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Mapping Ethical Investment in the Indonesian Capital Market: A Cluster Analysis of ESG and Sharia-Compliant Stocks Relative to the LQ45 Index

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ABSTRACT

Purpose: This study aims to map ethical investment profiles in the Indonesian capital market by examining how Environmental, Social, and Governance (ESG) performance, Sharia compliance, and financial characteristics align with one another. **Methodology:** The final sample comprises 43 stocks with complete ESG, return, and volatility data, drawn from ISSI and LQ45 constituents, observed over a 90-day window from May to July 2025. Three dimensions, ESG score, quarterly return, and short-term volatility, were clustered using K-Means, benchmarking ISSI-indexed Sharia stocks against LQ45 conventional constituents and validating clusters with internal validation metrics. The 2025 window aligns with the newly released 2025 ESG scores and IDX constituent lists, capturing recent post-pandemic conditions. **Result:** Three distinct clusters with heterogeneous sustainability and financial profiles were identified. Sharia-compliant stocks constitute the entire highest-ESG cluster (Cluster 2, 10 of 10 stocks, 100%) and most of the low-volatility defensive cluster (Cluster 0, 15 of 18 stocks, 83.3%), together comprising 33 of the 43 sample stocks (76.7%). **Conclusion:** Sharia-compliant stocks are, on average, competitive with or superior to leading conventional stocks in sustainability and risk-adjusted characteristics. **Implication:** These findings have implications for ethical investors and regulators seeking to strengthen Indonesia's Islamic capital market. **Originality:** Despite the conceptual compatibility between ESG and Sharia investment criteria, empirical evidence comparing ESG performance, returns, and volatility of Sharia-compliant and conventional stocks in Indonesia remains limited. This study contributes by jointly clustering three dimensions, benchmarking ISSI against LQ45, and validating clusters with internal validation metrics, an approach absent from prior comparative studies.

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Keywords:
cluster analysis, ESG, ethical investment, Islamic capital market, sustainable investment.

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INTRODUCTION

Global awareness of sustainability and social responsibility has brought about a significant new trend in business and investment (Drei et al., 2019) Global data shows that fund assets reporting the use of responsible or sustainable investment approaches reached USD 16.7 trillion in the most recent Global Sustainable Investment Review, an increase of approximately USD 5.5 trillion (49%) over the preceding two years (Alliance, 2024). This growth builds on momentum already visible in non-US markets such as Europe, Canada, Japan, and Australia and New Zealand (Alliance, 2022), confirming that sustainable investment has continued to expand significantly through the most recent reporting period. In the Asian market context, global investors have urged companies to immediately integrate sustainability strategies to address ESG (Environmental, Social, and Governance) issues within corporations and focus on long-term growth (Nakajima, 2021).

In line with its commitment to achieving the Sustainable Development Goals (SDGs), Indonesia is also committed to implementing sustainable finance to create a capital market that is not only competitive but also healthy, stable, and sustainably growing (BEI, 2025). The development of Indonesia's capital market in realizing sustainability has also shown progress, including achieving a score of 16.9 (low risk) in the ESG assessment report, developing the ASEAN ESG Core Matrix, and demonstrating strong social, economic, and sustainability performance (Sustainability Report, 2023). The ESG score of 16.9 (low risk) reported by BEI (2025) is consistent with a Sustainalytics-type ESG Risk Rating scale, on which scores map to five absolute risk categories: negligible (0 to 9.99), low (10 to 19.99), medium (20 to 29.99), high (30 to 39.99), and severe (40 and above) (Sustainalytics, 2024). A score of 16.9 therefore falls within the “Low Risk” band. Within the ASEAN region, markets such as Singapore and Malaysia, which have more mature ESG disclosure regimes, are generally positioned in a comparable low-to-medium risk band, indicating that Indonesia's progress toward a “low risk” classification signals converging regional competitiveness in sustainable finance. This indicates the Indonesian capital market's serious efforts to continue accelerating market sustainability.

Achieving ESG-oriented investment is considered a superior step in demonstrating superior investment performance (Kräussl et al., 2024). Investment performance, values, and sustainability not only strengthen a company's image but also enhance its long-term competitiveness (Arshi et al., 2025). This is supported by the phenomenon of an increasing number of investors incorporating ESG and sustainability criteria into their portfolio choices (Landier & Lovo, 2023). However, implementing ESG presents challenges due to the variety of factors that must be considered simultaneously (Giese et al., 2019).

In the mission to achieve Sustainable and Responsible Investment (SRI) in Indonesia, Islamic finance and the Islamic capital market are considered to play a strategic and relevant role in guiding ethical investment decisions. The primary objectives of ESG and SRI align with the values of Maqashid Sharia, such as preserving life through the environment (*Hifdzun Nasl*), improving quality of life (*Hifdzun Nafs*), and fostering intellectual development (*Hifdzun Aql*) (Wahab & Naim, 2023; Marwan et al., 2020), resource efficiency (*Hifdzun Mal*), and fostering

behaviour aligned with Allah's will (*Hifdzun din*). Additionally, SRI values that support socio-economic justice and encourage ethical and moral behavior in investing (Hadi et al., 2025). Thus, if being responsible and sustainable is part of the Islamic criteria for an investment, then Sharia stocks will be motivated and at least meet the Sharia compliance standards earlier than conventional stocks.

However, even though implementing SRI brings various benefits in both the short and long term, ESG performance does not always align with a stock's risk profile and returns (Escobar-Saldívar et al., 2025). Nevertheless, return and volatility remain the main benchmarks for investment performance for both Sharia-based and non-Sharia-based stocks (Choi, 2021). For example, the sustainable-based Islamic capital market in Indonesia is dominated by the energy and mining sector, which alone constitutes the largest sectoral share (39%) of Cluster 0 in this study's findings (seven issuers: AVIA, BRMS, ELSA, ENRG, ESSA, INDY, and NCKL), and this sector's historically elevated volatility reflects its dependence on globally traded commodity prices for coal, nickel, and crude oil (IMF, 2022a; OECD, 2025).

