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Sustainable Investing Through ESG Indices: A Comprehensive Study on Performance and Interconnectedness

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ABSTRACT

This study provides comprehensive evaluation of the performance and interrelationships among six ESG stock market indices—Europe, Japan, UK, US, Emerging Markets, and Asia Pacific—over a nine-year span from October 2014 to May 2024. Employing performance metrics such as Jensen's Alpha, Sharpe Ratio, and Treynor Ratio, the analysis reveals that while the Asia Pacific and US indices exhibit the strongest risk-adjusted performance, none of the indices achieve significantly positive Jensen's Alpha, thereby challenging prevailing assumptions regarding ESG-driven outperformance. Using the MGARCH-DCC model, the study reveals notable volatility dynamics, with the US index exhibiting the highest persistence of volatility and the UK index demonstrating the most stable returns. The analysis also highlights persistently high correlations among the indices, even during the COVID-19 pandemic, contradicting prior studies that presented ESG stocks as effective safe havens during crises. This finding highlights the growing interconnectedness of global markets, which restricts diversification opportunities and emphasises the importance of identifying less correlated assets. Notably, the lower correlations associated with Japan indicate potential diversification benefits. By addressing gaps in existing literature, this study provides valuable insights into the dynamic behaviour of ESG indices, and their implications for sustainable investing. The findings have practical implications for investors seeking to optimise portfolio diversification, policymakers promoting sustainable finance, and corporate leaders integrating ESG considerations into strategic decision-making.

Keywords: Stock market diversification; ESG; MGARCH-DCC; Jensen Alpha; Sharpe Ratio; Treynor Ratio; correlation study; portfolio diversification; Europe; Japan; UK; US; emerging and Asia Pacific

INTRODUCTION

Financial markets are essential to the global economy, providing the primary venues for investing, raising capital, and managing wealth. Indices such as the FTSE4Good Europe Index (Europe), FTSE4Good Japan Index (Japan), FTSE4Good United Kingdom Index (UK), FTSE4Good United States Index (US), MSCI International Emerging Markets ESG Leaders Index (Emerging), and STOXX Asia Pacific ESG Leaders 50 Index (AsiaPac) serve as benchmarks for specific market segments, offering insights into market trends and investor sentiment. Understanding the performance and interrelationships of these indices is essential for investors, policymakers, and researchers. While ESG investing has gained global traction in recent years, several overarching challenges persist that may undermine its effectiveness and appeal across different regions. Notably, disparities in ESG rating methodologies, a lack of standardisation in disclosures, inconsistent regulatory frameworks, and varying levels of investor awareness contribute to confusion and mistrust. These issues are further exacerbated by the growing financialisaton of ESG instruments, which often prioritises short-term returns over long-term sustainability goals. Moreover, the increasing interconnectedness of financial markets, as evidenced by high correlations among ESG indices, poses a significant limitation to diversification, a fundamental tenet of portfolio construction in sustainable investing. These challenges call into question the reliability and resilience of ESG indices as instruments of sustainable finance and necessitate a deeper examination of their actual performance and systemic impact across global markets.

As financial markets increasingly intersect with global environmental challenges, sustainability has become a central to economic and political agendas. Issues like pollution, resource depletion, and climate change necessitate a shift towards sustainable economic and social development (Javanmardi et al. 2023). This shift is reflected in financial markets through the integration of ESG (Environmental, Social, and Governance) criteria into investment decisions, which aim to balance financial returns with ethical and sustainable practices. This study seeks to evaluate how ESG indices across diverse regions align with international ESG standards and contribute to sustainable investment practices.

In recent years, there has been a growing emphasis on ESG criteria in investment decisions, with indices gaining attention for their integration of sustainability principles. Examining the performance of ESG indices from diverse geographical regions is crucial to understanding how local markets align with global ESG standards and for assessing their attractiveness to global investors. Evidence suggests that companies with strong ESG performance tend to achieve better market positioning, lower capital costs, and higher credit ratings (Henriksson et al. 2019). These attributes enhance the relevance of ESG indices as benchmarks for sustainable investing, particularly in emerging and Asia-Pacific markets, which remain underexplored in the existing literature.

This study has two main objectives: First, to evaluate the performance of Europe, Japan, UK, US, Emerging, and Asia-Pacific ESG indices using Jensen's Alpha, the Sharpe Ratio, and the Treynor Ratio. These performance metrics provide a comprehensive assessment of risk-adjusted returns, offering a nuanced understanding of ESG index performance under varying market conditions. Second, to analyse the dynamic interrelationships and potential diversification benefits among these indices using the Multivariate Generalized Autoregressive Conditional Heteroskedasticity-Dynamic Conditional Correlation (MGARCH-DCC) model. This advanced econometric approach enables a time-varying analysis of correlations, capturing how these relationships evolve during major global events such as the COVID-19 pandemic.

This study contributes to the discourse on sustainable finance by highlighting the evolving dynamics of ESG indices and their role in promoting responsible investing. The findings aim to inform investment strategies and policy decisions, emphasising the importance of integrating ESG considerations into financial markets. By leveraging advanced econometric models and focusing on underrepresented regions, this research offers a broader perspective on the performance and relevance of ESG indices in the global financial landscape.

The structure of this paper is organised as follows: Section 2 reviews the existing literature on ESG and conventional indices and develops the relevant hypotheses for this study. Section 3 outlines the research methodologies and analytical approaches used to achieve the study's objectives. Section 4 provides a comprehensive analysis of the data and findings. Finally, Section 5 concludes the paper by summarising the key findings, offering detailed interpretations, and providing the main conclusions drawn from the research.

LITERATURE REVIEW

Prior studies on ESG investments have approached the topic from diverse perspectives, ranging from safe-haven properties and performance metrics to methodological inconsistencies and regional comparisons. To position the current research within this broader academic discourse, we synthesise the key findings of four prominent studies thematically.

Several researchers have explored the resilience of ESG indices during periods of market stress. Rubbaniy et al. (2022), using a wavelet coherence framework, examined the safe-haven potential of ESG stocks during the COVID-19 pandemic. They observed that ESG stocks displayed positive co-movements with the global fear index (GFI) over longer frequencies (32–64 days), suggesting some hedging benefits. However, this relationship was inconclusive over shorter time horizons (0–8 days), indicating that ESG stocks do not consistently function as safe haven assets. Similarly, La Torre et al. (2020), focusing on the Eurostoxx50, found that ESG factors had limited influence on overall stock performance, with benefits mainly concentrated in sectors such as energy and utilities. These studies suggest that while ESG indices may offer limited protection in specific contexts or sectors, their role as consistent safe-haven assets remains uncertain.

Other studies have assessed ESG performance across different geographies and ownership structures. Deng and Cheng (2019) analysed ESG indices in China and observed a positive relationship between ESG performance and stock returns, especially in non-state-owned enterprises and secondary industries. Their findings contrast with those of La Torre et al. (2020), who noted minimal ESG impact across most Eurostoxx50 sectors. These differences underscore the importance of ownership and regional characteristics in shaping ESG outcomes. Henriksson et al. (2019) also support this view, asserting that firms with robust ESG practices achieve better market positioning and lower capital costs, further validating the strategic relevance of ESG integration.

Erhart (2022) highlighted critical inconsistencies in ESG rating methodologies, pointing to discrepancies between data providers such as Refinitiv and Sustainalytics. These inconsistencies stem from variations in aggregation formulas, weighting schemes, and data inputs, resulting in weak correlations between ESG ratings. This issue complicates the incorporation of ESG metrics into investment strategies and limits comparability across indices. Our study acknowledges this limitation but treats the indices uniformly for methodological consistency, a decision further justified by our focus on high-level inter-index comparisons rather than firm-level performance.

