was implemented using Python (see Appendix D for the code). Additionally, we decided to compare the portfolio's volatility not only with standard volatility measures but also with the VIX, the CBOE Volatility Index. This decision was influenced by frequent spikes and outliers observed in daily volatility movements, which prompted us to explore alternative volatility measurement tools. Studies by K. Victor Chow, Wanjun Jiang, and Jingrui Li (2018) indicated that the VIX tends to statistically understate true volatility, with estimation errors being strongly and negatively correlated with the third return moment, or skewness.

Our analysis revealed a notable reduction in daily volatility spikes to under 10%. Furthermore, the VIX results showed robustness, exhibiting a significant positive correlation with our measures, although there were occasional instances where the VIX overestimated volatility (Figure 1).

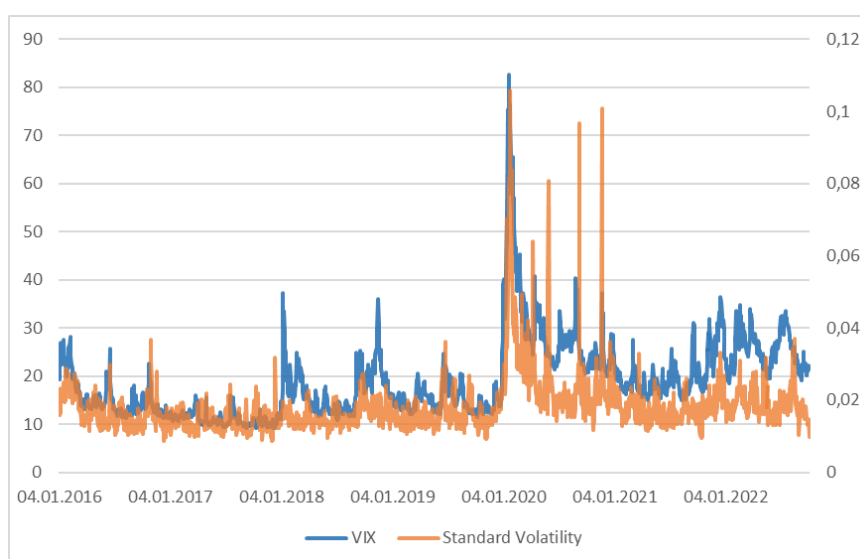


Figure 1. VIX and Standard Volatility of NYSE

Tables 3a and 3b provide a statistical overview of the return index RI. They reveal a higher mean daily return for Nasdaq at approximately 0.082%, compared to a lower mean daily return for NYSE at 0.063%. Additionally, greater standard deviation, minimum, and maximum values for Nasdaq are observed, which can be attributed to its higher volatility compared to the NYSE.

Table 3. Descriptive Statistics

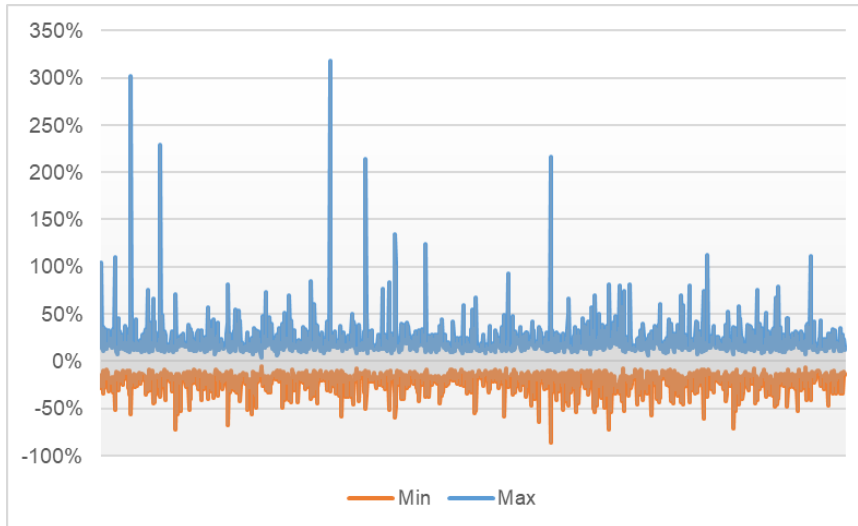
(a) NYSE

| Mean   | Standard Deviation | Min      | Max     | Median |
|--------|--------------------|----------|---------|--------|
| 0.063% | 2.567%             | -21.656% | 23.183% | 0.063% |

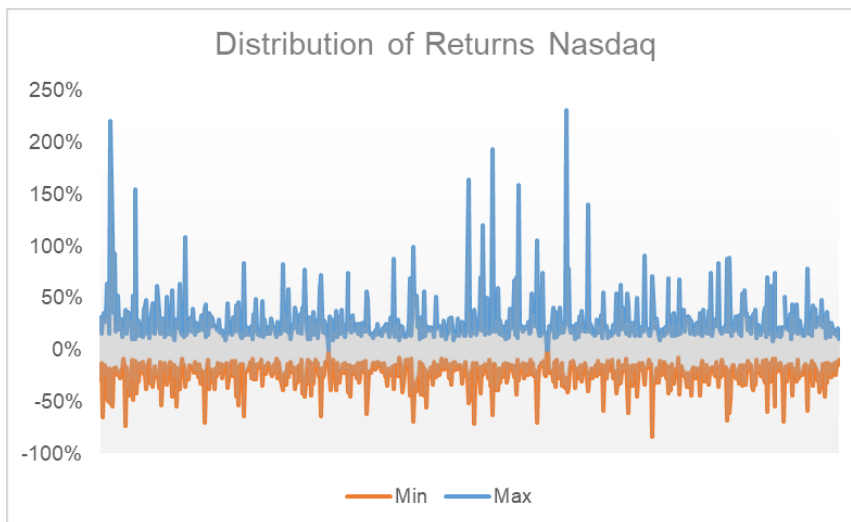
(b) Nasdaq

| Mean   | Standard Deviation | Min      | Max     | Median |
|--------|--------------------|----------|---------|--------|
| 0.082% | 2.999%             | -23.538% | 28.239% | 0.029% |

In Figures 2a and 2b, the minimum and maximum values of daily returns are observed. It becomes apparent that there is a greater variation in the minimum and maximum values in the Nasdaq index, thus confirming our statistical description.



(a) NYSE



(b) Nasdaq

Figure 2. Distribution of Daily Standard Deviation

In the final figure, Figure 3, the cumulative returns of both indices are compared, revealing a greater overall performance of the Nasdaq with a difference of almost 10%, specifically Nasdaq at 94.1% and NYSE at 84.6%.

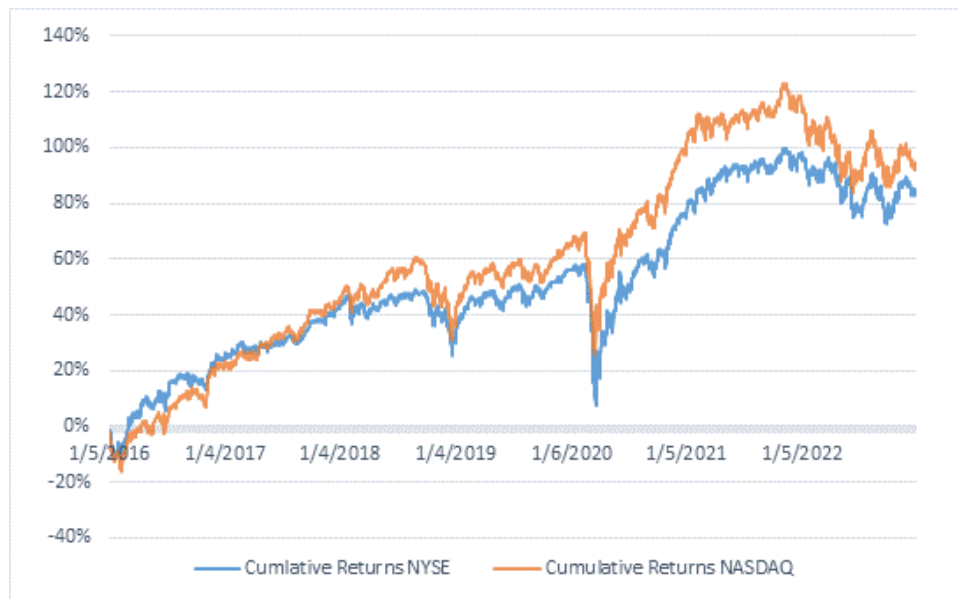
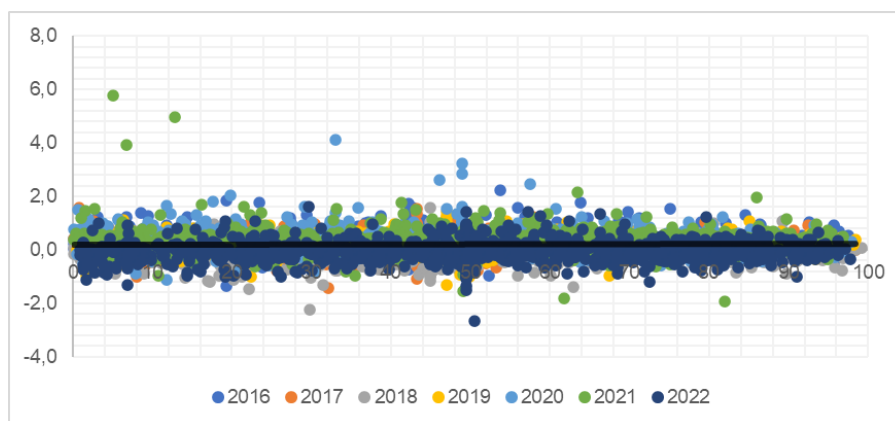