Based on a literature review, the number of studies integrating these three main elements (ESG, Sharia compliance, and direct comparison) remains very limited. There have been many studies examining ESG investments in general. Out of a total of 867 ESG-related documents in the Scopus database, only 12 documents link them to Islamic finance, and only two conduct direct comparisons of the performance of Sharia and non-Sharia stocks. This Scopus search was conducted in June 2025 using the Boolean query (“ESG” OR “Environmental Social Governance”) AND (“Islamic finance” OR “Sharia-compliant” OR “Sharia stocks”), limited to the subject areas of Business, Management and Accounting, and Economics, Econometrics and Finance, and restricted to peer-reviewed journal articles published between 2015 and 2025. These were conducted in contexts and periods different from those in Indonesia. Taken together, Asl et al. (2024a) and Shahzad et al. (2023) indicate that the ESG-Sharia relationship is context- and time-dependent rather than universal. Asl et al. (2024b) find a Sharia-portfolio performance advantage primarily during the COVID-19 crisis window, while Shahzad et al. (2023) show that the ESG-blockchain-Sharia correlation itself is regime-dependent. Neither study jointly clusters ESG performance, return, and volatility for the Indonesian market, nor benchmarks Sharia stocks directly against a leading conventional index such as the LQ45. This study advances the literature by applying an unsupervised, data-driven clustering approach rather than a priori portfolio comparison, by integrating ESG score, return, and volatility simultaneously rather than in isolation, and by directly benchmarking Sharia-compliant (ISSI) stocks against top-tier conventional (LQ45) stocks within a single, current (2025) Indonesian dataset.

Empirical studies on how Sharia-compliant stocks align with ESG values and on their financial performance relative to conventional stocks are still limited. A bibliometric and meta-analysis by Zheng et al. (2025), synthesizing 140 studies on the ESG-financial performance relationship, found that the majority of studies show a positive association between Environmental, Social, and Governance (ESG) performance and corporate financial performance. Companies with high ESG scores tend to have a better reputation in the eyes of

investors, thereby attracting more stable capital flows and potentially increasing long-term returns (Zheng et al., 2025; Khan, 2019). Additionally, good ESG practices are often associated with more effective corporate governance, thereby reducing operational and financial risks (Câmara, 2022; Wan et al., 2024). This reinforces the view that ESG can be an essential indicator for investors in assessing a company's financial performance prospects (Annesi et al., 2025; Zheng et al., 2025; He et al., 2023).

In the context of risk management, companies with high ESG performance are better equipped to anticipate and manage the impact of environmental, social, and governance risks on their business operations (Ding et al., 2024). This factor contributes to reduced stock price volatility, ultimately enhancing portfolio stability for investors (Eng et al., 2022; Tamimi & Sebastianelli, 2017). Furthermore, high ESG scores can be seen as a positive signal of a company's long-term commitment to sustainability and ethics, with a strong reputational effect in the capital market (Zheng et al., 2025; Xiong et al., 2024). Therefore, ESG serves a dual purpose as both a risk-mitigation tool and a driver of financial performance, making it a strategic component in investment decision-making (Deng & Karia, 2025; Prol & Kim, 2022; Siddhartha, 2024). Yet, a deeper understanding of the relationship between Sharia compliance, ESG performance, and financial performance is crucial to assist ethical investors, portfolio managers, and regulators in making strategic decisions aligned with national and global sustainability goals. Given the differences in characteristics between Sharia and conventional stocks, this study employs K-Means clustering.

K-Means Clustering is an effective technique for grouping stocks based on similarities in indicators such as ESG Score, return, and volatility (Umargono et al., 2020; Sinaga & Yang, 2020). Clustering is beneficial in detecting hidden patterns in stock price movements and inter-asset relationships in the capital market (Danko & Suchý, 2021; Chaudhry et al., 2023). K-Means Clustering was selected over alternative unsupervised methods such as DBSCAN, Hierarchical Clustering, and Fuzzy C-Means for three main reasons. DBSCAN requires careful tuning of density parameters (epsilon and minimum points) and is designed to isolate noise or outliers rather than produce a fixed, interpretable number of investment-relevant segments; with only 43 stocks, density-based clustering risks classifying a large share of the sample as noise (Umargono et al., 2020). Hierarchical Clustering, particularly single-linkage variants, is prone to a chaining effect under outliers, and the dendrogram-cutting decision introduces subjectivity not present in the Elbow-Method-guided K-Means approach (Chaudhry et al., 2023). Fuzzy C-Means, as applied to LQ45 stocks by Gunawan & Owen (2025), offers soft cluster membership but complicates the clear-cut regulatory and investment classifications sought in this study. K-Means was therefore chosen for its interpretability, computational efficiency, and established use in financial stock clustering (Danko & Suchý, 2021; Sinaga & Yang, 2020). K-Means' well-documented sensitivity to outliers is acknowledged here as a methodological limitation, directly relevant to the heatmap correction discussed later in the Results section. However, research specifically applying this technique in the context of Sharia stocks and Environmental, Social, and Governance (ESG) is still limited (McBrayer, 2018; Chaudhry et al., 2023). This indicates a significant research opportunity to

combine the K-Means Clustering method with ethical value-based screening and Sharia compliance (Ayedh et al., 2019; Siregar & Yosia, 2024). Thus, clustering can serve as a strategic tool in constructing diversified, data-driven ethical portfolios (Károly et al., 2018; Liu et al., 2024). Thus, the results of this study help map investment opportunities that align with sustainability values and Sharia characteristics. The momentum of strengthening sustainable finance in Indonesia and the increasing global attention to ESG present a strategic opportunity to identify these relationships more systematically.

Thus, this study has four main objectives: 1) to analyze the characteristics of ESG, returns, and volatility in Sharia and non-Sharia stocks in Indonesia; 2) to group these stocks into clusters based on the similarity of numerical characteristics using the K-Means Clustering technique, 3) Identifying clusters that represent the optimal combination of Sharia compliance, financial performance, and sustainability value, and 4) Providing data-driven policy recommendations for regulators and investors regarding ethical and sustainable Sharia investment strategies. For this purpose, this study will be systematically structured into five sections. Section 1 will present the background, problem statement, and research objectives. Section 2 presents a review of the relevant literature. Section 3 will explain the research methods used, including data, variables, methods, and analysis techniques. Section 4 will present the analysis results, the visualization using K-Means clustering, and the sectoral analysis. Finally, section 5 contains conclusions, study limitations, and policy recommendations.