This research is grounded in Stakeholder Theory and the ESG-adjusted risk-return trade-off. Stakeholder Theory highlights the importance of aligning investment strategies with broader societal interests, while the ESG-adjusted risk-return framework suggests that investors may accept slightly lower returns in exchange for long-term sustainability. Against this backdrop, our study contributes to the literature by employing advanced time-varying econometric models (MGARCH-DCC) to examine the performance and interrelationships of six ESG indices across global regions. Unlike most previous studies that rely on static methods, our approach captures dynamic correlation structures during both stable and crisis periods.

Our study extends existing research by synthesising conflicting findings, addressing methodological gaps, and offering a comprehensive cross-regional evaluation of ESG index behaviour. These insights are critical for investors seeking robust diversification strategies and for policymakers aiming to understand the systemic implications of ESG investing.

The hypotheses underpinning this research are as follows: (1) ESG indices demonstrate superior risk-adjusted performance compared to conventional indices, particularly during market stress, and (2) ESG indices offer diversification benefits due to their unique focus on sustainability and ethical practices. By linking these hypotheses to the research objectives, this study aims to address critical gaps in the literature and provide actionable insights for investors and policymakers.

RESEARCH METHODOLOGY

DATA

This study utilises daily closing prices of six ESG stock market indices selected for their geographical diversity and market prominence: Europe, Japan, UK, US, Emerging, and Asia Pacific. The sample period spans from 1 October 2014 to 31 May 2024, covering nine years and eight months. The start date was chosen to ensure data availability and consistency across all six ESG indices, ensuring a uniform time frame and avoiding potential discontinuities or biases arising from differing inception dates. Additionally, the period up to May 31, 2024 provides a sufficiently long horizon to capture both stable and crisis periods, including the COVID-19 pandemic, thereby enabling a robust analysis of risk-return dynamics and correlation behaviour across multiple market cycles.

For analytical purposes, the data are transformed into returns using the formula: $r_t = \ln(P_t/P_{t-1})$, where rt denotes the return series derived from the natural logarithm, and Pt represents the index value at time t. This study employs a multifaceted methodological approach to examine the impact of ESG integration on stock market performance. Specifically, Jensen's Alpha, the Sharpe Ratio, and the Treynor Ratio are employed to evaluate the performance of the indices. Additionally, to investigate the time-varying correlations among the indices, the MGARCH-DCC model is applied. The ESG indices analysed are derived from established frameworks such as the FTSE4Good Index Series and MSCI ESG Leaders Indices. These indices incorporate region-specific ESG inclusion criteria, often combining both exclusionary screening and positive ESG weighting. Variability in ESG scoring methodologies, underlying data sources, and weighting schemes can lead to differences in index composition, potentially influencing both performance and correlation outcomes.

RISK-ADJUSTED PERFORMANCE MEASURES

To assess implementation, standard risk-adjusted performance and risk measures are applied. These metrices are widely used in the literature, including studies such as Useche et al. (2024), which compared the performance of various indices and mutual funds. Three performance measures used in this study are outlined below.

JENSEN'S ALPHA

Jensen's Alpha, introduced by Michael Jensen and Benington in 1970, is an absolute risk-adjusted measure of returns, based on Capital Asset Pricing Model (CAPM) developed by Sharpe (1964) and Lintner (1965). This metric, commonly referred to simply as Alpha, captures the average return of a portfolio or investment above or below the return predicted by the CAPM, given the portfolio's Beta and the average market return (Rm). A positive alpha value indicates superior performance, while a negative alpha value indicates inferior performance. By incorporating the risk-free rate (Rf) of return over a given period, Jensen's Alpha effectively evaluates whether a portfolio manager has successfully outperformed the market on a risk-adjusted basis. The formula for Jensen's Alpha is expressed as:

$$\text{Alpha} = R(i) - (R(f) + B \times (R(m) - R(f)))$$

where:
R(i) = the realised return of the portfolio or investment
R(m) = the realised return of the appropriate market index

The market return (Rm) for the S&P 500 and S&P ESG indices, based on 30 years of data, is 10.47%. For the F4GBM and KLCI indices, based on 27 years of data, the market return (Rm) is 2.8%. The risk-free rate (Rf) is 2.5% for the S&P 500 and S&P ESG indices and 3.935% for the F4GBM and KLCI indices. Each index has a yearly Beta of 1. The total stock index return (Ri) for the S&P 500 is 61%, which translates to an annual return of 6.476%; for the S&P ESG, it is 61.85%, translating to 6.565% annually. In contrast, the total return for the F4GBM is 0.66%, with an annual return of 0.07%; for the KLCI, it is -9.78%, with an annual return of -1.038%.

SHARPE RATIO

Introduced by Sharpe (1966) and grounded in the Capital Asset Pricing Model (CAPM), the Sharpe ratio is a fundamental metric for evaluating risk-adjusted performance. It assesses an investment's excess return relative to its total risk profile, distinguishing whether elevated returns stem from superior portfolio management or merely heightened exposure to volatility. Specifically, the ratio quantifies the marginal return generated per unit of total risk, encompassing both systematic and unsystematic components. The numerator represents the differential between the realised or expected portfolio return and a specified benchmark, typically the risk-free rate. The denominator comprises the standard deviation of these returns over the corresponding period, acting as a proxy for total volatility. Consequently, a higher Sharpe ratio denotes superior risk-adjusted performance. Conversely, a negative ratio indicates that the portfolio's return is either an absolute negative or insufficient to surpass the risk-free rate. The Sharpe ratio is formally defined as:

Sharpe Ratio = $\frac{R_p - R_f}{\delta_p}$

R_p = return of portfolio

R_f = risk-free rate

δ_p = standard deviation of the portfolio's excess return

TREYNOR RATIO

The Treynor ratio, also known as the reward-to-volatility ratio, is a performance metric that measures the excess return a portfolio generates per unit of systematic risk. Excess return is defined as the premium earned above a risk-free benchmark, conventionally proxied by government treasury bills. In this framework, risk is strictly delineated as systematic risk and is quantified by the portfolio's Beta, which captures the asset's sensitivity to broad market fluctuations. Grounded in the Capital Asset Pricing Model (CAPM), the Treynor ratio is a risk-adjusted performance measure; a higher value indicates superior investment performance. While conceptually analogous to the Sharpe ratio, which penalises returns based on total volatility (standard deviation), the Treynor ratio explicitly isolates systematic risk. Consequently, it is recognised as a more robust and theoretically appropriate measure for large, highly diversified portfolios in which unsystematic risk has been effectively eliminated. The formula for the Treynor ratio is expressed as:

Treynor Ratio = $\frac{r_p - r_f}{\beta_p}$ where

r_p = Portfolio return

r_f = Risk-free rate

β_p = Beta of the portfolio

MGARCH-DCC MODEL

The study employs the MGARCH-DCC model to investigate the time-varying correlations among ESG stock market indices. This model is particularly suitable for the objectives of the study because it captures the dynamic nature of volatility and correlation across different time horizons, providing a more nuanced understanding of the indices' interdependencies. Unlike static correlation models, which assume constant relationships over time, the MGARCH-DCC model accounts for evolving market conditions and the impact of global events, such as the COVID-19 pandemic, on index behaviour.

By allowing for conditional volatilities and correlations to adjust dynamically, the MGARCH-DCC model provides a robust framework for analysing the stability and interconnectedness of financial markets. Its ability to model heteroscedasticity and time-dependent correlations makes it ideal for assessing the diversification potential and risk-return dynamics of ESG indices. This methodology ensures a more accurate representation of the indices' performance and relationships during periods of market turbulence, contributing to a deeper understanding of their behaviour under varying economic conditions.

The MGARCH-DCC model, developed by Engle in 2002, is applied here to assess the dynamic interconnections between green and conventional financial indices. It facilitates the analysis of variances and covariances within the series, and their evolution over time. Unlike the conventional univariate GARCH model, which is commonly applied for volatility and correlation analysis in financial time series data, the MGARCH-DCC framework uniquely estimates fluctuating correlations among multiple financial instruments. This feature makes it indispensable for portfolio management and risk analysis.