Figure 3. Cumulative Returns NYSE and Nasdaq

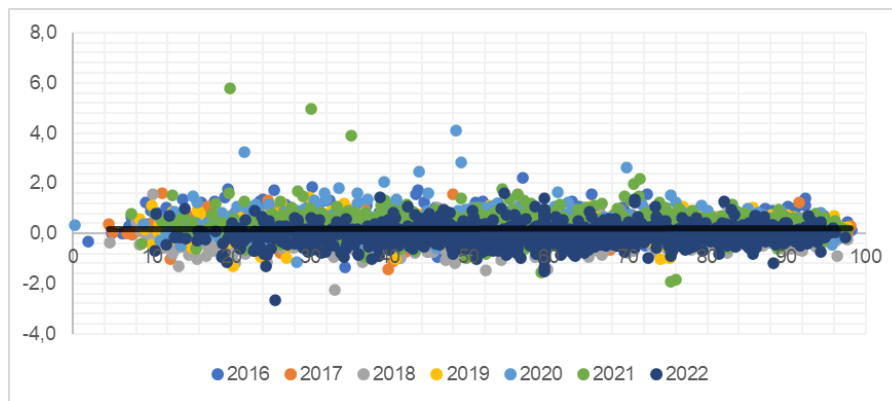
### 3. Empirical research and results

#### 3.1 Correlation analysis

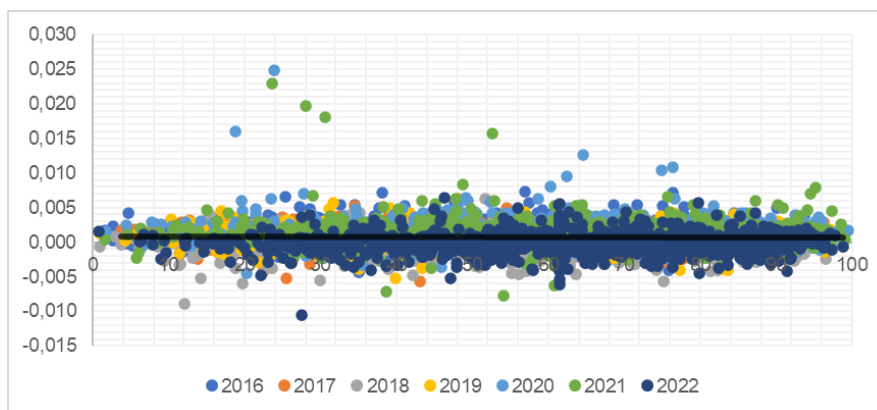
The raw data indicates no relationship between daily returns of the NYSE Index and the E, S, and G scores (Figures 4a, 4b, and 4c). The correlation between daily returns and the E, S, and G scores was analysed annually for each year in the selected period from 2016 to 2022. Below, the aggregated graph for each year is presented. This lack of correlation may explain why regression-based methods applied to the entire market do not find a relationship between returns and ESG scores.



E - score



S - score



G - score

Figure 4. Correlation NYSE Daily Returns and ESG pillars

However, actual equity portfolios do not include all market stocks. In the final part, different proportions in the weights of each asset will also be considered. Portfolio composition is an endogenous decision aimed at optimizing the trade-off between expected return and risk within a given set of constraints. Due to space constraints, only the overall graph of each year's E, S, and G scores has been plotted. For a detailed analysis, please refer to the Appendix A.

### 3.2 Portfolios analysis

#### (a) Performance analysis

Before the analysis is introduced, it should be clarified that in this section, monthly returns were chosen to achieve a more efficient and immediately comprehensible analysis over the long period considered (7 years). Additionally, using monthly returns is more straightforward compared to daily returns. The performance analysis began with the import of a combined data frame of portfolio returns and NYSE returns (and later also for Nasdaq). The first visualization graph, useful for quickly viewing the returns, is the histogram of the return distribution.

In Figure 5, the distribution of each monthly return alongside the NYSE Index distribution is presented.

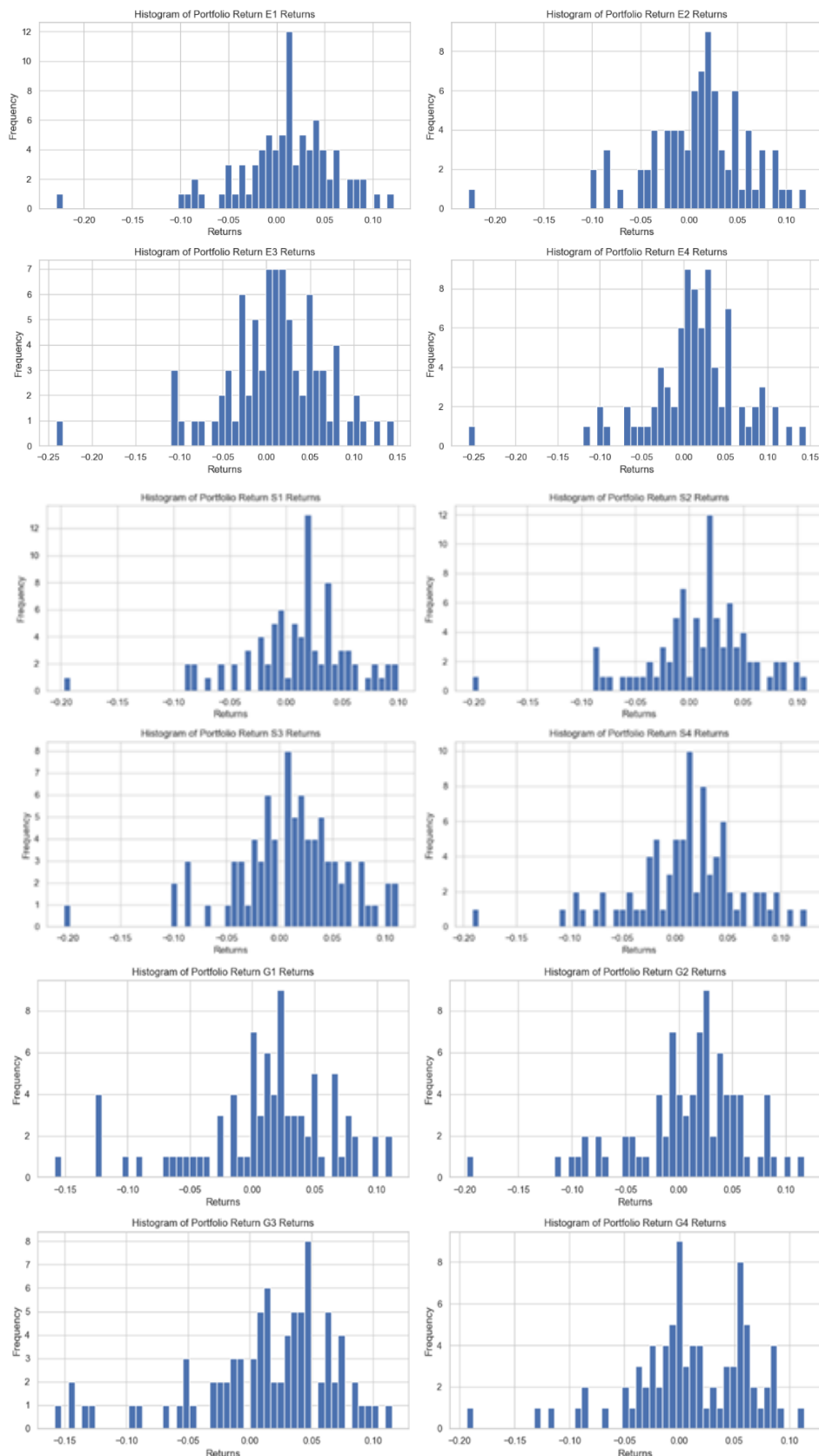


Figure 5. Distribution of Monthly Returns of Portfolios

These distributions (refer to Figure 5) generally do not appear to be normally distributed. The primary reason for this is the number of observations; since monthly returns are used, there are only 84 observations, which explains the gaps. Additionally, skewed distributions are observed rather than symmetric ones. The histograms display higher peaks and heavier tails than what would be expected from a normal distribution, indicating leptokurtosis. Finally, several outliers are present. However, it should be clarified that with a larger dataset (obtained with daily returns), a normal distribution would likely be observed.