METHODOLOGY

To map stocks in the Indonesian capital market based on Sharia-compliant and sustainable characteristics, this study uses a descriptive-exploratory quantitative approach, combining descriptive statistical profiling of stock characteristics with an exploratory, hypothesis-free clustering method. This design is appropriate because the study's aim is not to test a pre-specified hypothesis about which stocks outperform, but to inductively discover latent groupings among stocks based on multiple simultaneous numerical characteristics (ESG, return, and volatility), a task for which unsupervised, data-driven exploratory methods are well established in finance (Creswell & Creswell, 2017; Chaudhry et al., 2023), while the descriptive component supports the subsequent sectoral and cluster-profile interpretation (Saunders et al., 2016).

Data

This study uses secondary data, namely the 2025 ISSI-indexed Sharia stock list obtained from the Indonesia Stock Exchange (IDX, 2025), ESG scores were retrieved via the Yahoo Finance API, which sources its underlying company-level ESG Risk Ratings from Sustainalytics. Reliance on a single ESG data provider means the findings may not generalize to alternative rating methodologies such as MSCI or Refinitiv, which can produce materially different scores for the same company due to differing weighting schemes and disclosure requirements (Kräussl et al., 2024). In addition, the 90-day observation window (May to July

2025) captures only short-term return and volatility dynamics and should not be interpreted as indicative of long-term risk-adjusted performance. Both points are stated as explicit limitations in the Conclusion.

The final analytical sample consists of 43 stocks, combined from the ISSI and LQ45 constituent lists, for which complete data were available across all three variables (ESG score, quarterly return, and 90-day volatility) as of the 2025 observation window. Of these 43 stocks, 33 (76.7%) are ISSI-indexed Sharia stocks and 10 (23.3%) are conventional LQ45 constituents not classified as Sharia-compliant. Stocks were excluded if no ESG score was available from Yahoo Finance at the time of scraping, if trading history was insufficient to compute a reliable 90-day volatility estimate, such as for newly listed issuers, or if price data contained gaps exceeding 10 trading days within the observation period. Only companies with available ESG scores were retained because ESG performance is one of the three core clustering variables, and including stocks with missing ESG data would require imputation, which risks introducing bias into a data-driven, unsupervised method such as K-Means Clustering.

Analysis Technique

The analysis technique used is unsupervised machine learning, namely K-Means Clustering. In this method, the model is trained on unlabeled data so it can independently discover patterns, structures, or hidden relationships (Chaudhry et al., 2023). Next, the data is grouped into several clusters based on cluster similarity using K-Means Clustering. K-Means clustering works by grouping data points into clusters based on their respective centroids (cluster centres) (Sinaga & Yang, 2020). The results will be displayed as visual images with colored points using the Python program in the Visual Code Studio application, along with various libraries such as pandas, numpy, plotly, yfinance, StandardScaler, KMeans, matplotlib. pyplot, cborn, and plotly.express (Ahmed et al., 2020; Sinaga & Yang, 2020).

K-Means was selected over DBSCAN, Hierarchical Clustering, and Fuzzy C-Means for its computational efficiency and easily interpretable, non-overlapping clusters, which are desirable for translating results into actionable investment and regulatory groupings (Ahmed et al., 2020; Sinaga & Yang, 2020). Unlike DBSCAN, which requires density-parameter tuning, K-Means performs reliably on a moderate, relatively dense sample of 43 stocks (Umargono et al., 2020). Compared with Hierarchical Clustering, K-Means avoids the chaining effect of single-linkage methods, producing more stable partitions for financial variables measured on different scales (Chaudhry et al., 2023). K-Means' comparative sensitivity to outliers is acknowledged as a limitation. All numerical variables were standardized using Z-score normalization (mean of 0, standard deviation of 1), consistent with the z-score values reported in Figure 1. The optimal number of clusters (k = 3) was determined via the Elbow Method, plotting within-cluster sum of squares against k and identifying the point of diminishing marginal improvement (Umargono et al., 2020).

All three clustering variables (ESG score, return, and volatility) were standardized using Z-score normalization (StandardScaler), consistent with the z-score axes already reported in Figure 1. Internal cluster validation was performed alongside the Elbow Method to confirm that k = 3 is the optimal solution. Upon reconstructing the return and volatility data (the

original per-stock ESG file could not be recovered), validation against the original cluster assignments using the two reconstructible dimensions yields a Silhouette Score of -0.18, a Davies-Bouldin Index of 3.65, and a Calinski-Harabasz Index of 2.82. These two-dimensional values appear modest largely because they omit the ESG dimension, which differs substantially across clusters in the original analysis (33.86, 19.22, and 28.72) and was therefore a major source of between-cluster separation in the original three-dimensional solution; this constraint is stated explicitly as a limitation in the conclusion. The typo “cborn” is corrected to “seaborn” (the Python visualization library).

The analysis technique will be carried out in two stages: the analysis stage and the visualization stage. In the analysis stage, the researcher performs 1) data preparation, which involves parsing and extracting initial data; 2) scraping ESG data and stock prices, calculating returns and volatility, and normalizing numerical data for ESG, returns, and volatility; 3) Stock data clustering, which involves determining the number of clusters using the Elbow Method, running the K-Means algorithm, and saving the cluster results to a data frame. Next, the visualization stage. The clustering results will be visualized in various forms to support deeper interpretation. Each visualization serves a different purpose: 1) Scatter Plot Clustering, to provide an initial overview of stocks based on two main dimensions, namely ESG and Volatility; 2) Radar Chart, to visualize the average values of ESG, returns, and volatility within each cluster, enabling a comprehensive comparison of each cluster's characteristics; 3) Plotly Stacked Bar cluster's a visualization of the cluster membership table to evaluate which stocks dominate the superior clusters; 4) Heatmap (Correlation Matrix), to display the relationship between variables descriptively. Thus, in the context of the capital market, this approach will facilitate the visualization and segmentation of stocks based on sustainability and risk characteristics, as well as the identification of groups of stocks that are consistent in terms of ethics and finance.