In the MGARCH-DCC framework, understanding the mean and variance is critical. The mean, or expected value, indicates a financial asset's central tendency or average projection over a given period. Given the non-stationary nature of financial time series data, where statistical properties evolve over time, the mean is typically modelled using autoregressive (AR) and moving average (MA) specifications. Variance, which measures the degree of dispersion or volatility, is treated as a dynamic process in the MGARCH-DCC framework, reflecting the fluid nature of financial markets. The model simultaneously estimates each asset's conditional variances and inter-asset correlations, ensuring a comprehensive representation of relationships among multiple financial instruments. By capturing the dynamic aspects of means, variances, and conditional correlations between assets, the MGARCH-DCC framework serves as a powerful tool for analysing and managing financial market risks.

For the primary objective of this study, the MGARCH-DCC model is applied to analyse conditional cross-asset correlations. Both normal and t-distributions are utilised to optimise estimation results. To compute these correlations, the MGARCH model incorporates the MGARCH-DCC methodology, as illustrated by the following formula:

$$\tilde{\rho}_{ij,t-1}(\phi) = \frac{q_{ij,t-1}}{\sqrt{q_{ii,t-1}q_{jj,t-1}}}$$

Where $q_{ij,t-1}$ is represented as

$$q_{ij,t-1} = \bar{\rho}_{ij}(1 - \phi_1 - \phi_2) + \phi_1 q_{ij,t-2} + \phi_2 \tilde{r}_{i,t-1}\tilde{r}_{j,t-1}$$

The correlation between assets (i) and (j) is denoted by as $\bar{\rho}_{ij}$. The parameters $\phi 1$ and $\phi 2$, representing estimated values, are collectively constrained such that $\phi 1 + \phi 2 < 1$, a necessary condition to ensure model stability. The standardised deviations in asset values are expressed as $\tilde{r}_{i,t-1}$. Moreover, the parameters (1 – λi1 – λi2) are critical in characterising the mean reversion process of the model, reflecting the speed at which values revert to their mean. To assess the reliability and precision of the estimates, we implement numerous robustness checks in accordance with the methodologies proposed by Pesaran and Pesaran (2010). These checks are essential to validate the efficacy of the model and the credibility of the results.

Prior to estimating the MGARCH-DCC model, we conducted preliminary tests to ensure data suitability. These included assessing stationarity using the ADF test, verifying the presence of ARCH effects, and ensuring residuals were well-behaved. These diagnostics confirm the appropriateness of the model for capturing volatility dynamics in ESG indices. Full details are available upon request.

While this study applies Jensen's Alpha, Sharpe Ratio, Treynor Ratio, and the MGARCH-DCC model to capture risk-adjusted performance and time-varying correlations, it does not incorporate wavelet or continuous wavelet transform (CWT) techniques. The exclusion is primarily due to this research's defined scope and objectives, which emphasise index-level performance evaluation and dynamic correlation modelling. Incorporating wavelet methods would have required a dual-framework approach, potentially diverting focus from the intended analysis and extending the study beyond its methodological boundaries. Nonetheless, wavelet-based approaches remain highly valuable for uncovering frequency-dependent co-movements, and their application is acknowledged as an important avenue for future research to validate further and complement the present findings.

RESULT AND DISCUSSION

DESCRIPTIVE STATISTICS

Figure 1 depicts the performance of several ESG financial indices from different regions over the period 1 October 2014 to 31 May 2024. The US index (green line) demonstrates a significant upward trend throughout the observed period. While occasional dips are evident, the index maintains a strong upward trajectory, particularly after 2020 reflecting robust growth in the US market. The Emerging Markets index (blue line) exhibits relatively flat performance compared to the US. The lack of significant upward momentum suggests constrained growth or a more stable, less volatile pattern over the same period. The Asia Pacific index (red line) shows moderate growth with noticeable fluctuations. Periods of upward and downward trends indicate a more volatile market compared to the US, yet with greater growth potential than Emerging Markets. The UK index (orange line) shows modest growth with several peaks and troughs. Growth is less pronounced than the US and Asia Pacific, suggesting moderate performance potentially influenced by economic challenges or slower recovery phases. The Japan index (pink line) demonstrates growth patterns similar to those of the UK, marked by moderate gains and occasional volatility. The overall trend is upward but less steep than that of the US market. The Europe index (purple line) exhibits steady but modest growth. It has periods of relative stability punctuated with slight upward trends, indicating moderate market performance.

Between 2017 to 2019, most indices experienced some volatility; however, the general trend was upward, probably attributed to global economic conditions favouring market growth. A market decline across almost all indices occurred in early 2020, likely due to the impact of the COVID-19 pandemic. Despite the downturn, the US index quickly recovered and continued its strong upward trend. The US market showed accelerated growth, whereas other indices recovered at a more gradual pace. Emerging Markets and Europe demonstrated the weakest recovery, with comparatively flatter upward trends.

The US index outperforms all other indices by a significant margin, indicating a robust economic environment and strong market confidence. Despite their potential, Emerging Markets display the least growth, possibly constrained by various economic, political, and structural challenges. Asia Pacific and UK indices show moderate growth with significant volatility, indicating market uncertainties. Japan and Europe show steady but modest growth, reflecting stable but slower economic performance compared to the US.

The analysis highlights that the US market has been the most robust and resilient over the past decade, especially in the post-2020. In contrast, other markets, such as Asia Pacific and UK, display moderate growth with higher volatility, while Emerging Markets lag behind in performance. The impact of global events, notably the COVID-19 pandemic, is evident across all indices, highlighting the interconnected nature of global financial markets.

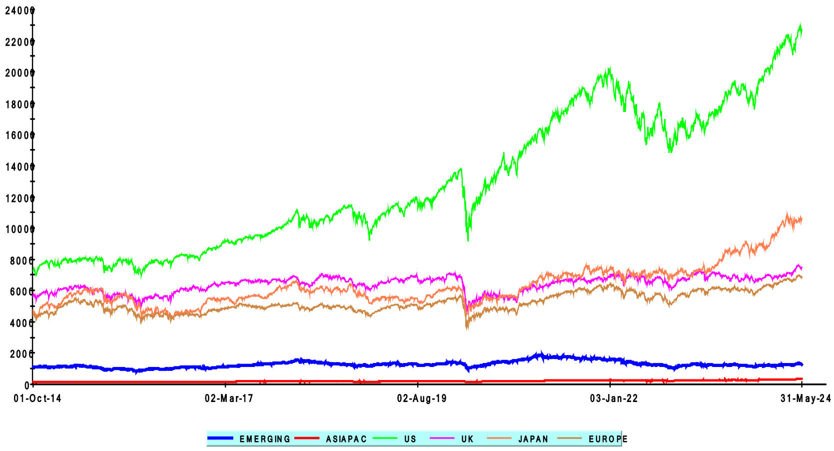


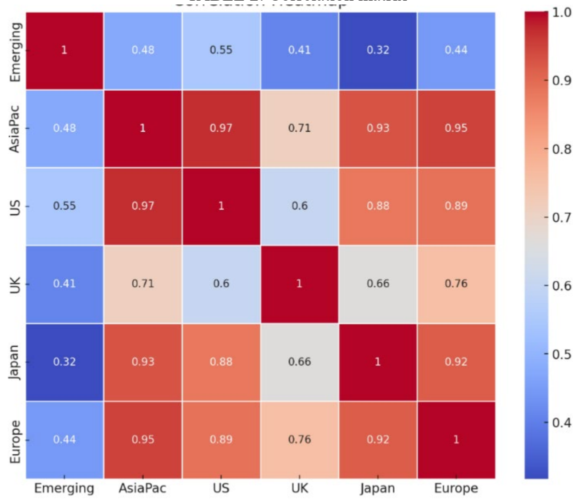
FIGURE 1. Dynamics of original data series