The performance of each portfolio is then examined by analysing their simple returns (Figure 6), and their cumulative returns (Figure 7). Generally, monthly returns range from -0.1 to 0.1, with some exceptions on both the positive and negative sides. Notably, returns dipped as low as -0.3 during the Covid-19 pandemic in 2020.

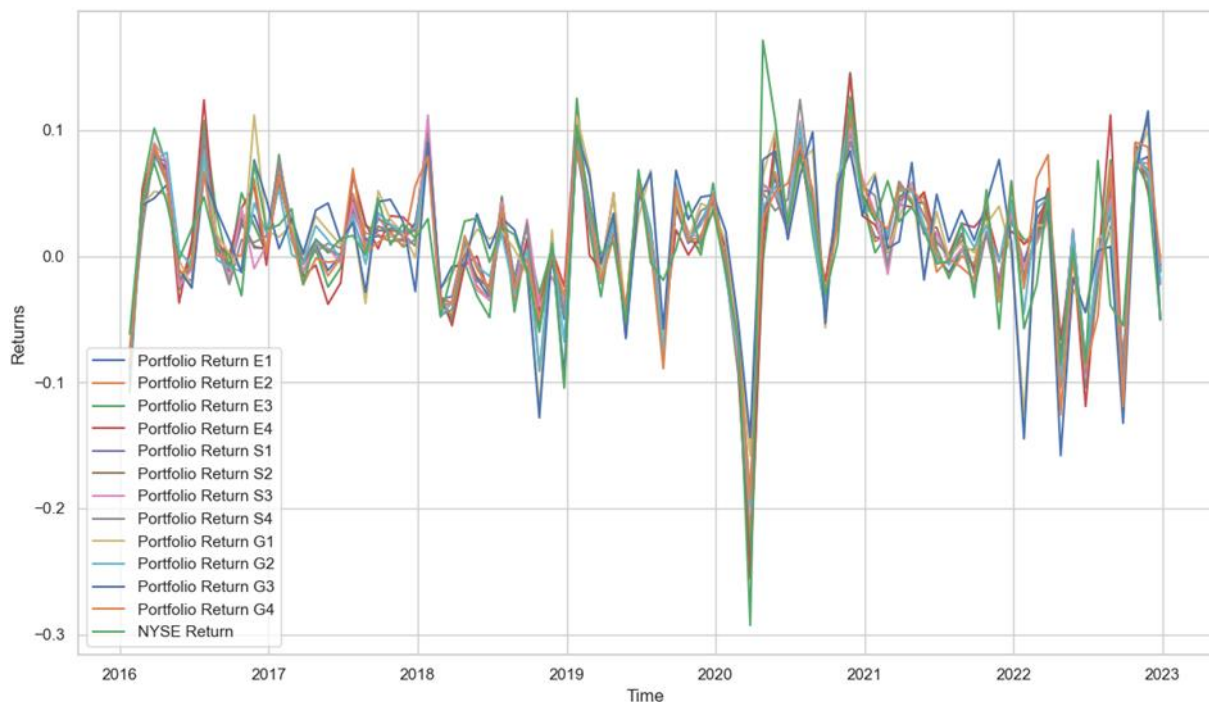


Figure 6. Monthly Returns of Portfolios

Using the alternate red dashed line to represent the NYSE Index, it is observed that most portfolios generally follow the market's return. However, some portfolios, such as G3 and E4, consistently outperform the market throughout the entire period. Overall, considering the cumulative returns, it is found that all portfolios, except for E1, perform slightly better than the NYSE Index.

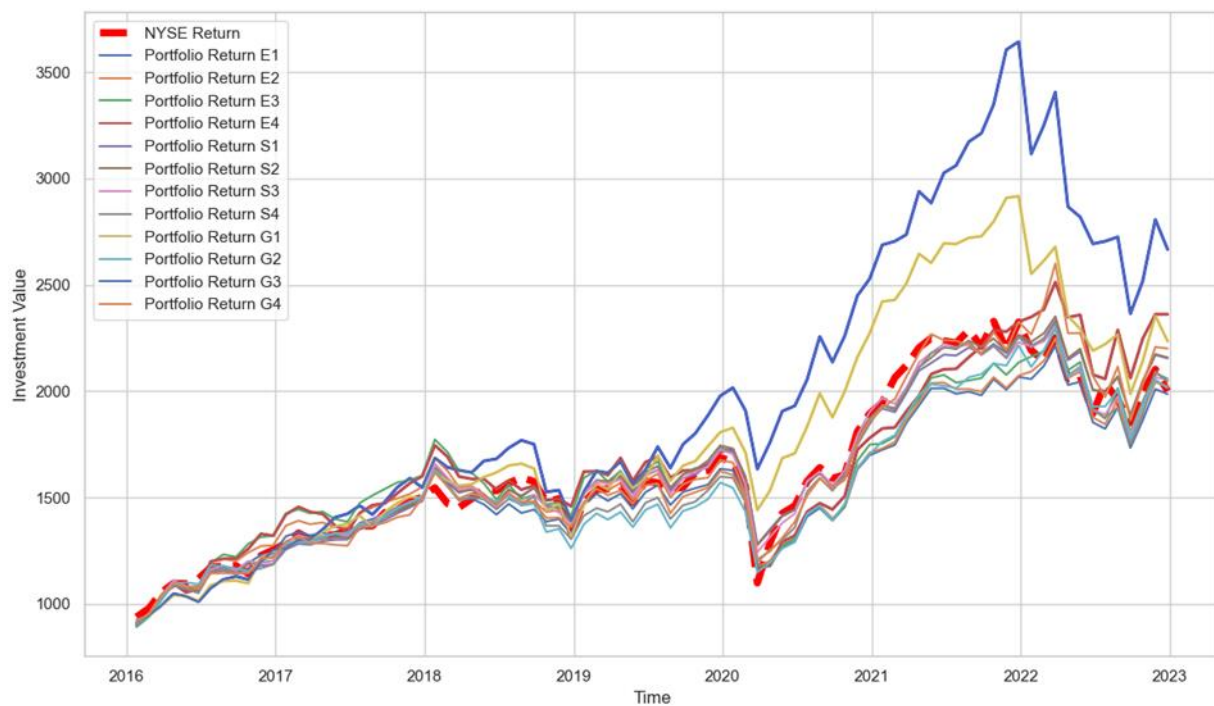


Figure 7. Cumulative Returns of Portfolios

The cumulative returns are calculated based on an initial investment of 1000 €. Specifically, Table 4 shows that the best-performing portfolio is G3, followed by E4. Other portfolios, such as G1, G4, S2, and S1, exhibit returns ranging from 115.5% to 123.5%, which translates to 15.5% to 23.5% higher returns than the NYSE Index. Finally, there is a group of portfolios, including E3, S3, S4, E2, and G2, that perform slightly better than the NYSE.

It is also observed that most of the E portfolios, except for E4, underperform compared to the others. Notably, the two best-performing portfolios have the most stringent filters, supporting the research that ESG portfolios with more constraints perform better than those with fewer filters.

Table 4. Overall Return of Portfolios

| Portfolio           | Final value        | Overall return |
|---------------------|--------------------|----------------|
| Portfolio E2        | 2023.198836        | 102.32%        |
| Portfolio E3        | 2058.832405        | 105.88%        |
| <b>Portfolio E4</b> | <b>2361.553572</b> | <b>136.16%</b> |
| Portfolio S1        | 2154.980333        | 115.50%        |
| Portfolio S2        | 2158.788991        | 115.88%        |
| Portfolio S3        | 2054.409939        | 105.44%        |
| Portfolio S4        | 2045.592706        | 104.56%        |
| Portfolio G1        | 2235.365392        | 123.54%        |
| Portfolio G2        | 2015.644946        | 101.56%        |
| <b>Portfolio G3</b> | <b>2666.958765</b> | <b>166.70%</b> |
| Portfolio G4        | 2200.733081        | 120.07%        |
| Portfolio E1        | 1986.76181         | 98.68%         |
| <b>NYSE Index</b>   | <b>2000.21885</b>  | <b>100.02%</b> |

In the final part, the Sharpe Ratios of the portfolios and the NYSE Index are presented. Generally, all portfolios outperformed the NYSE Index. Notably, Portfolio G3 has the highest Sharpe ratio of 0.8, followed by S1, S2, and E4, each with a ratio near 0.74. Since the portfolios are categorized based on ESG scores (E, S, G), their higher Sharpe ratios suggest that ESG-focused investments can provide superior risk-adjusted returns. This supports the notion that incorporating ESG factors into investment strategies can enhance performance by potentially reducing risks associated with non-sustainable practices