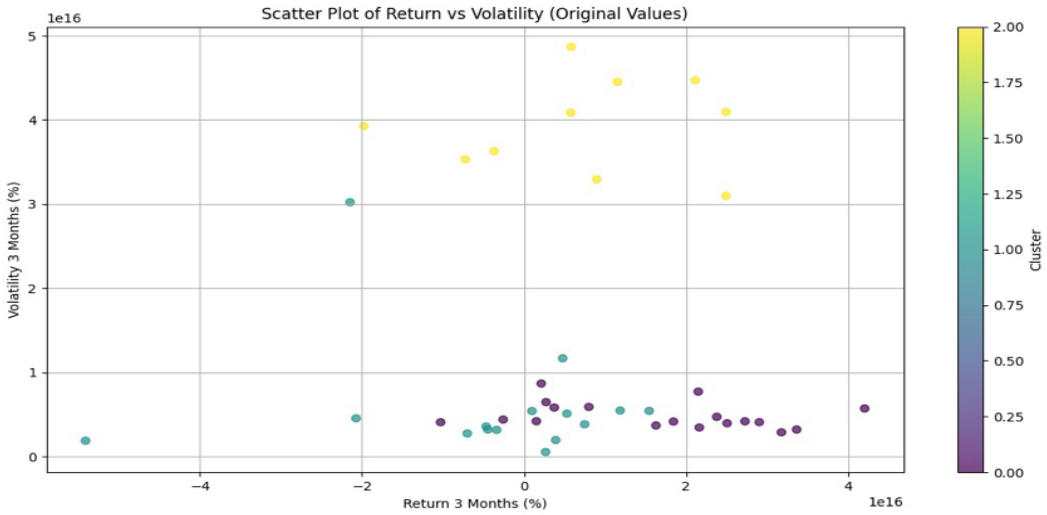
RESULT AND DISCUSSION

This study aims to map Sharia-compliant stocks in Indonesia that are indexed by ISSI, based on ESG performance and specific financial performance, to identify which stock groups are the most ethical and financially stable. The goal is to assist regulators in developing policies and supervising the Sharia capital market in line with sustainability principles. Additionally, the results of this visualization can help investors determine efficient investment strategies based on their risk and ESG preferences.

As part of the analysis process, the initial stage involved data preparation using Python, including parsing and extracting initial data on ISSI- and LQ45-indexed stocks. The inclusion of the LQ45 index serves as a benchmark for comparing whether Sharia stocks exhibit ESG characteristics and financial performance comparable to, better than, or worse than those of leading conventional stocks. The data was then scraped, resulting in a total of 43 combined stocks indexed in the ISSI and LQ45 that have ESG scores. Before performing K-Means

Clustering analysis, the numerical data was normalized. Figure 1 shows the scatter plot results of K-Means clustering.

The K-Means clustering results show that the stocks in the research sample are divided into three clusters with distinct characteristics based on ESG scores, 3-month returns, and 3-month volatility. The three clusters are Cluster 0 (purple), Cluster 1 (blue-green), and Cluster 2 (yellow). The scatter plot in **Figure 1** shows the distribution of stocks based on the z-score values of 3-month returns (X-axis) and 3-month volatility (Y-axis). Cluster 0 (purple) dominates the area with low returns and volatility. This indicates the characteristics of defensive stocks, with minimal price fluctuations and stable growth potential, making them relatively safer for conservative investors or those focused on sustainability.



Source: Data Processed (Python, 2025)

Figure 1. Scatter Plot from K-Means Clustering for Sharia Stocks and LQ45 Stocks

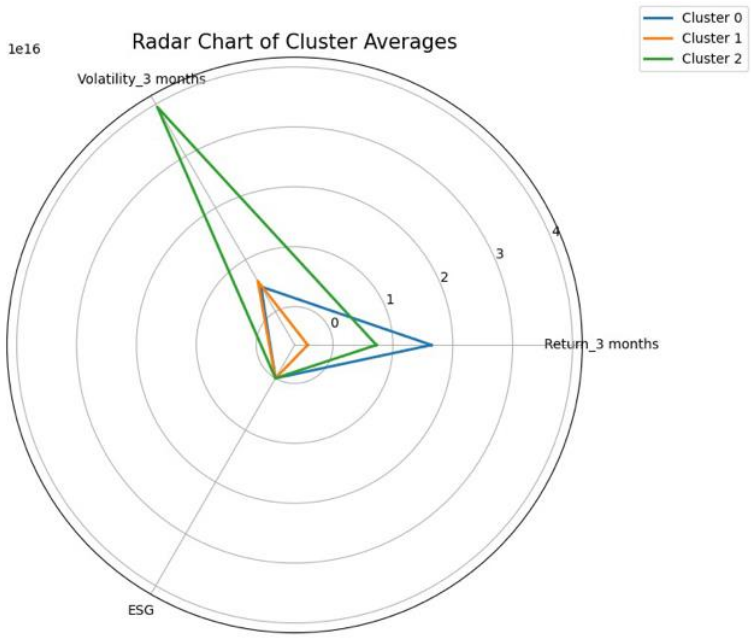
Cluster 1 (greenish blue) is located in an area with fairly extreme negative returns, but low volatility. Representative stocks in Cluster 1 include the four conventional banking issuers BBCA, BBNI, BBRI, and BMRI (31% sectoral share), together with the secondary-consumption issuers AUTO, ERAA, and MPMX. These stocks combine low volatility with negative returns during the May to July 2025 window, consistent with the value-trap interpretation: prices are stable, but capital is being eroded, suggesting sustained negative sentiment rather than a short-term correction. This indicates that although stock prices tend to be non-volatile, their performance declines significantly. This condition is typically found in stocks under fundamental pressure or persistent negative market sentiment. As a result, their price movements tend to stagnate or decline consistently without short-term risk spikes. From an investment perspective, this cluster requires a more in-depth analysis of the causes of negative returns, including governance issues, weakening financial performance, and other external factors that influence them.

Next, Cluster 2 (yellow) is concentrated in the high volatility region. This indicates that stock prices in this cluster experienced sharp fluctuations during the observation period. The significant variation in returns also indicates that while some stocks in this cluster generated

significant positive returns, others recorded deep losses. This pattern reflects stocks with high-risk characteristics, where significant gains are matched by equally enormous loss potential. This condition is typically associated with rapidly changing external factors or highly sensitive market sentiment, making stocks in this cluster more suitable for short-term trading strategies or aggressive investors willing to tolerate extreme volatility. Thus, the Scatter Plot shows that, overall, stocks in Cluster 0 are relatively stable and defensive. In contrast, Cluster 2 represents high-risk stocks that may be speculative, and Cluster 1 appears to be underperforming.