TABLE 1. Descriptive Statistics

Index	No. of observation	Mean	Std. Deviation	Min	Max	Skewness	Kurtosis
EMERGE	2523	1276	208	830	1894	0.666	0.135
ASIAPAC	2523	206	48	124	341	0.583	-0.609
US	2523	12883	4362	6970	22880	0.421	-1.148
UK	2523	6411	507	4635	7606	-0.625	-0.320
JAPAN	2523	6308	1313	4184	10798	1.209	1.434
EUROPE	2523	5242	634	3704	6972	0.483	-0.606

Table 1 presents descriptive statistics of six ESG indices, including EMERGE, ASIAPAC, US, UK, Japan, and Europe, based on 2,523 observations. The key metrics analysed include the mean, standard deviation, minimum, maximum, skewness, and kurtosis of daily price movements. The US index shows the highest average performance and volatility, indicating its potential as a high-risk, high-reward market. Similarly, the Japan index shows significant volatility with a broad range of performance values. The Emerging Markets and Asia Pacific indices in contrast, show lower volatility and narrower performance ranges, suggesting more stable but lower-growth markets. The skewness and kurtosis values provide insights into the return distributions. Right-skewed distributions (positive skewness) indicate the potential for occasional high returns, while left-skewed distributions (negative skewness) suggest more frequent higher returns interspersed with extreme losses. Japan notably has the highest skewness of 1.209 indicating a right-skewed distribution and more frequent returns on the lower side, but in the presence of occasional high positive returns. Meanwhile, kurtosis values indicate propensity for extreme events. Japan's highest kurtosis of 1.434 suggests a leptokurtic distribution characterised by more frequent extreme values.

TABLE 2. Correlation matrix



Note: Each cell in the heatmap shows the correlation coefficient between the stock indices, with values closer to 1 indicating a strong positive correlation and values closer to -1 indicating a strong negative correlation. A value close to 0 suggests little to no linear correlation.

The correlation heatmap in Table 2 provides insights into the relationships between the performance of various financial indices, including Emerging Markets, Asia Pacific, US, UK, Japan, and Europe. The correlation coefficients range from -1 (perfect negative correlation) to 1 (perfect positive correlation).

The Asia Pacific and US indices (0.97) exhibit a very high positive correlation, suggesting that these markets tend to move in the same direction, reflecting similar market conditions or economic linkages. A similarly high positive correlation is observed between Asia Pacific and Europe (0.95), indicating that these two regions also experience similar market trends. The correlation between the US and Europe (0.89) is also strong, suggesting interdependence and synchronised market movements. The high correlation between Asia Pacific and Japan (0.93) moreover indicates close relationships, possibly due to geographic and economic ties. Japan and Europe (0.92) also show a strong correlation, indicating similar market trends.

In contrast, the correlation between Emerging Markets and the US (0.55) is moderate, indicating some degree of independence. The correlation between Emerging Markets and Asia Pacific (0.48) is moderate, reflecting some shared trends but also distinct market behaviours. Similarly, the correlations between Emerging Markets and Europe (0.44) and the UK (0.41) are moderate to low, indicating relatively independent movements. The lowest correlation in the heatmap is between Emerging Markets and Japan (0.32), highlighting significant independence between these markets.

The high correlations among developed markets (US, Europe, Asia Pacific, Japan) indicate a significant degree of global market integration. These markets tend to move in tandem, reflecting global economic conditions and investor sentiment. Such strong correlations among developed markets suggest strong economic linkages and possibly similar responses to global events which can be useful for economic forecasting and policymaking. In contrast, the relatively lower correlations between Emerging Markets and other indices suggest greater independence in their movements. This may be due to differing economic conditions, growth rates, and market dynamics. For investors seeking diversification, the inclusion of Emerging Markets in their portfolios may be beneficial, since their lower correlation with other indices can help reduce overall portfolio risk.

PERFORMANCE OF STOCK PRICE INDICES

TABLE 3. Performance summary of stock price indexes

Indices	Jensen Alpha	Sharpe Ratio	Treynor Ratio
Emerging	-0.113	-4.64E-05	-0.00967
AsiaPac	-0.065	7.98E-04	0.03827
US	-0.056	1.07E-05	0.04669
UK	-0.102	1.21E-06	0.00061
Japan	-0.069	2.59E-05	0.03405
Europe	-0.091	1.85E-05	0.01171

Table 3 presents the performance metrics for six indices, including Emerging Markets, Asia Pacific, US, UK, Japan, and Europe, using Jensen's Alpha, Sharpe Ratio, and Treynor Ratio. These metrics provide insights into risk-adjusted performance and market efficiency.

Jensen's Alpha measures a portfolio's excess return over the expected return based on the Capital Asset Pricing Model (CAPM). A positive Jensen's Alpha indicates outperformance, while a negative value suggests underperformance. The US index shows the least negative Jensen's Alpha, indicating performance closest to its expected return. The AsiaPac (-0.065) and Japan (-0.069) indices also display relatively mild underperformance. In comparison, the UK (-0.102) and Europe (-0.091) indices show more significant underperformance relative to their expected returns. The Emerging Markets index (-0.113) has the most negative Jensen's Alpha, indicating the greatest underperformance.

The Sharpe Ratio measures the risk-adjusted return of an investment, calculating the average return in excess of the risk-free rate per unit of volatility. A higher ratio indicates better risk-adjusted performance. The AsiaPac index (0.000798) has the highest Sharpe Ratio, suggesting the best risk-adjusted return. The Japan (0.0000259) and Europe (0.0000185) indices also yield positive risk-adjusted returns, though lower than AsiaPac. The US (0.0000107) and UK (0.00000121) indices have very low positive values, indicating minimal excess return per unit of risk. The Emerging Markets index (-0.0000464) records a negative Sharpe Ratio, indicating underperformance relative to the risk-free rate after adjusting for risk.

The Treynor Ratio measures the returns earned in excess of the risk-free rate per unit of market risk (Beta). A higher Treynor Ratio reflects stronger performance relative to market risk. The US index, with a Treynor Ratio of 0.04669, demonstrates the best market risk-adjusted return. The Asia Pacific (0.03827) and Japan (0.03405) also show strong performance on this basis. The Europe index shows a moderate ratio, while the UK (0.00061) exhibits minimal excess return per unit of market risk. The Emerging Markets index (-0.00967) indicates underperformance when adjusted for market risk.

In summary, the Asia Pacific and US indices demonstrate the best risk-adjusted performance based on the Sharpe and Treynor Ratios. Despite slightly negative Jensen's Alpha values, their capacity to generate excess returns relative to both total and market risk is noteworthy. The negative Jensen's Alpha values across all indices suggest that none significantly outperformed expectations under the CAPM, indicating potential inefficiencies or model limitations. Conversely, the Emerging Markets index shows the weakest performance across all metrics.

This study emphasises that integrating ESG criteria does not significantly increase excess returns, as evidenced by the negative Jensen's Alpha and the Sharpe Ratios. These findings challenge the assumption that ESG integration necessarily leads to superior financial outcomes. Our findings contradict Kim and Li (2021), who report a positive effect of ESG factors on corporate profitability, particularly for larger firms.

While the statistical results offer important insights into the relative performance of ESG indices, their economic and practical implications deserve further elaboration. For instance, the slightly higher Treynor ratios observed in the US and Asia Pacific regions indicate more efficient compensation for market risk, guiding institutional investors toward these regions. Though the differences in Sharpe ratios are modest, they may still influence capital allocation decisions, particularly for large portfolios. Persistently high conditional correlations during crises such as COVID-19 reduce the benefits of geographic diversification, highlighting the need for alternative strategies, such as sectoral or ESG factor-based allocations. Furthermore, the presence of high volatility persistence in some markets highlights the importance of dynamic risk management strategies, including volatility targeting and regular portfolio rebalancing. These insights help translate the statistical findings into actionable strategies for investors, policymakers, and ESG portfolio managers.