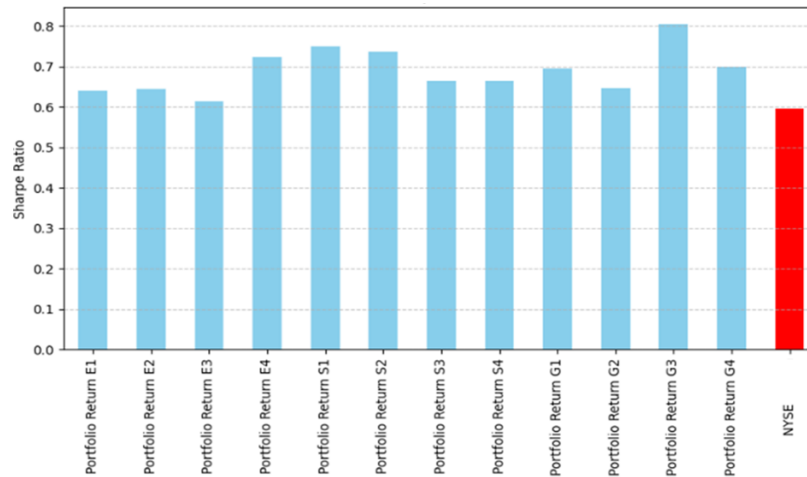


Figure 8. Sharpe Ratios of Portfolios

#### (b) Volatility analysis

The box plot graph (Figure 9) illustrates the monthly returns for various portfolios (E1 to G4) and the NYSE index. The median returns for most portfolios (E1 to G4) and the NYSE are positive, indicating overall positive monthly returns. Notably, portfolios G3, G1, G2, S1, and S2 have higher median returns than the NYSE, suggesting superior central performance compared to the benchmark. The variability, as indicated by the interquartile range (IQR), is larger for some portfolios compared to the NYSE return, indicating these portfolios experience more fluctuation in their performance. Specifically, portfolios E3 and S4 show a considerable spread, indicating higher volatility. Outliers are present in all portfolios.

Portfolios E4 and G2 have notable outliers on the negative side, reflecting occasional significantly poor performance. In contrast, the NYSE return has fewer outliers, implying more stable performance.

Finally, portfolios S3, S4, and G4 outperform the NYSE in terms of median returns, indicating better average performance. Conversely, portfolios G3, E4, S1, and S2, despite having higher medians, exhibit comparable or slightly higher variability, meaning that while they offer higher potential returns, they come with a slightly increased risk. Overall, the choice between these portfolios ultimately depends on the investor's risk tolerance and return expectations.

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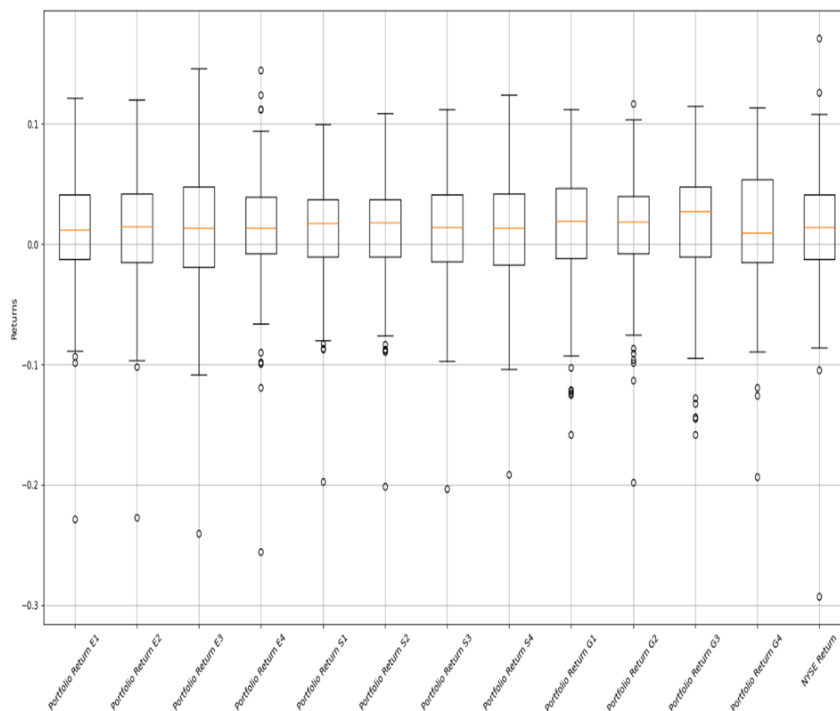


Figure 9. Box Plot of Portfolio Returns

The figure 10 presents the monthly portfolio volatility for all portfolios compared to the VIX volatility index. Despite fluctuations, the portfolio volatilities tend to move together, suggesting that these portfolios are similarly affected by market conditions. Noticeable spikes in the VIX index generally correspond with spikes in the portfolio volatilities. This indicates that during periods of high market uncertainty (as represented by the VIX), the volatilities of the portfolios also increase. Two significant spikes in volatility and the VIX are evident. The first spike is connected to the market downturn in the second half of 2018, which was influenced by a general slowdown in global economic growth and concerns that the Federal Reserve was raising interest rates too quickly, contributing to a pessimistic reaction in the stock market. The second peak coincides with the impact of the COVID-19 pandemic on the financial markets in 2020. Our portfolios systematically follow the VIX peaks, maintaining lower volatility values than the VIX for most of the time. After the major spike in early 2020, there is a gradual decline in volatility for both the VIX and the portfolios, although periodic spikes still occur, indicating ongoing market adjustments and reactions to various events.

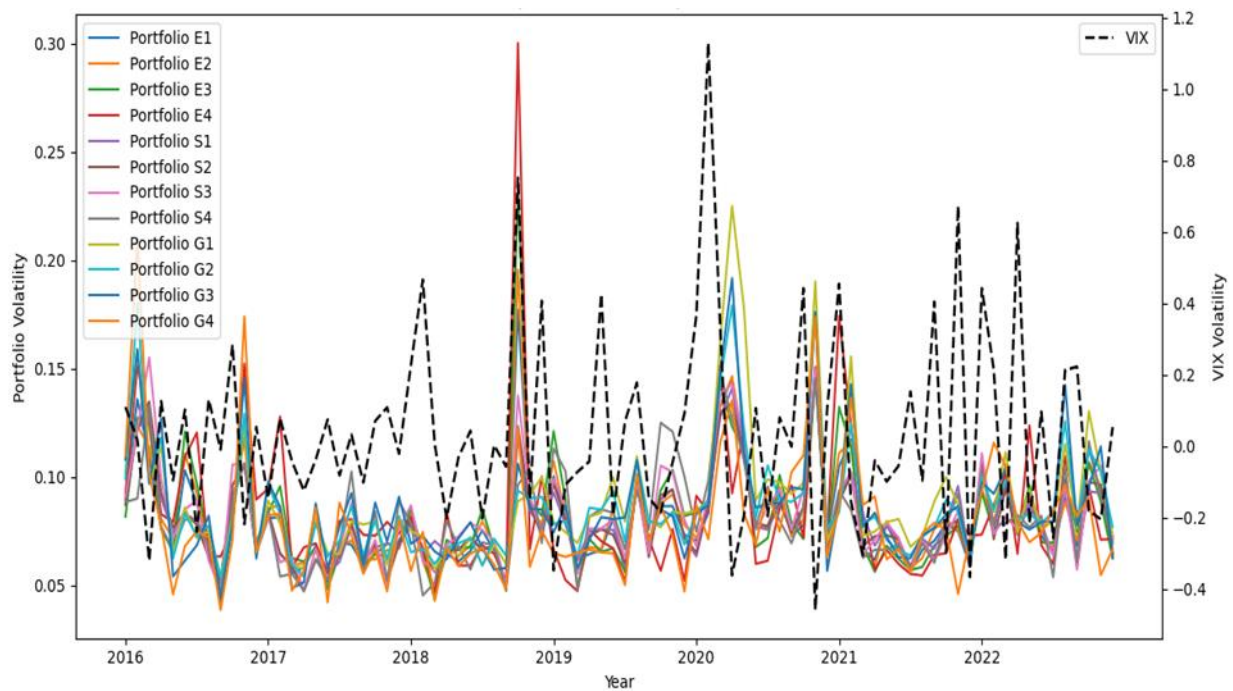


Figure 10. Monthly Portfolio Volatility and VIX

The graph indicates a clear positive relationship between the VIX and portfolio volatilities. When the VIX spikes, indicating increased market volatility and uncertainty, the portfolios' volatilities also rise, though to a lesser extent. This relationship demonstrates that these portfolios are sensitive to market-wide risk factors, albeit with some buffering possible due to diversification and the ESG components of portfolio.

The figure 11 shows the annualized volatility of the portfolios compared to the annualized volatility of the NYSE Index. The volatility of the portfolios ranges from approximately 0.155 to 0.215, while the NYSE Index has a volatility of around 0.200. The NYSE Index has higher volatility than most of the portfolios, except for Portfolios G3, E3, and E4. This suggests that the majority of the portfolios are less risky and volatile compared to the benchmark.

Portfolios S1, S2, S3, and S4 exhibit the lowest volatility among all, indicating they are the least risky or most stable in terms of price fluctuations. This stability can be attributed to the social benefits (S score) of these portfolios, which place greater emphasis on workforce and employee status, potentially reducing the overall risk of the companies within them. On the other hand, Portfolios G3, E3, and E4 have the highest volatility, indicating a higher level of risk as well as the best performance.