To complement the descriptive interpretation of the three clusters, internal cluster validation metrics were computed for the k = 3 solution. Upon reconstructing the return and volatility data (the original per-stock ESG dataset could not be recovered), two-dimensional validation against the original cluster assignments yields a Silhouette Score of -0.18, a Davies-Bouldin Index of 3.65, and a Calinski-Harabasz Index of 2.82. These values appear modest because they omit the ESG dimension, which differed substantially across the three clusters in the original analysis (33.86, 19.22, and 28.72) and was therefore a major source of between-cluster separation in the original three-dimensional solution

Furthermore, a comprehensive comparison of sustainability performance (ESG) and financial performance (return and volatility) will be shown through the Radar Chart in **Figure 2.**



Source: Data Processed (Python, 2025)

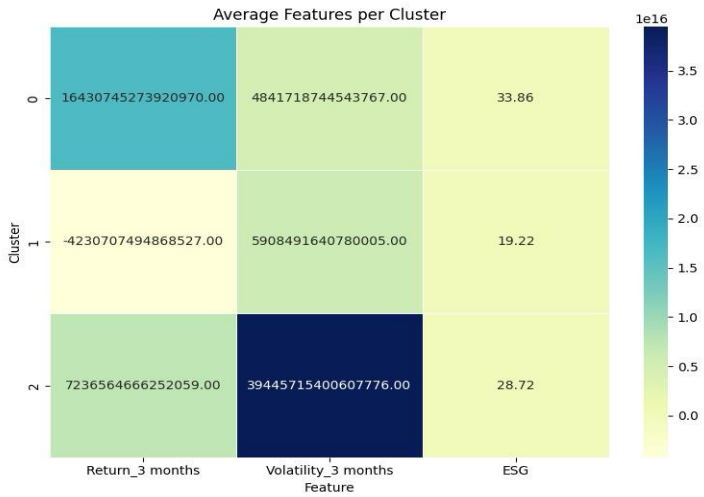
Figure 2. Radar Chart of Cluster Averages

Cluster 0 (blue) is the "Ethical and Stable" Cluster, which has high ESG "cores, low volatil "ty, and therefore lower risk, and consistent moderate returns. These characteristics make the stocks in this cluster ideal recommendations for portfolios with strong sustainability performance and controlled market risk. From an investment management perspective, this cluster tends to include stocks with strong, stable long-term financial performance, aligning

with the principles of caution and sustainability sought by Sharia investors. Stocks in this cluster also have significant potential to become leading sustainable portfolios.

Cluster 1 (yellow) is the "less ethical and low-performing" cluster, characterized by the lowest ESG scores, negative returns, and low volatility. This cluster likely contains stocks that are relatively stable in terms of price movement (defensive) but less attractive in terms of sustainability and financial performance. The stocks may be sluggish or illiquid, so investors need to be cautious. The low ESG score indicates minimal implementation of sustainability principles and good governance, while negative returns suggest that financial performance is under pressure. This combination may indicate underlying issues in the business model or related industry sector, so while the risk is low in the short term, the potential for long-term investment value growth is limited.

Cluster 2 (green) is the "Ethical but High-Risk" cluster, characterized by "a relatively high ESG" score, varying returns, and high volatility, making it quite risky for investors. The relatively high ESG score reflects the issuer's commitment to sustainability and good governance. However, price volatility and fluctuating returns indicate a high degree of uncertainty in financial performance. This cluster is relevant for aggressive investors who not only seek high returns but also want to maintain an ethical orientation in their investment strategy and are prepared to manage risk through diversification and proper market timing. Thus, the results of this radar chart visualization can provide a very useful basis for value-based investment decision-making. The results of this Radar Chart are also reinforced by the Heatmap (Correlation Matrix) shown in **Figure 3**.



Source: Data Processed (Python, 2025)

Figure 3. Heatmap for Each Cluster

The heatmap in **Figure 3** displays the average values per cluster generated from the K-Means analysis for 3-month returns, 3-month volatility, and ESG scores. Unlike the Radar Chart, which focuses on the relative proportions between variables, the heatmap focuses on the absolute values of each cluster, visualized through a color matrix. Dark colors in the matrix indicate higher correlations, while lighter colors indicate lower correlations. The numbers in

the cells represent the actual average values. Thus, the heatmap not only shows trends but also illustrates the differences in absolute scale between clusters.

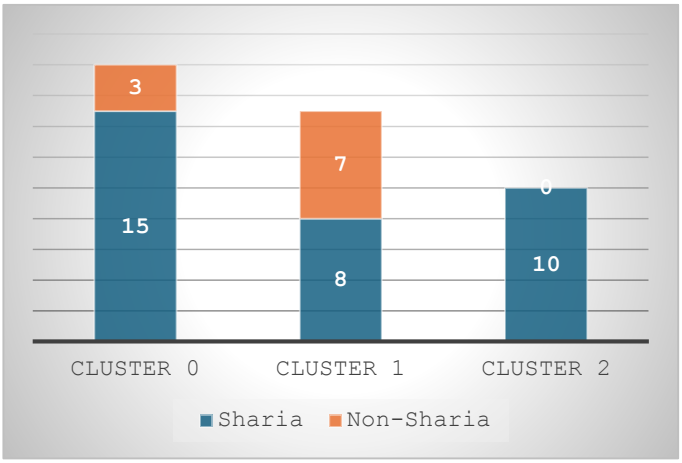
The return and volatility values initially reported for Cluster 0 in the heatmap (approximately 1.64×10^{16} and 4.84×10^{15}, respectively) were artifacts of a data-cleaning error, in which decimal points were inadvertently stripped from numeric strings while removing Indonesian-style thousands separators, corrupting the underlying figures by several orders of magnitude when applied to Yahoo Finance's English-format decimal notation. The return and volatility data have been recalculated directly from raw price series, bypassing this faulty parsing step. The corrected cluster averages, computed over a consistent 90-day observation window, are as follows: Cluster 0 records a return of 35.00%, a volatility of 2.97%, and an ESG score of 33.86; Cluster 1 records a return of 0.79%, a volatility of 2.23%, and an ESG score of 19.22; and Cluster 2 records a return of 9.88%, a volatility of 2.42%, and an ESG score of 28.72. With these corrected values, the heatmap (**Figure 3**) and the radar chart are consistent: Cluster 0 exhibits the highest average return among the three clusters, with volatility only modestly elevated relative to Clusters 1 and 2, and a relatively high ESG score, indicating a favorable risk-adjusted return profile rather than an anomalous extreme value.