MGARCH-DCC FINDINGS

This section analyses the estimates of the MGARCH-DCC model (as reported in Table 4), comparing results under the Multivariate Normal and Multivariate t distributions. The parameters of interest are λ1, which represents the persistence of volatility shocks in the conditional variance equations; λ2, indicating the speed at which the conditional variance reverts to its long-term mean; δ1, and δ2, along with the maximised log-likelihood and degrees of freedom (df) for the Multivariate t distribution, as shown in Table 4. All T-ratios indicate high statistical significance. Under the Multivariate Normal distribution, the US index records the highest λ1 (0.8953), indicating a slow decay of variance, suggesting that past variances significantly influence future variances. The Emerging Markets and Japan indices also show high λ1 values, while the Asia Pacific, UK, and Europe indices have considerably lower λ1 values, indicating quicker variance decay. Regarding λ2, the Emerging Markets, US, and Japan indices have high values, indicating slow covariance decay, while the Asia Pacific, UK, and Europe indices display more rapid decay. Under the Multivariate t distribution, all indices, particularly the Asia Pacific, UK, and Europe, exhibit even higher λ1 values, suggesting slower variance decay, whereas in contrast λ2 values indicate more rapid covariance decay across all indices compared to the Normal distribution. The δ1 estimates confirm the significant influence of past shocks on current variances, which is even more pronounced under the t distribution. The δ2 values however remain small, suggesting minimal influence on current covariances in both distributions. The Multivariate t distribution yields a higher log-likelihood value (55336) than the Multivariate Normal Distribution (54466) suggesting a better fit for the data. The degrees of freedom (7.3141) indicate the t distribution's flexibility in capturing tail behaviour and extreme values. These results underscore the high persistence of volatility (λ1) across all indices, the significant mean reversion parameters (λ2), and the importance of modelling time-varying dynamic correlations. The MGARCH-DCC model provides valuable insights into the indices' volatility dynamics and conditional correlations, emphasising the necessity of accounting for heavy-tailed events in financial data. Given its superior fit and statistically robust T-ratios the Multivariate t distribution is preferred for subsequent analyses.

TABLE 4. Estimates of λ_{i1} and λ_{i2}, and δ_1 and δ_2, for the six indices

		Multivariate Normal Distribution		Multivariate *t* Distribution	
		Estimate	T-Ratio	Estimate	T-Ratio
Lamda 1 ($\lambda 1$)	EMERGE	0.8909	55.715	0.9294	69.387
	ASIAPAC	0.0672	8.167	0.9432	110.299
	US	0.8953	79.944	0.8802	59.606
	UK	0.0734	10.593	0.9407	87.466
	JAPAN	0.8184	46.904	0.9274	65.817
	EUROPE	0.1292	11.198	0.9425	97.772
Lamda 2 ($\lambda 2$)	EMERGE	0.8794	52.146	0.0424	6.187
	ASIAPAC	0.0709	8.401	0.0427	7.495
	US	0.8729	43.010	0.0907	8.846
	UK	0.0954	7.395	0.0405	6.622
	JAPAN	0.8930	66.480	0.0589	5.833
	EUROPE	0.0719	9.191	0.0416	6.840
Delta 1 δ_1		0.8884	38.141	0.9205	47.263
Delta 2 δ_2		0.0201	8.140	0.0191	7.792
Maximised log-likelihood		54466		55336	
Degree of freedom (df)		-		7.3141	

Note: λ_1 and λ_2 are decay factors for variance and covariance, respectively.

Table 5 presents the estimated unconditional volatility matrix for the returns of six stock indices: Europe, Japan, UK, US, Emerging and Asia Pacific. The diagonal elements represent each index's unconditional variance (a measure of risk), while the off-diagonal elements indicate the covariances between pairs of indices.

The estimated unconditional volatility matrix for six stock indices reveals that the US index exhibits the highest individual volatility (0.01149), followed closely by the Asia Pacific (0.01141) and Japan (0.01135) indices, indicating significant market fluctuations. In contrast, the UK index records the lowest volatility (0.00975), suggesting more stable returns. Correlation analysis indicates strong co-movement between the Asia Pacific and Europe indices (0.96316), as well as between the UK and Europe (0.90442) and the Asia Pacific and UK (0.86138), reflecting closely integrated markets. Moderate correlations are observed between the US and Europe (0.57135), Asia Pacific and US (0.56679), and US and Emerging Markets (0.39430). The Japan index exhibits the lowest correlations, with the US (0.20609), Asia Pacific (0.33652), and Europe (0.35371), indicating more independent market movements.

Overall, the matrix reveals significant differences in both volatilities and correlations among the six stock indices. The higher volatilities of the US, Asia Pacific, and Japan indices suggest greater exposure to market fluctuations, while the UK's lower volatility indicates comparatively stable returns. The strong correlations among the Asia Pacific, UK, and Europe indices highlight the interconnectedness of these markets, while the lower correlations involving the Japan suggest greater potential for portfolio diversification. These insights are valuable for investors seeking to enhance diversification and implement effective risk management strategies.

TABLE 5. Estimated unconditional volatility matrix for stock indices return

	EMERGE	ASIAPAC	US	UK	JAPAN	EUROPE
EMERGE	0.01049 (4)	0.51373	0.39430	0.53422	0.43972	0.54166
ASIAPAC	0.51373	0.01141 (2)	0.56679	0.86138	0.33652	0.96316
US	0.39430	0.56679	0.01149 (1)	0.52491	0.20609	0.57135
UK	0.53422	0.86138	0.52491	0.00975 (6)	0.32887	0.90442
JAPAN	0.43972	0.33652	0.20609	0.32887	0.01135 (3)	0.35371
EUROPE	0.54166	0.96316	0.57135	0.90442	0.35371	0.01028 (5)

Table 6 presents the ranking of unconditional correlations among the returns of six stock indices: Europe, Japan, UK, US, Emerging and Asia Pacific. It identifies which indices and variables are most correlated, providing insights into the relationships and dependencies between these financial instruments. The analysis reveals that Europe consistently shows the highest correlations with multiple indices, highlighting its significant role in global market co-movements. Specifically, Europe is most strongly correlated with the Emerging Markets, Asia Pacific, US, and UK indices, indicating shared economic conditions and investor sentiment. In contrast, Japan frequently shows the lowest correlations, suggesting more independent market movements. The US and Asia Pacific indices also demonstrate strong correlations with other regions, particularly with Europe and each other, reflecting their interconnectedness within the global financial landscape. These findings underscore the importance of regional influences and market linkages for effective portfolio diversification and risk management. The ranking of unconditional correlations offers significant insights into the interrelationships and co-movements of global financial markets. Europe emerges as a key influencer, showing the highest correlations with multiple indices, while Japan exhibits more independent movements. These findings highlight the importance of considering regional influences and market interconnectedness when analysing global stock indices. Understanding these correlations is crucial for investors seeking to optimise portfolio diversification and manage risk effectively.

TABLE 6. Ranking of unconditional correlations among the stock indices return and other variables

EMERGE	ASIAPAC	US	UK	JAPAN	EUROPE
EUROPE	EUROPE	EUROPE	EUROPE	EMERGE	ASIAPAC
UK	UK	ASIAPAC	ASIAPAC	EUROPE	UK
ASIAPAC	US	UK	EMERGE	ASIAPAC	US
JAPAN	EMERGE	EMERGE	US	UK	EMERGE
US	JAPAN	JAPAN	JAPAN	US	JAPAN

This study employs a comprehensive, unconditional approach to examine volatilities and correlations over a period of nine years and eight months. While this method provides a broad overview, it may not fully capture the dynamic nature of these metrics. To address this, the Dynamic Conditional Correlation (DCC) model is utilised. Figure 2 illustrates the conditional volatilities of the six stock indices, Europe, Japan, UK, US, Emerging and Asia Pacific, from 1 October 2014, to 31 May 2024. The plot provides insights into the dynamic nature of market volatilities, identifying significant periods of market stress and stability. The conditional volatilities are depicted by different coloured lines representing each index.