In summary, the graph indicates that most portfolios have lower volatility than the NYSE Index, suggesting they are generally less risky. This may be related to the fact that ESG portfolios are less volatile and risky compared to the overall market.

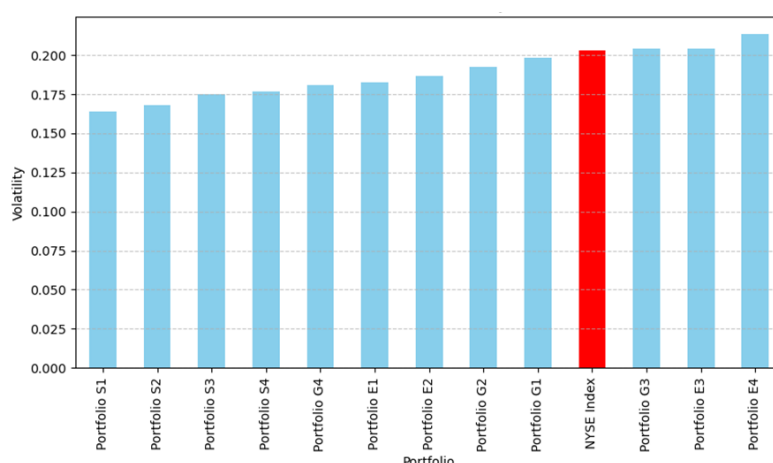


Figure 11. Annualized Volatility of Portfolios and NYSE Index

The figure 12 illustrates the rolling 6-month beta for various portfolios. Beta measures a portfolio's volatility relative to the overall market: a beta of 1 indicates that the portfolio's price moves in line with the market, a beta greater than 1 indicates greater volatility than the market, and a beta less than 1 indicates less volatility than the market. On average, the portfolio's beta fluctuates between 0 and 1.5, indicating that it generally follows market trends. The highest peak occurred in 2016 during the 2015-2016 stock market selloff. The lowest point was reached during the 2020 COVID-19 pandemic, as the market responded to unprecedented fiscal and monetary interventions and the subsequent gradual recovery.

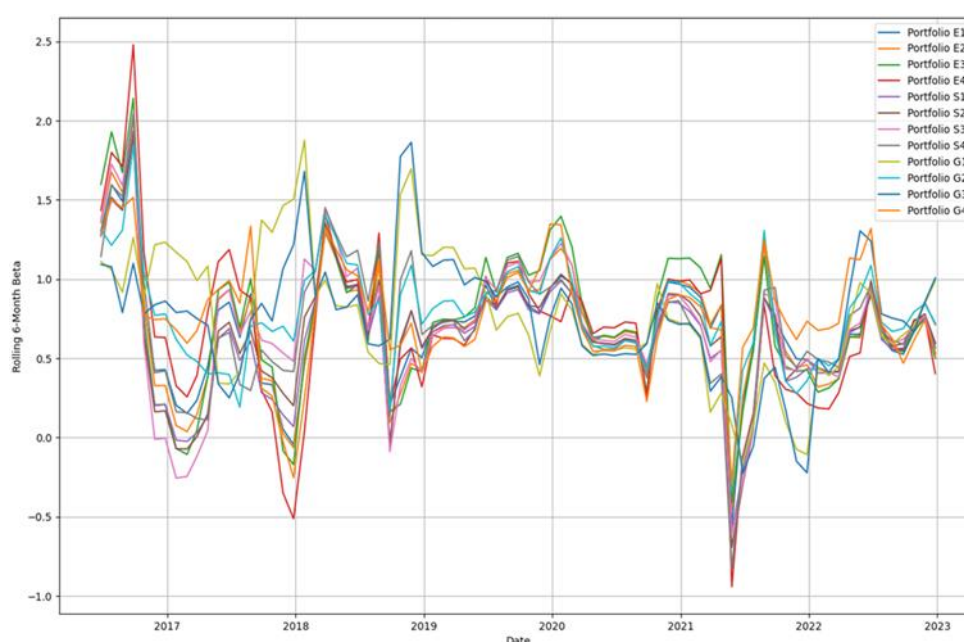


Figure 12. Rolling 6-month Beta of Portfolios

The figure 13 depicts the overall beta values of each portfolio, showing that all portfolios have a beta lower than 1, ranging between 0.64 and 0.76. This suggests that the difference between the market beta and our portfolios' beta can be attributed to the ESG components, which likely reduce overall risk and consequently the beta of the portfolios.

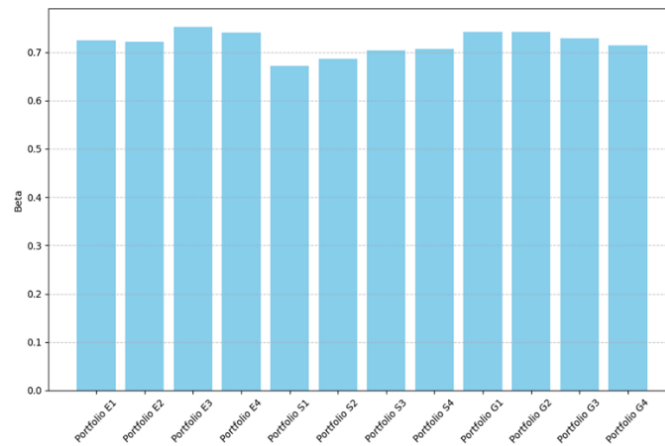


Figure 13. Beta Values of Portfolios

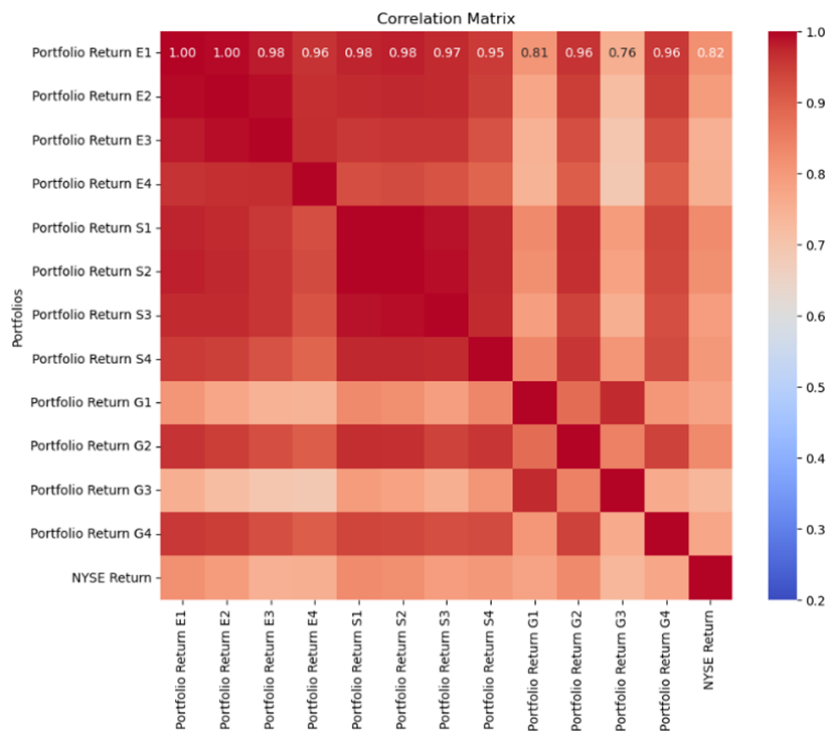


Figure 14. Correlation Matrix of Portfolio and NYSE Index

To conclude this section, a correlation matrix (Figure 14) is presented, providing insights into the relationship between the returns of various portfolios and the NYSE Index. Overall, portfolios in the same ESG category show high correlations, typically above 0.85, except for the G portfolios, which have an average correlation of 0.70. Additionally, all portfolios exhibit correlations with the NYSE Index ranging from 0.70 to 0.80. This supports our assumption that the portfolios are influenced by ESG components, and the differences in correlation with the NYSE Index reflect the impact of ESG factors.

### 3.3 NYSE vs Nasdaq

The same analysis was conducted for the Nasdaq dataset, but the decision was made not to repeat the same graphs and pathways used for the NYSE analysis to avoid redundancy. Instead, a couple of graphs are presented here to provide a concise overview of the overall analysis.

Initially, the cumulative returns exhibit a similar trend to those observed in the NYSE analysis. Notably, several portfolios showed significant outperformance, particularly in the latter part of 2022. During this period, most portfolios experienced smaller losses compared to the index, which is indicative of their resilience (Figure 15). This trend suggests a lower level of volatility within these portfolios. Furthermore, all portfolios have lower annualized volatility relative to the benchmark (Figure 16). This lower volatility is a positive sign, indicating more stable returns over the observed period. Additionally, the analysis reveals that all portfolios boast a better Sharpe Ratio compared to the benchmark, which stands at 0.65. The Sharpe Ratios for these portfolios range from 0.70 to 0.91, underscoring their superior risk-adjusted returns (Figure 17).