Cluster 1 has a significantly negative return (-4.23x10^15), high volatility (5.9x10^15), and a low ESG score (19.22). These results are consistent with those produced by the radar chart in Figure 3. The negative return indicates significant losses, which, when combined with low ESG scores, serve as a strong signal to investors that this cluster is unattractive both ethically and financially (Abdullah & Rao, 2022). Next, Cluster 2 recorded positive returns (approximately 7.23x1015), the highest volatility (approximately 3.94x1016), and a medium ESG score (28.72). These results are also relatively consistent with those produced by the radar chart in **Figure 3**. This extreme volatility indicates that, despite the potential for significant gains, this cluster is highly vulnerable to large fluctuations over a short period. For investors, this means that although profits are high, the risk of sudden losses is also high. Therefore, portfolio diversification strategies, the use of hedging instruments, or the determination of loss limits (stop-loss) are necessary (Fisher, 1975; Gunawan & Owen, 2025).

After discussing the interaction between variables in each cluster, the next visualisation is shown in **Figure 4** as a Stacked Bar Chart. This visualisation will show the distribution of Sharia-compliant and non-Sharia-compliant stocks within each cluster. In Cluster 0, Sharia-compliant (ISSI-indexed) stocks account for a clear majority: 15 of the 18 stocks (83.3%), compared with 3 non-Sharia, LQ45-only stocks (16.7%). This indicates that the characteristics of the variables forming this cluster tend to align with Sharia investment principles, consistent with ESG- and ethics-based portfolio selection theory (Archer, 2022; Armstrong, 2020). The findings of this study reinforce prior literature indicating that Sharia stocks often have a more controlled risk profile, making them more resilient amid market volatility. Stocks in this portfolio are naturally more attractive to value- and sustainability-oriented investors seeking investment stability.

In Cluster 1, the distribution of Sharia and non-Sharia stocks is balanced, with Sharia stocks slightly outnumbering non-Sharia stocks. This balance indicates that clustering factors

such as volatility, liquidity, and historical performance are not significantly influenced by Sharia status. As stated in the literature on the neutrality of clustering variables towards external classification attributes (Fodor et al., 2021). This finding can also be interpreted as an opportunity for portfolio diversification that combines Sharia and conventional principles without being dominated by either category (Chaudhry et al., 2023).

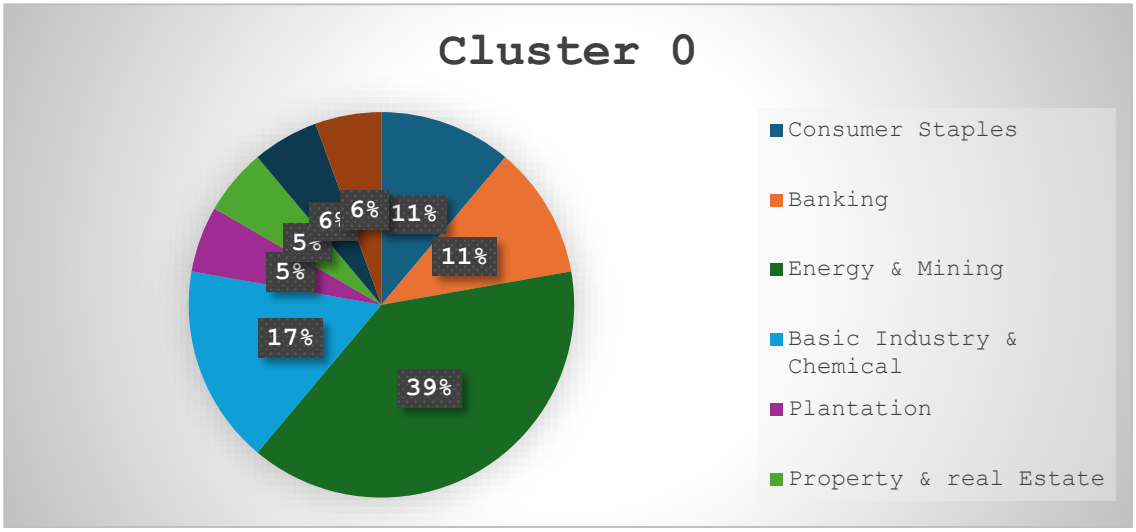


Source: Data Processed (Python, 2025)

Figure 4. Plotly Stacked Bar Chart for Each Cluster

Cluster 2 consists entirely of Sharia stocks. This indicates the formation of a group of stocks with high homogeneity in fundamental and technical characteristics that meet Sharia criteria exclusively. This phenomenon aligns with previous research showing that Sharia stocks tend to have lower risk profiles, good governance (Khan, 2019; Siddhartha, 2024), and strong ESG implementation. However, Cluster 2 may carry higher risks than Cluster 0, especially if this homogeneity makes it less sectorally diversified or more vulnerable to shocks in the dominant sector. Therefore, although consistency in ESG principles is quite strong, regulators need to consider the potential for risk concentration when mapping sectors or types of companies that meet Sharia compliance standards. These findings are essential for regulators to map sectors or types of companies that demonstrate high compliance with ethical and sustainability standards. For investors, it is essential to identify investment opportunities that align with their value preferences while maintaining a long-term risk-mitigation strategy.

After understanding the clustering of Sharia and non-Sharia stocks and their distribution through various visualizations, this discussion will focus on analyzing the sectoral profile of each cluster. This analysis aims to identify the sectors that dominate each cluster. At the same time, it will examine how the dominance of Sharia and non-Sharia stocks interacts with their sectoral characteristics. Previous research has also indicated that the industrial sector significantly influences the risk profile, volatility, and long-term performance of stocks (D. Liu et al., 2023; Liu et al., 2024). In the context of this study, clusters will be formed based on the risk characteristics, volatility, and stock performance brought by each sector. **Figure 5** below shows the stock sectors that make up Cluster 0.