The volatilities of all indices exhibit general stability interspersed with significant spikes, indicating periods of heightened market uncertainty and risk. From the start of the period until early 2017, all indices show relatively low and stable volatility. Between post-2017 to mid-2019, volatility increases, with several noticeable peaks, particularly around August 2019. A prominent spike was observed in August 2019 across all indices, with Japan (green) and Emerging Markets (blue) displaying particularly high volatility. This surge may be attributed to specific global economic events or market disturbances during that time.

Another notable increase in volatility occurs in early 2020, likely corresponding to the onset of the COVID-19 pandemic, which caused global market disruptions. Following this period, there is a general trend towards stabilisation, although some fluctuations persist. The volatility levels eventually return to lower levels after the initial pandemic-induced spike.

During the latter part of the period, the US (cyan) and Europe (orange) indices show relatively higher volatility compared to others, indicating more significant market fluctuations. The US and Emerging Markets indices exhibit higher average volatilities throughout the period, suggesting these markets experience more substantial fluctuations. Conversely, the UK (brown) and Asia Pacific (red) indices show relatively lower average volatilities, indicating more stable market conditions. These varying levels of volatility reflect differences in market structures, economic conditions, and investor behaviour across regions. The higher volatility in the US and Emerging Markets suggests these markets are more sensitive to global economic developments.

The plot of conditional volatilities reveals critical insights into the behaviour of different stock indices over the observation period. Significant volatility spikes correspond to global economic events, notably the COVID-19 pandemic, which profoundly impacted market stability. Although volatilities have generally stabilised in the post-pandemic period, some indices, such as the US and Emerging Markets, continue to exhibit higher fluctuation levels. These findings underscore the importance of monitoring conditional volatilities to understand market dynamics and to manage investment risk effectively.

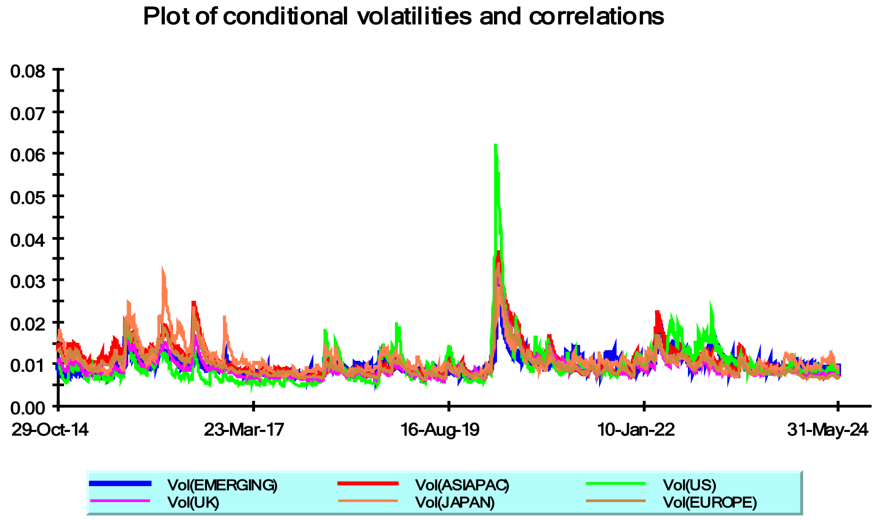


FIGURE 2. Conditional volatilities of green and conventional stock indices return

Figure 3 presents the plot of conditional volatilities and correlations among the six stock indices from 1 October 2014, to 31 May 2024. The figure illustrates how correlations between pairs of indices evolve over time. The correlations between the US and Asia Pacific indices, as well as between the UK and Asia Pacific indices, remain high and relatively stable throughout the period, generally ranging from 0.8 to 0.9. The correlations between Emerging Markets and Asia, Europe and Emerging Markets, Europe and the UK generally fluctuate between 0.5 and 0.7, indicating moderate co-movement. Similarly, the US-Emerging Markets, US-Europe, and Japan-Asia pairs exhibit moderate correlations, fluctuating between 0.4 and 0.7 over the observed period. In contrast, correlations between Emerging Markets and Japan, the UK and Emerging Markets, and Japan and the US are generally lower, often fluctuating between 0.2 and 0.5, indicating weaker co-movement. Initial correlations start relatively high, especially for pairs involving Europe and Asia Pacific, before stabilising to more stable levels. A significant spike in early 2020, aligning with the onset of the COVID-19 pandemic, indicates heightened market co-movement during the crisis. While correlations generally stabilise following this event, they remain higher than pre-2020 levels, reflecting a period of sustained market interconnectedness. The high and stable correlations between indices such as US-Asia and UK-Asia suggest strong interconnectedness, likely driven by global economic linkages and synchronised market responses to international developments. The spikes in early 2020 underscore the impact of global economic disturbances, such as trade tensions and the COVID-19 pandemic, which increased market co-movement and diminished diversification benefits. The stabilisation of correlations at elevated post-2020 levels indicates that markets have adapted to new economic conditions yet remain highly interconnected. Overall, the plot of conditional volatilities and correlations highlights significant insights into the interrelationships among major global stock indices. High and stable correlations, particularly between US-Asia and UK-Asia, point to strong market integration, while moderate and lower correlations indicate potential for diversification. Spikes in early 2020 reflect the influence of global economic events, emphasising the need for investors to consider these dynamics in risk management and portfolio diversification strategies. Understanding these patterns is crucial for effectively navigating the interconnected global financial landscape.

Figure 4 presents the plot of conditional volatilities and correlations among stock indices, focusing on the correlations between Japan and the other five indices from 1 October 2014, to 31 May 2024. Throughout this period, correlations between Japan and the other indices exhibit considerable fluctuations. Initially, correlations are relatively high, especially for Emerging Markets and Asia Pacific. The Japan-Emerging Markets (blue) correlation fluctuates significantly, often between 0.2 and 0.5, with peaks around 0.6, most notably in early 2020, likely in response to global market events. The Japan-Asia Pacific (red) correlation remains relatively stable but fluctuates between 0.3 and 0.5, indicating moderate co-movement and shared regional economic conditions. The Japan-UK (green) correlation is generally lower, fluctuating between 0.1 and 0.4, suggesting weaker co-movement and more independent market behaviour. The Japan-US (cyan) correlation also fluctuates moderately, ranging between 0.2 and 0.4, with periods of increased correlation, particularly during early 2020, aligning with global disruptions such as the COVID-19 pandemic. The Japan-Europe (pink) correlation tends to remain low, often between 0.2 and 0.4, with occasional spikes but overall weaker co-movement compared to other pairs.