In summary, the analysis of the Nasdaq dataset mirrors the findings from the NYSE to some extent but also highlights the unique performance characteristics of the portfolios during the latter part of 2022. The lower volatility and higher Sharpe Ratios provide strong evidence of the robustness of these portfolios in comparison to the benchmark

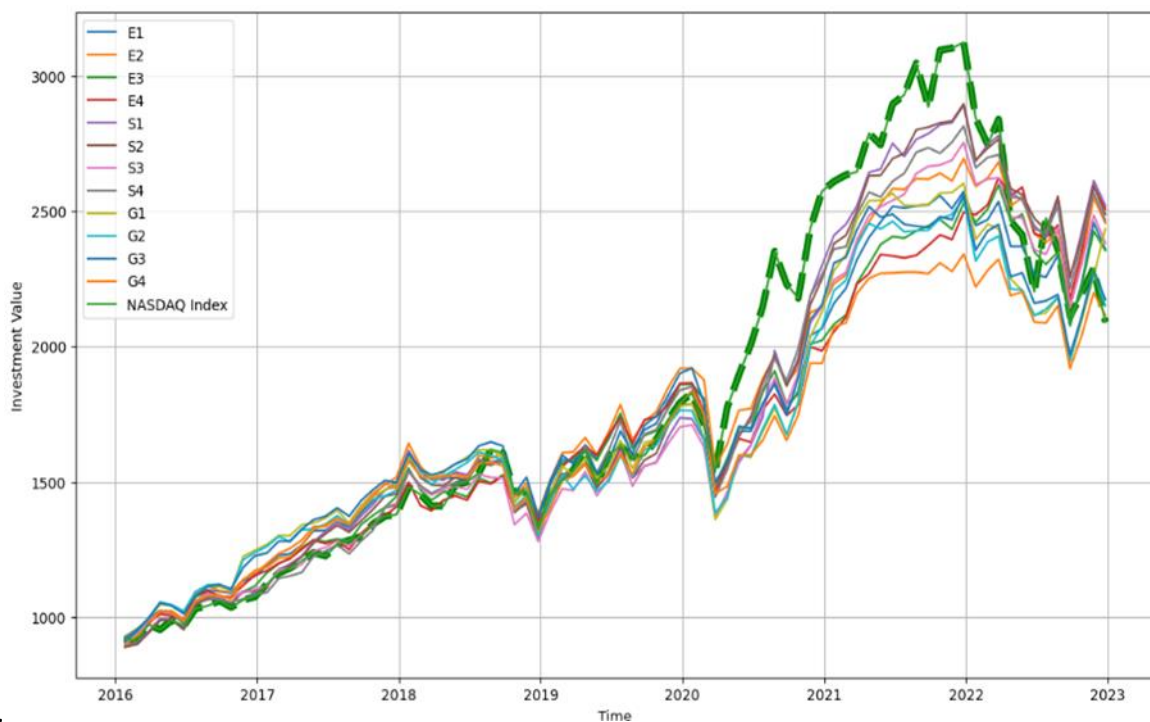


Figure 15. Cumulative Returns of Portfolios (Nasdaq)

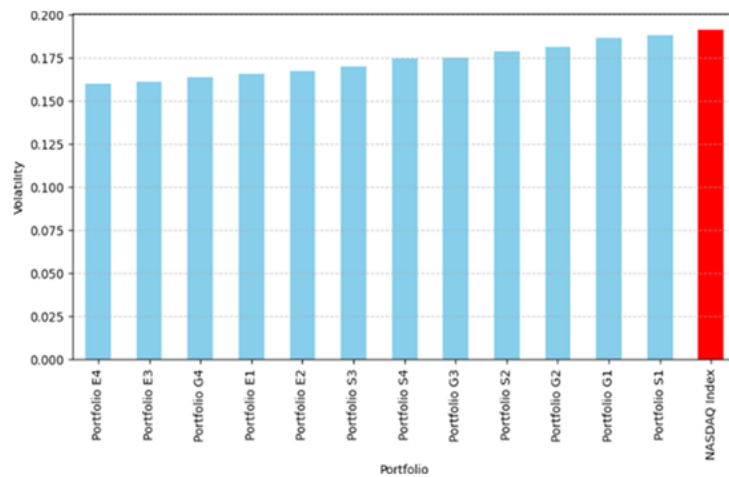


Figure 16. Annualized Volatility (Nasdaq)

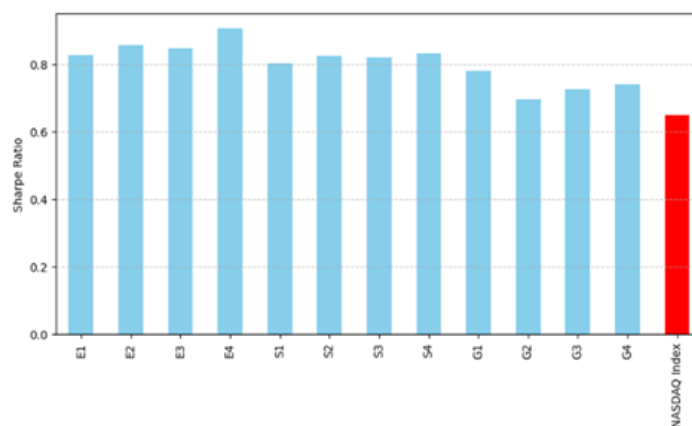


Figure 17. Sharpe Ratios (Nasdaq)

### 3.4 Sector Analysis

The sector was briefly analysed using the Refinitiv Business Classification (TRBC), which organizes global companies into 11 sectors. The dataset was divided based on their E, S, and G scores, selecting only those with the highest average combined ESG scores.

This analysis identified five sectors with the top ESG scores: Healthcare, Consumer Non-Cyclicals, Basic Materials, Utilities, and Technology. Among these, three sectors—Technology, Healthcare, and Basic Materials—outperformed the NYSE Index. Specifically, the Technology and Healthcare sectors achieved annualized returns of 17.99% and 14.56%, respectively, over the period from 2016 to 2022, compared to the benchmark return of 7.66%.

These results were expected, as the technology sector has been the best-performing sector over the past twenty years and the rise in the healthcare sector was mainly driven by the COVID-19 crisis. In conclusion, no significant relationship between sector performance and ESG scores for the period 2016-2022 can be established. In Table 5, it is possible to visualize the performance of each sector for each year and the annualized return.

Table 5. Sector Performance

| Year       | Consumer Non-Cyclicals | Healthcare | Basic Materials | Utilities | Technology | NYSE Return |
|------------|------------------------|------------|-----------------|-----------|------------|-------------|
| 2016       | 7.97%                  | -6.19%     | -3.62%          | 8.27%     | -6.57%     | 23.75%      |
| 2017       | 9.60%                  | 20.47%     | 33.50%          | 22.79%    | 25.24%     | 18.33%      |
| 2018       | 7.23%                  | 18.92%     | 8.82%           | 3.84%     | 27.93%     | -10.43%     |
| 2019       | 2.32%                  | 15.69%     | -7.65%          | 16.02%    | 15.44%     | 24.40%      |
| 2020       | -22.87%                | -9.85%     | -33.49%         | -21.95%   | -12.09%    | 20.25%      |
| 2021       | 70.12%                 | 71.93%     | 123.96%         | 31.29%    | 105.86%    | 21.43%      |
| 2022       | 1.74%                  | 0.81%      | 12.06%          | 15.62%    | -4.90%     | -12.92%     |
| Annualized | 6.99%                  | 14.56%     | 12.21%          | 8.35%     | 17.99%     | 7.66%       |

#### 4. Analysis and Discussion

##### *Efficient Frontier - Simplistic Approach*

From the analysis in part three, the best-performing portfolio was selected, and the computation of the efficient frontier was performed. The selected portfolios are G3, E4, G1, G4, S2, and S1. A mean-variance plot allows the visualization of the trade-off between risk and return for each portfolio, where the expected return is measured by:

$$E(R_p) = \sum_i w_i E(R_i)$$

And for portfolio variance:

$$\sigma_p^2 = \sum_i \sum_j w_i w_j \sigma_{ij}$$

It is possible to adjust the number of assets considered in each portfolio.

Using the list of mean-variance pairs generated, these portfolios can now be plotted. In this plot, each point represents a portfolio. It is important to note that most portfolios shown here are not on the Efficient Frontier. This is addressed in the next subsection.