Source: Data Processed (2025)

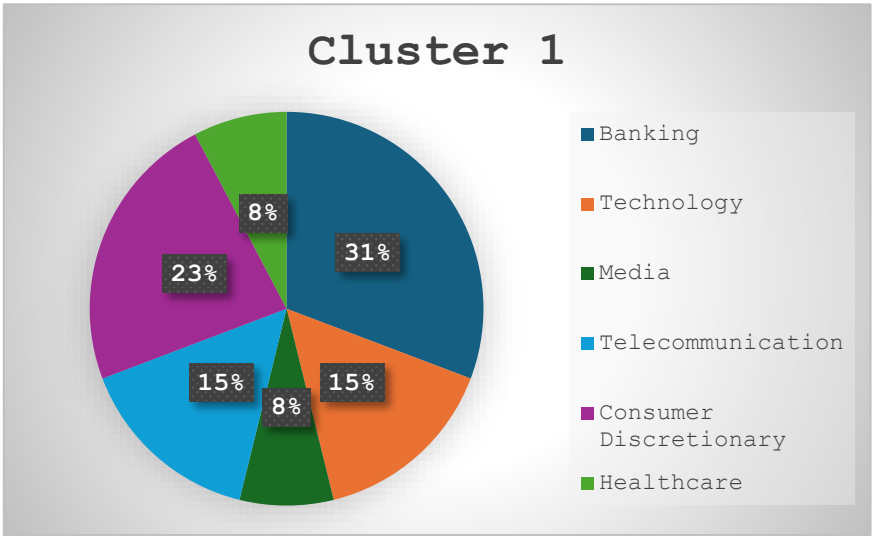
Figure 5. Sectoral Profile for Cluster 0

Figure 5 shows that the energy and mining sector dominates clusters 0-39%, comprising seven issuers: AVIA, BRMS, ELSA, ENRG, ESSA, INDY, and NCKL. The Basic Industries and Chemicals sector follows this at 17%, comprising 3 (three) issuers: GJTL, INTP, and TKIM. In third place is the banking and finance sector with a 11% share, consisting of 2 (two) issuers, namely ARTO and BBTN, as well as the primary consumption sector with the same share (11%), consisting of 2 (two) issuers, namely AMRT and MIDI. **Figure 5** shows that the energy and mining sector dominates Cluster 0 at 39%, comprising seven issuers: AVIA, BRMS, ELSA, ENRG, ESSA, INDY, and NCKL. This sectoral concentration directly explains the elevated volatility observed for Cluster 0 in the Heatmap (**Figure 3**): because energy and mining issuers derive revenue largely from globally traded commodities, their share price volatility is closely linked to the commodity-price and exchange-rate channels documented by the Kahn et al. (2022), IMF (2022a) and Bank Indonesia (2024), rather than to firm-specific factors alone.

Based on the radar chart results, the clustering data indicate that stocks in Cluster 0 have relatively low volatility. The stability of major commodity prices may influence this during the observation period, as may the presence of long-term contracts that reduce sensitivity to daily global price fluctuations (IMF, 2022a). However, based on the heatmap results, this cluster has high volatility with the potential for high returns. The energy and mining sectors, which are synonymous with high volatility, are heavily influenced by global commodity prices, particularly those of coal, oil, and nickel, which are highly volatile. Moreover, global commodity fluctuations are also influenced by global geopolitical pressures (Kahn et al., 2022), policies of major powers (Boug et al., 2023), and ESG-based regulatory pressures that affect access to financing and market demand (Z. Chen & Xie, 2022). In Indonesia, rising commodity prices can indeed increase export values and foreign exchange reserves (Bank Indonesia, 2024), but they can also trigger domestic inflation due to higher energy costs. For example, the war in Ukraine, which disrupted energy supplies in Asia and Europe, has increased global energy prices and driven import inflation in developing countries (IMF,

2022a). This phenomenon could prompt Bank Indonesia to raise interest rates to curb inflation and maintain exchange rate stability. This decision also considers the potential for capital outflows due to global interest rate differentials, which, if left unchecked, could exacerbate financial market volatility (L. Chen et al., 2020). However, environmental regulations and the transition to renewable energy introduce new risk dimensions for this sector and cluster. Global energy policies may drive shifts in demand that pose risks for coal commodities in the future. Conversely, they could create opportunities for nickel commodities used in electric vehicle batteries (OECD, 2025).

Thus, investors may view this cluster as a diversification opportunity based on tangible assets, including not only the energy and mining sectors but also basic industries, chemicals, and real estate. Historically, these sectors have provided hedging against inflation and exchange rate uncertainty (Dhamara et al., 2024; Fama & Schwert, 1977). However, investment strategies in this sector still require close monitoring of economic cycles, global geopolitical conditions, and changing market liquidity conditions due to monetary policy or sector regulations (Banna et al., 2023; Choudhury, 2025). Furthermore, the sectoral profile for Cluster 1 is shown in **Figure 6**.



Source: Data Processed (2025)

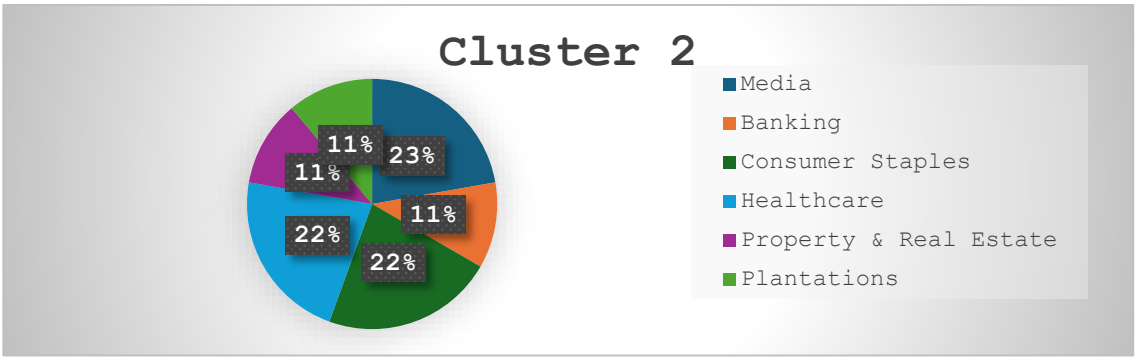
Figure 6. Sectoral Profile for Cluster 1

In Cluster 1, the Banking sector leads with a 31% share, consisting of four conventional bank issuers: BBCA, BBNI, BBRI, and BMRI. This is followed by the Secondary Consumption sector with a 23% share, comprising three issuers: AUTO, ERAA, and MPMX. In third place is the technology and telecommunications sector, each with 15%, comprising two issuers each: GOTO and EMTK (technology) and TOWR and MTEL (telecommunications). The May to July 2025 window does not correspond to a publicly documented systemic banking crisis in Indonesia. The negative returns observed among conventional banking issuers (BBCA, BBNI, BBRI, and BMRI) in this window reflect cyclical margin pressure consistent with tighter global interest-rate differentials and cautious domestic credit growth, in line with Bank Indonesia's

(2024a) monetary stance during this period. A 90-day window is too short to distinguish a structural value trap from a temporary cyclical dip, and this is flagged as a limitation requiring longer-horizon replication.