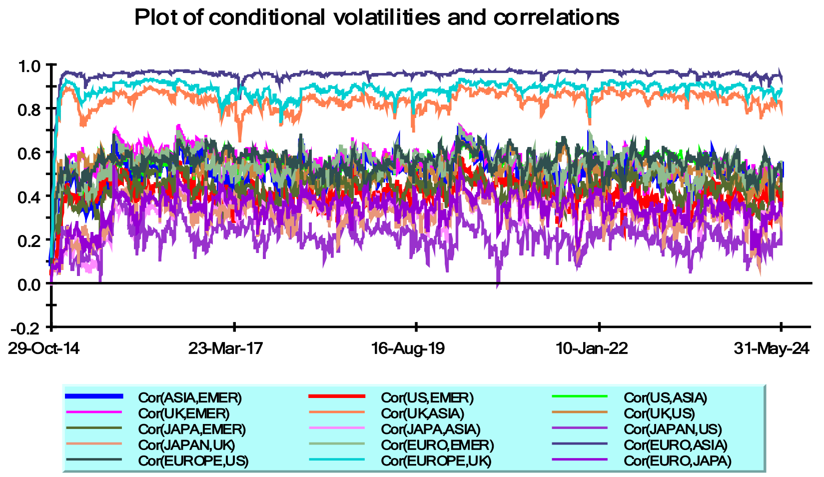


FIGURE 3. Conditional correlation of S&P 500 with F4GBM and KLCI

DAY 3

Around August 2019, correlations for most pairs, particularly Japan-Emerging Markets and Japan-Asia Pacific, showed noticeable spikes, reflecting increased market synchronisation due to global economic developments. A further significant spike occurs in early 2020, coinciding with the onset of the COVID-19 pandemic, indicating heightened market co-movement during the crisis. Following this pandemic-induced spike, correlations generally stabilise but remain above pre-2020 levels, reflecting sustained market interconnectedness.

The relatively higher and more stable correlation between Japan and Asia Pacific suggests strong regional economic linkages and synchronised market responses to regional events. The spikes in correlations around mid-2019 and early 2020 underscore the impact of global economic disturbances, such as trade tensions and the COVID-19 pandemic, co-movement and reduce diversification benefits. In contrast, the lower which increase market and more fluctuating correlations between Japan and the UK, and Japan and Europe, indicate potential for diversification, as these indices show more independent movements.

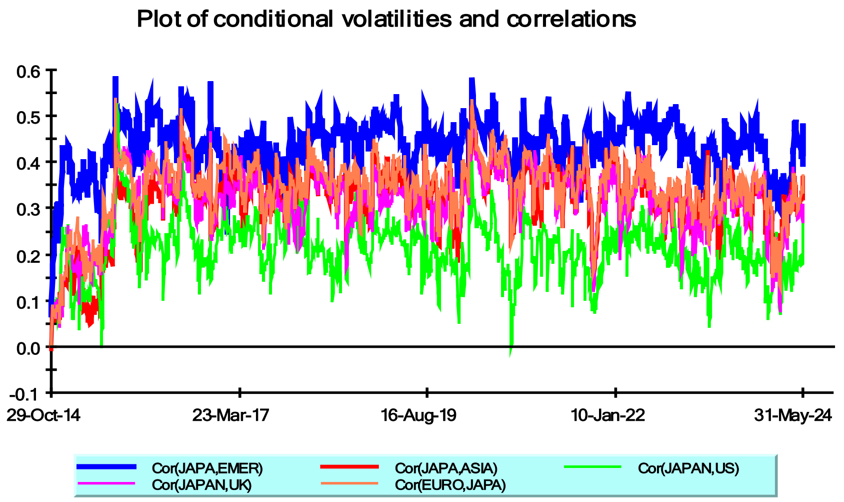


FIGURE 4. Conditional correlation of Japan with five other ESG Indices

Figure 4 presents the plot of conditional volatilities and correlations among stock indices, focusing on the correlations involving the US index with the five other major indices over the period from 1 October 2014, to 31 May 2024. The correlation between the US and Emerging Markets (blue) fluctuates moderately, generally between 0.3 and 0.6, and early 2020 with notable increases around mid-2019, likely driven by global economic events impacting both markets. The correlation between the US and Asia Pacific (red) remains relatively high and stable throughout the observation period, fluctuating between 0.5 and 0.6, indicating strong co-movement and reflecting shared economic conditions and market responses in these regions. Similarly, the correlation between the US and UK indices (green) is high and stable, ranging between 0.4 and 0.6, suggesting strong economic ties and synchronised market behaviour. In contrast, the correlation between the US and Japan (purple) is more variable, generally ranging between 0.2 and 0.5, indicating relatively weaker co-movement and more independent market movements. The US-Europe (pink) correlation also fluctuates moderately, typically between 0.3 and 0.5, with peaks during periods of global economic disruption, particularly in early 2020. Significant spikes in correlations are observed in early 2020, corresponding with the onset of the COVID-19 pandemic, indicating heightened market co-movement during the crisis. Following the pandemic-induced spike, correlations generally stabilise but remain higher than pre-2020 levels, signalling sustained market interconnectedness.

The persistently high and more stable correlations between the US and both Asia Pacific and UK, suggest strong regional economic linkages and synchronised market responses to regional developments. The spikes in correlations in early 2020 underscore the impact of global economic shocks, such as trade tensions and the COVID-19 pandemic, which intensify market co-movement and diminish diversification benefits. In contrast, the lower and more fluctuating correlations between the US and Japan indicate potential for diversification, as these markets appear to move more independently relative to others.

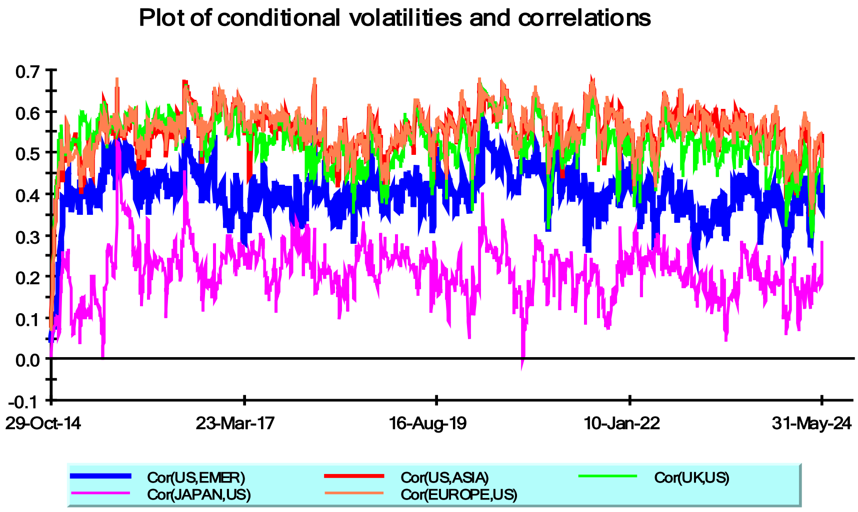


FIGURE 5. Conditional correlation of US with five other ESG Indices

Our MGARCH-DCC analysis offers deeper insights into volatility dynamics and inter-index correlations. The elevated and sustained conditional correlations observed among ESG indices, notably during the COVID-19 pandemic, indicate a strong tendency for these assets to co-move under market distress. These results diverge from the conclusions of Rubbaniy et al. (2022), whose wavelet coherence analysis suggested that ESG equities function as safe-haven assets during crisis periods. While Rubbaniy et al. focused on firm-level ESG stock performance, our findings suggest that ESG indices as aggregates may not offer the same diversification benefits, especially during systemic events.

Japan's index displayed relatively low correlation with other indices, confirming its diversification potential. This aligns partially with La Torre et al. (2020), who highlighted sector-specific ESG benefits, particularly in energy and utilities, suggesting that performance and correlation effects may vary across both regions and sectors.

By applying the MGARCH-DCC model, this study addresses the limitations of prior research that primarily relied on static correlation methods. The dynamic modelling approach used here captures evolving relationships over time, reinforcing the importance of time-varying analysis in ESG performance and diversification research. Our findings suggest that while ESG indices may offer moderate diversification benefits in normal market conditions, their collective behaviour under stress may reduce their effectiveness as diversification tools.

Ultimately, this research advances the existing literature by providing a dynamic, cross-regional analysis that simultaneously supports and refutes established empirical evidence. These results highlight the need for careful evaluation of ESG performance at both the micro (company) and macro (index) levels, and highlight the importance of methodological rigour in assessing ESG effectiveness.