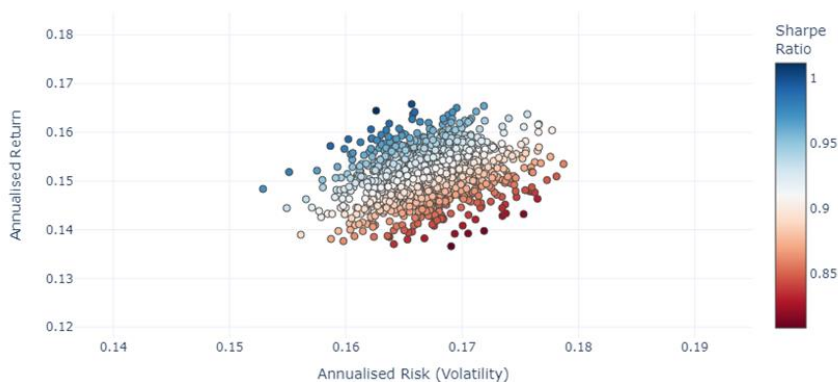


Figure 18. S1 Random Portfolios



Figure 19. S2 Random Portfolios

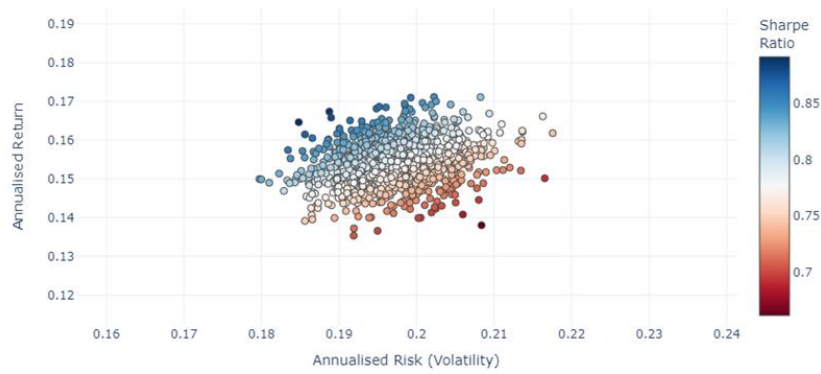


Figure 20. G1 Random Portfolios

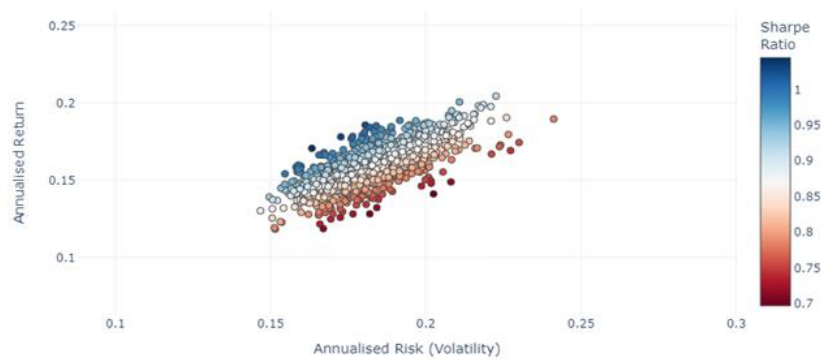


Figure 21. G4 Random Portfolios

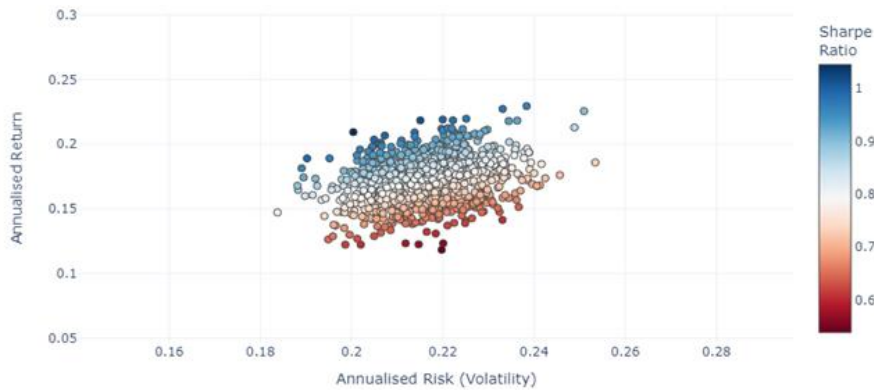


Figure 22. E4 Random Portfolios

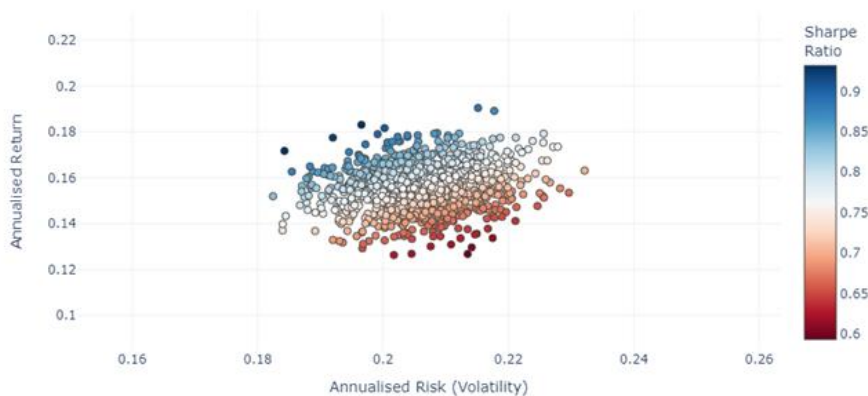


Figure 23. G3 Random Portfolios

### ***Efficient Frontier - Complex Version***

Previously, portfolio weights were randomly sampled; now, a more efficient approach can be implemented. By introducing the concept of *domination*, unnecessary sampling of suboptimal portfolios can be avoided.

As a rational investor, given two portfolios with equal returns, the one with lower risk is preferred. Similarly, given two portfolios with equal risk, the one with a higher return is preferred. Thus, the optimal portfolios lie at the top left of the plot. Any portfolio with another portfolio above it and to the left is considered dominated and would not be chosen by any rational investor.

To improve efficiency, the code should exclude any portfolios dominated by those already sampled.

In this version, the asset names and weights for each portfolio are also stored. Using the interactive features of Plotly, hovering over each point on the plot will display the assets and weights for each portfolio.

This sampling technique quickly identifies portfolios along the efficient frontier. Although some early sampled portfolios are visible below the efficient frontier, this can be easily remedied by only including portfolios after a certain number of iterations.

Figures 24-29 describe the efficient frontier for each portfolio. Overall, annualized returns range between 0.14 and 0.25, while annualized risks range between 0.15 and 0.24. The best efficient frontier combinations are observed in portfolios G4 and E4, which are also the most filtered portfolios. This confirms the hypothesis regarding the influence of ESG factors on portfolio return and risk.