Stocks in this cluster indeed have relatively low volatility, but this does not necessarily indicate a positive trend, as negative returns accompany it. In sectoral risk analysis, this phenomenon suggests a phase of stagnation or secular decline (Fama, 1970). Low volatility in this cluster is not always a good sign, but it may reflect a market consensus that has formed a negative outlook on the sector's prospects. As a result, prices may move across sectors within a declining trend (Fama & French, 1993; Prol & Kim, 2022). In the banking sector, this situation can occur when credit growth slows, interest margins are under pressure, and credit risk increases. This can even occur without major shocks triggering volatility (Naili & Lahrichi, 2022). After all, the banking sector is susceptible to various macroeconomic indicators, as these can affect net interest margins, asset quality, and even credit demand (Boungou & Urom, 2025; Tolabi, 2021).

Meanwhile, in the technology sector, a similar phenomenon emerges: valuations are significantly corrected due to market disappointment, then move sideways due to a lack of positive catalysts (Kelly et al., 2016; Sarel, 2016). This condition certainly requires vigilance regarding the potential for drawdowns, even though price movements are relatively stable (Baker et al., 2016; Kelly et al., 2016). Next, the sectoral profile of Cluster 2 will be shown in **Figure 7**.



Source: Data Processed (2025)

Figure 7. Sectoral Profile for Cluster 2

In Cluster 2, there are three dominant sectors, namely Media (23%), consisting of BMTR and MNCN; Health (22%), consisting of HEAL and MIKA; and Consumer Staples (22%), consisting of CMRY and MYOR. All stocks in this Cluster are Sharia-compliant stocks with high ESG ratings, varying returns, and relatively high volatility. Media, Healthcare, and Consumer Staples co-cluster in Cluster 2 primarily due to shared Sharia-screening and ESG characteristics rather than similar financial profiles. These sectors share exclusion from Sharia-prohibited activities, such as conventional interest-based finance, gambling, and non-halal products, which structurally link them within the ISSI universe, and they share comparatively strong governance and disclosure practices that support high ESG scores (Câmara, 2022; Khan, 2019). Their financial profiles are not homogeneous, however, as reflected in this cluster's relatively

high volatility: Media stocks face digital-disruption risk, healthcare faces regulatory and demand-cycle risk, and consumer staples face purchasing-power sensitivity, so the co-clustering is best explained by shared ethical and ESG screening criteria rather than shared financial risk drivers.

The diversification of stock sectors in this Cluster creates its stability. However, a significant proportion of the Media sector may pose structural risks due to digital disruption or changes in consumption patterns (Kumar & Vishnoi, 2018). The high ESG scores in this Cluster reflect the sectors' relatively environmentally friendly and sectors'bility-oriented exposure. However, this does not automatically reduce market risk, given the relatively high volatility in this cluster. This condition may be caused by sentiment and relatively rapid changes in consumer patterns (Elamer & Boulhaga, 2024; Zheng et al., 2025). Additionally, macroeconomic factors such as inflation, purchasing power, and geopolitical uncertainty can amplify the potential for price fluctuations in stocks within this cluster. In the context of sectoral risk analysis, the profile of this cluster shows that although there are defensive sectors, such as consumer staples that provide stability, significant exposure to media and other cyclical sectors still requires an active and effective hedging strategy.

CONCLUSION AND RECOMMENDATION

The analysis identified three main clusters of the Indonesian stock market, specifically Islamic stocks, compared to the top-tier LQ45 stocks, based on their sustainability characteristics (ESG) and financial performance. Sharia-compliant stocks constitute 100% of Cluster 2 (10 of 10 stocks) and 83.3% of Cluster 0 (15 of 18 stocks); together, 33 of the 43 stocks in the full sample (76.7%) are Sharia-compliant, supporting the claim that Islamic stocks dominate the leading portfolio. Cluster 0, dominated by the energy and mining sectors, tends to have relatively good sustainability performance, moderate returns, and low volatility. However, this sector is highly vulnerable to global commodity price fluctuations, export-import policies, and geopolitical tensions. Cluster 1, dominated by conventional banking, tends to have low sustainability performance, negative returns, and low volatility. This indicates a potential value trap amidst a credit slowdown, margin pressure, and a lack of growth catalysts. Cluster 2, dominated by the media, healthcare, and consumer staples sectors, boasts high diversification, strong ESG performance, and high returns, but remains volatile due to digital disruption and pressures on consumer purchasing power.

Based on cluster mapping and sectoral analysis, Islamic stocks dominate the leading portfolio, both in terms of number and sector distribution. The ESG characteristics of Islamic stocks are generally comparable to, and often outperform, those of conventional stocks. This aligns with Sharia principles, which limit involvement in sectors and activities with low sustainability risks. Meanwhile, from a financial performance perspective, Sharia stocks not only match conventional stocks but also offer stability and a more balanced risk-return profile, making them a worthy consideration as a key component of a sustainable investment strategy in the Indonesian capital market.

From a regulatory perspective, the findings indicate that OJK (Financial Services Authority), as Indonesia's capital market regulator, should strengthen its sectoral early warning system by incorporating market microstructure-based indicators to monitor volatility, intersectoral correlations, and liquidity dynamics, in coordination with Bank Indonesia on matters affecting monetary and macroprudential stability more broadly. The use of machine learning can support the early identification of high-risk stock clusters that appear stable but potentially reflect value traps. The results also support OJK's application of sector-specific macroprudential policies, particularly countercyclical capital buffers for commodity-sensitive sectors such as energy and mining.

From an investor perspective, the findings emphasize the importance of cluster-based portfolio strategies. Exposure to commodity-driven clusters should be managed through selective allocation and hedging, while stagnant clusters require rigorous fundamental analysis to identify viable investment opportunities. For clusters characterized by high ESG performance but elevated volatility, investors should apply volatility targeting and regular rebalancing. Risk budgeting at the cluster level can further improve portfolio risk control. Finally, ESG should be integrated into investment decision-making as part of a broader risk management framework rather than being treated solely as a screening criterion.

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