CONCLUSION

This study provides a comprehensive analysis of the performance and interrelationships of six ESG stock market indices—Europe, Japan, UK, US, Emerging Markets, and Asia Pacific—over a period of nine years and eight months, from 1October 2014, to 31May 2024. The performance metrics, including Jensen's Alpha, Sharpe Ratio, and Treynor Ratio, reveal that the Asia Pacific and US indices exhibit the strongest risk-adjusted performance despite slightly negative Jensen's Alpha values. In contrast, the Emerging Markets index consistently shows the weakest performance across all metrics. None of the indices have significantly positive Jensen's Alpha values, indicating potential inefficiencies or market conditions not fully captured by the CAPM. This finding contrasts with earlier studies, such as Kim and Li (2021), which found ESG factors to positively influence corporate profitability, particularly in larger firms.

The MGARCH-DCC model highlights significant insights into the volatility dynamics and conditional correlations among the indices. The US index exhibits the highest volatility persistence ($\lambda 1$), while the Emerging Markets and Japan indices also exhibit high decay factors. The analysis confirms that the Multivariate t Distribution offers a better fit for the data, more accurately capturing tail risk behaviours and extreme values. The estimated unconditional volatility matrix reveals that the US index has the highest individual volatility, suggesting greater market fluctuations, while the UK index displays the lowest volatility, indicating more stable returns. Strong correlations are observed between the Asia Pacific, UK, and Europe indices, highlighting regional market interconnectedness. In contrast, the Japan index exhibits more independent movements, offering potential diversification benefits.

The dynamic conditional correlation analysis demonstrates that profound global shocks, notably the COVID-19 pandemic, significantly amplified cross-market linkages, thereby diminishing the efficacy of portfolio diversification. Although correlations have generally stabilised post-pandemic, they remain higher than pre-2020 levels, reflecting sustained global market interconnectedness. The high and stable correlations between the US and Asia Pacific, and between the US and UK, suggest strong regional economic linkages and synchronised market responses to regional shocks. Nevertheless, the robust and sustained correlations observed across major ESG indices during the COVID-19 crisis diverge from the conclusions of Rubbaniy et al. (2022), who posited that ESG equities might serve as context-dependent safe havens amid financial turmoil. This contradiction implies that ESG indices may not consistently provide the diversification benefits or safe-haven qualities often attributed to them during periods of market stress.

Ultimately, these results highlight the critical necessity of tracking conditional volatilities and cross-market correlations to navigate complex market dynamics and mitigate investment risk. To optimise portfolio performance, investors must account for the amplifying effect of macroeconomic shocks on asset co-movement by strategically identifying diversification opportunities in less integrated markets. Furthermore, the slightly negative Jensen's Alpha values observed across all indices challenge optimistic assumptions about ESG-driven outperformance. The sector-specific nature of ESG impacts and the strong correlation patterns observed during crises call for further investigation into the circumstances under which ESG integration contributes to financial resilience, profitability, and diversification benefits. Collectively, these findings underscore the multifaceted nature of ESG investing, demonstrating that its performance and risk-mitigation benefits are highly heterogeneous across different sectors, industries, and macroeconomic regimes.

IMPLICATIONS FOR STAKEHOLDERS

These findings offer critical insights for portfolio risk management, particularly during episodes of macroeconomic turbulence. While the empirical evidence underscores pronounced cross-market linkages between the US and broader Asia-Pacific indices, the relative independence of the Japanese market presents a distinct and viable avenue for strategic diversification. Effective diversification can help mitigate risk and enhance returns. A clearer understanding of how global economic shocks, such as the COVID-19 pandemic, impact market co-movements enables investors to make more informed decisions during crises, thereby facilitating the construction of more resilient portfolios.

For policymakers, the study emphasises the significant influence of global events on market stability and interconnectedness. Ultimately, these insights provide a crucial foundation for formulating robust strategies designed to curtail systemic vulnerabilities and bolster overall market resilience. By identifying regions and indices with higher market co-movement, regulators can design targeted policies to address specific vulnerabilities, thus ensuring a more robust financial system.

From a corporate perspective, the findings of this study can guide the development of proactive strategies to navigate market volatility and mitigate adverse impacts on equity valuations. This understanding enhances strategic planning and risk management practices. Additionally, knowledge of their index's performance and volatility characteristics can enable companies to communicate more effectively with investors, particularly regarding their risk exposure and market positioning. These findings enable companies to better align their corporate strategies with broader market dynamics, enhancing their financial stability and investor confidence.

IMPLICATIONS TO ACADEMIA

This study contributes to academic literature by integrating traditional and advanced econometric models in ESG performance analysis, offering robust methodological advancements through application of the MGARCH-DCC framework. The study also propose avenues for future research, including the use of wavelet and copula-based models.

LIMITATION

One key limitation of this study is the absence of conventional non-ESG indices for comparative purposes. As such, while the analysis provides meaningful insights into the internal dynamics of ESG indices, it does not conclusively establish whether ESG indices outperform traditional benchmarks.

While this study models ESG indices as representative benchmarks for sustainable investment performance, it is important to acknowledge the heterogeneity in their construction. ESG scoring frameworks differ across providers, such as Refinitiv, Sustainalytics, MSCI, and FTSE, due to variations in factor weighting, data sources, and emphasis on materiality. These methodological differences may influence each index's relative performance, volatility, and correlation behaviour. Although the current analysis treats these indices uniformly for modelling consistency, such methodological distinctions may introduce bias or limit comparability. Consequently, the findings should be interpreted cautiously, considering the underlying diversity in ESG index composition, which may influence their risk-return profiles and co-movement dynamics.

This study adopts an index-level, cross-regional approach to assess the interconnectedness and risk-adjusted dynamics of ESG investments. However, as noted in prior literature, ESG performance is also influenced by sector-specific factors, firm-level characteristics, and regional regulatory environments. While incorporating such granularity was beyond the scope of this analysis, we acknowledge that a more detailed breakdown, particularly by sector or firm-level ESG exposure, could offer richer insights into the conditions under which ESG integration enhances portfolio resilience and diversification. Future research may consider applying the MGARCH-DCC framework at these levels to evaluate whether specific industries or business models amplify or moderate ESG's impact on market dynamics.

FUTURE RESEARCH

Future studies could extend the analysis period beyond May 2024 to capture more recent developments and long-term trends. Incorporating additional indices, particularly from Emerging Markets, would enhance the global perspective. Sector-specific analyses within each region could offer deeper insights into how different industries respond to market volatility and economic shocks, helping stakeholders understand sectoral vulnerabilities and investment opportunities. Given the growing importance of ESG considerations, future research should explore how ESG scores and initiatives impact stock performance and volatility, providing valuable insights for sustainable investment strategies. Utilising more advanced econometric techniques, such as wavelet, machine learning algorithms, regime-switching DCC, or copula-GARCH, could enhance the accuracy of volatility and correlation forecasts by capturing non-linear relationships and complex market dynamics. These models may also better detect the presence of structural breaks or tail dependencies. Incorporating microeconomic factors, such as corporate governance practices, management decisions, and company-specific events, would offer a more granular understanding of stock performance and volatility. Exploring the impact of investor behaviour and sentiment on market volatility and correlations could enhance understanding into how psychological factors influence market dynamics, thereby enhancing the predictive power of financial models. Assessing the effectiveness of various regulatory and policy measures in stabilising markets and mitigating volatility can better guide policymaking, thus contributing to the development of more resilient financial systems. Future studies could incorporate sectoral or industry-level disaggregation to further illuminate how ESG performance varies across economic segments. Additionally, incorporating conventional non-ESG indices as benchmarks would enable a more rigorous comparison, allowing for a clearer assessment of ESG outperformance and diversification potential. Future research can also extend the analysis through comparing the DCC model with alternative specifications such as the Baba-Engle-Kraft-Kroner (BEKK) and Constant Conditional Correlation (CCC) models to assess robustness of findings and capture structural nuances in volatility transmission across ESG indices. Such model comparisons may help validate the findings of this study and potentially yield further insights into cross-market dynamics.

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