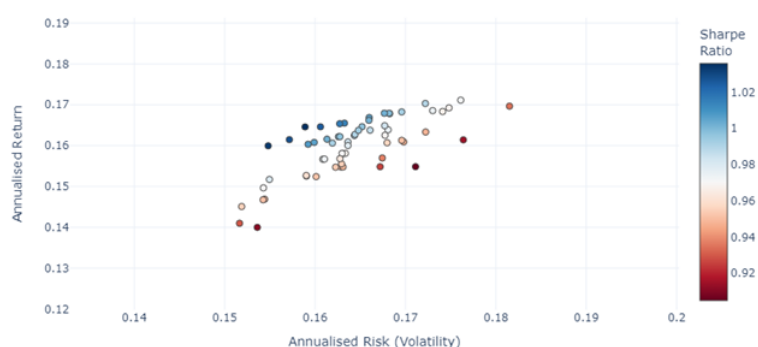


Figure 24. S1 Efficient Frontier

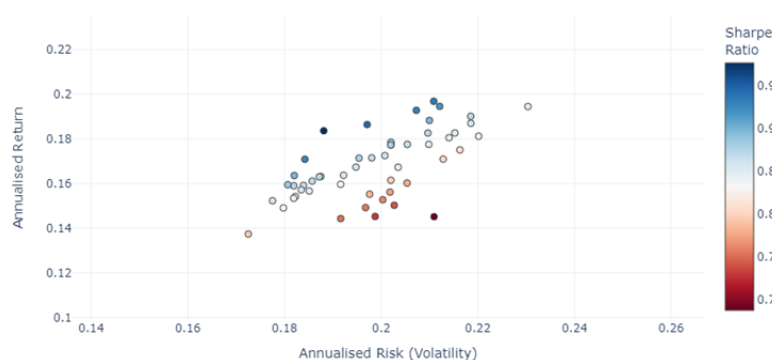


Figure 25. G3 Efficient Frontier

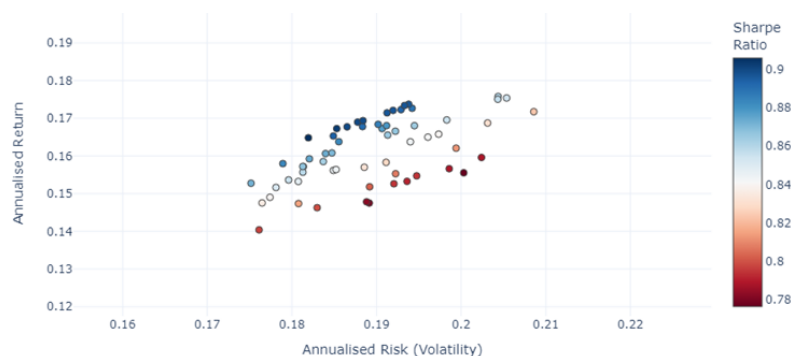


Figure 26. G1 Efficient Frontier

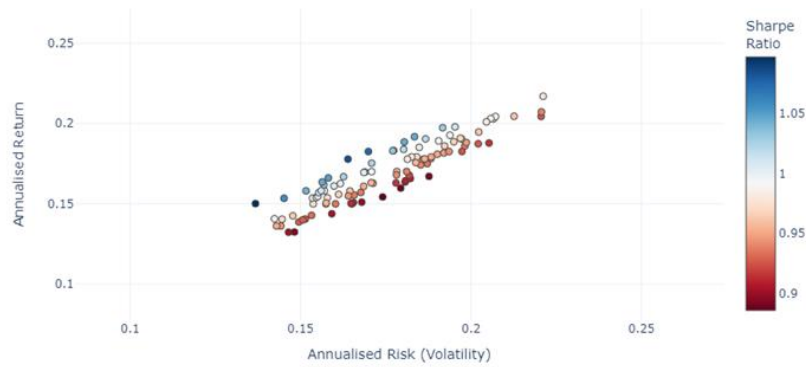


Figure 27. G4 Efficient Frontier

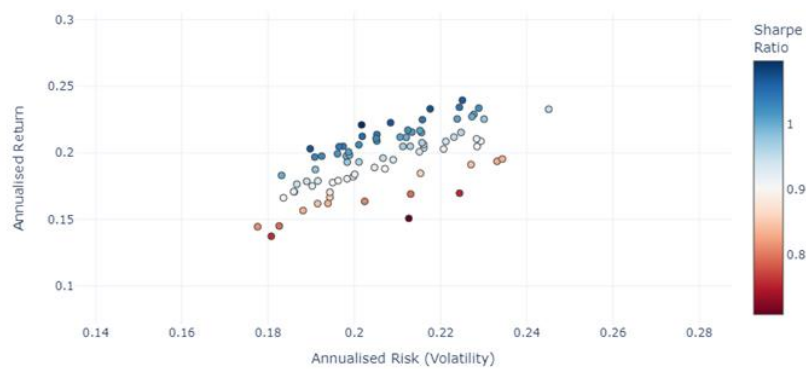


Figure 28. E4 Efficient Frontier

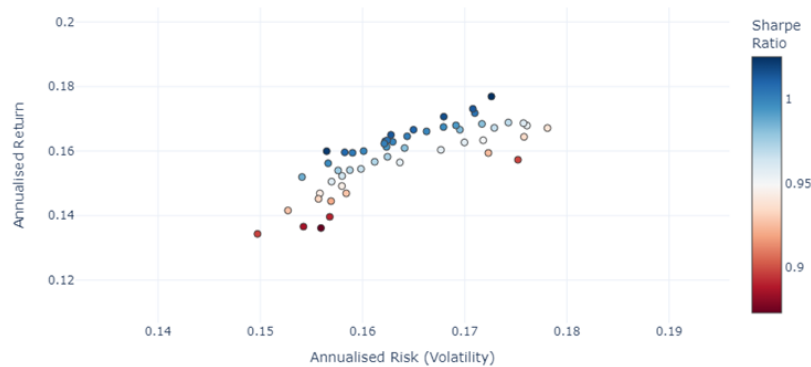


Figure 29. S2 Efficient Frontier

#### 4. Conclusion and Future Work

This paper makes a significant contribution to the field of empirical finance by examining the impact of ESG (Environmental, Social, and Governance) factors on stock market performance, specifically focusing on the NYSE and Nasdaq from 2016 to 2022. The study initially explores the broad question of whether ESG factors positively or negatively influence overall market performance. Although preliminary analysis suggests no direct relationship between ESG scores and returns on the NYSE and Nasdaq, this does not provide a comprehensive answer.

To delve deeper, specific portfolios based on ESG criteria were constructed to evaluate whether companies with higher ESG scores outperformed or underperformed the broader market. Four portfolios for each ESG pillar (Environmental, Social, and Governance) were created to examine their individual effects and responses. The findings indicate that portfolios with stricter ESG criteria generally outperformed the market, as evidenced by higher Sharpe ratios, suggesting a superior return-to-risk relationship.

Regarding risk assessment, the ESG-focused portfolios demonstrated lower annualized volatility, reflecting more stable performance over time. This was further supported by Beta values, which were consistently below 1, indicating lower market risk compared to the broader market. Thus, our analysis concludes that integrating ESG components reduces overall portfolio risk relative to the market.

To conclude this section, the NYSE Index was compared with the Nasdaq Index. The analysis revealed that while both indices performed comparably, the Nasdaq generally outperformed the NYSE over the same period. This superior performance can largely be attributed to the Nasdaq's significant exposure to the technology sector, which experienced substantial growth.

Following this, the sectors with the highest ESG scores were briefly examined. However, no clear correlation between ESG components and sector performance was identified. The technology sector's dominance during the period, driven by its strong performance, and the healthcare sector's resilience, particularly in response to the COVID-19 crisis and subsequent recovery, likely overshadowed any potential ESG impacts.

The final part of our research involved identifying the efficient frontier for optimal portfolio allocation. This analysis demonstrated a strong risk-return relationship, allowing us to determine the best asset allocation strategies to maximize returns while minimizing risk.

However, several limitations of our study should be acknowledged.

First, relates to the variation in ESG scores across different rating agencies. For this study, a single ESG rating was utilized due to constraints in data availability, time, and the necessity for simpler interpretation. Future research would benefit from incorporating multiple ESG ratings from different agencies to address the significant disparities observed in ESG assessments, as highlighted in the introduction of this research.

Another limitation is the relatively short period analysed, spanning only seven years. While this period is sufficient for assessing stock portfolio performance, extending the timeframe in future studies would provide more robust insights, especially as additional ESG data becomes available. The selected duration was mainly due to the limited availability of ESG data.

Finally, alternative approaches and statistical models could be explored in future research to evaluate risk, return, and overall portfolio performance. These methods could offer deeper insights and more robust assessments of the relationship between ESG factors and financial outcomes.

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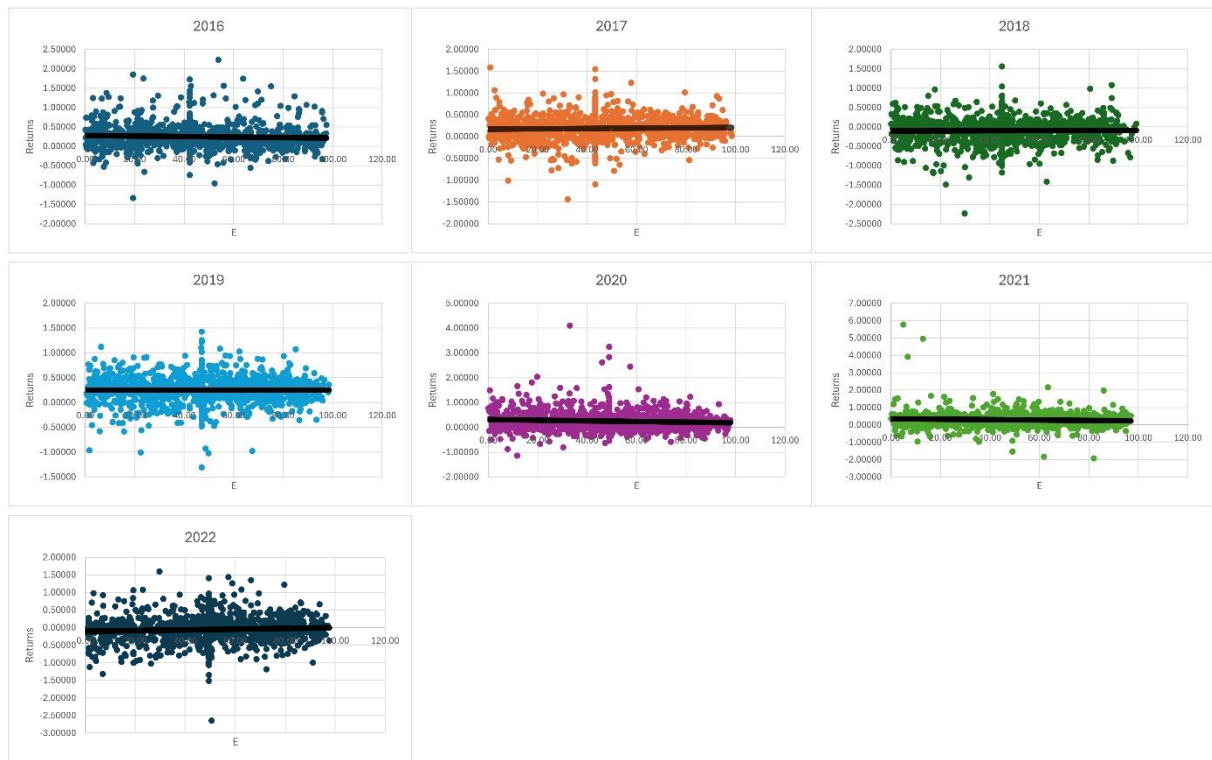
## APPENDIX

### Appendix A – Correlations between daily returns and ESG elements

#### A.1 Correlation for each year between daily returns and S score yearly.



A.2 Correlation for each year between daily returns and E score yearly.



A.3 Correlation for each year between daily returns and G score yearly.

