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Research Article

Algorithmic Approaches to Unraveling ESGC Impact on Financial Performance Based on the Ethical Investing in the Energy Sector

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Abstract: This study investigates the connection between Environmental, Social, Governance, and Controversies (ESGC) scores and financial performance in the energy sector across 27 countries and 521 firms from 2000 to 2021 through algorithms and machine learning techniques. The research employs advanced machine learning methods such as clustering analysis (k-means, DBSCAN, Hierarchical Clustering, and Affinity Propagation), violin plots, co-occurrence analysis, and regression techniques to examine the effects of sustainable practices on corporate financial outcomes using a dataset with 640 variables. The study highlights sector-specific and geographical differences in the effectiveness of ESGC practices and demonstrates a positive association between high ESGC scores and better financial indicators, such as profitability, earnings quality, liquidity ratios, and leverage. By presenting a strong case for incorporating ESGC scores into investment strategies, policy formulation, and corporate governance, the study suggests that responsible and ethical practices lead to enhanced operational efficiencies and better risk-adjusted returns. The findings, analyzed using machine learning techniques, indicate that companies with strong ESG practices have higher earnings quality and profitability, showing that sustainable practices benefit not only the environment and society but also the financial base line.

Keywords: machine learning; clustering and regression algorithms; environmental, social, governance, and controversies (ESGC) scores; ethical investing; energy sector

Araştırma Makalesi

Enerji Sektöründe Etik Yatırıma Dayalı Finansal Performans Üzerindeki ESGC Etkisini Açığa Çıkarmada Algoritmik Yaklaşımlar

Özet: Bu çalışma, 27 ülkede ve 521 firmada, 2000'den 2021'e kadar enerji sektöründe Çevresel, Sosyal, Yönetişim ve Tartışmalar (ESGC) skorları ile finansal performans arasındaki bağlantıyı algoritmalar ve makine öğrenmesi teknikleri aracılığıyla araştırmaktadır. Çalışmada, kümeleme analizi (k-means, DBSCAN, Hiyerarşik Kümeleme ve Affinity Propagation), keman grafikleri, eşgörü analizi ve regresyon teknikleri gibi gelişmiş makine öğrenmesi yöntemleri kullanılarak, sürdürülebilir uygulamaların kurumsal finansal sonuçlar üzerindeki etkileri 640 değişkenlik bir veri seti üzerinden incelenmektedir. Araştırma, ESGC uygulamalarının etkinliğinde sektöre özgü ve coğrafi farklılıkları vurgulamakta ve yüksek ESGC skorları ile daha iyi finansal göstergeler, örneğin kârlılık, kazanç kalitesi, likidite oranları ve kaldıraç gibi, arasında pozitif bir ilişki olduğunu ortaya koymaktadır. ESGC skorlarının yatırım stratejilerine, politika oluşturmaya ve kurumsal yönetişime entegre edilmesi gerektiği yönünde güçlü bir argüman sunan çalışma, sorumlu ve etik uygulamaların gelişmiş operasyonel verimliliklere ve daha iyi risk uyarlamalı getirilere yol açtığını öne sürmektedir. Bul-

gular, makine öğrenmesi teknikleriyle analiz edilen veriler ışığında, güçlü ESGC uygulamalarına sahip şirketlerin daha yüksek kazanç kalitesi ve kârlılığa sahip olduğunu, sürdürülebilir uygulamaların sadece çevre ve topluma değil, aynı zamanda finansal temele de fayda sağladığını göstermektedir.

Anahtar Kelimeler: makine öğrenmesi; kümeleme ve regresyon algortimaları; çevresel, sosyal, yönetişim ve tartışmalar (ESGC) skorları; etik yatırım; enerji sektörü

1. Introduction

Environmental, Social, Governance, and Controversial (ESGC) scores have become increasingly vital for businesses, particularly energy firms, to demonstrate sustainability and responsibility. These scores, along with sustainability practices and financial metrics, are pivotal for energy companies to gain competitive advantage and stakeholder trust for long-term success.

This study explores the energy sector's critical role in addressing global challenges like energy crises, geopolitical tensions, and pandemics. It emphasizes the complexity of investment decisions in the sector, which must account for wide-ranging environmental, social, governance, and controversial impacts.

The research investigates the influence of ethical investments in the energy sector through ESGC elements. It aims to guide ethical investors in forming sustainable portfolios and understand how global crises influence energy investments. By analyzing ESGC impacts on financial performance, the study offers insights for strategic, sustainable decision-making in the sector.

This analytical endeavor aims to provide a detailed perspective on the energy sector's sustainable trajectory, highlighting the critical role of ethical investments in addressing externalities. It's designed to arm investors, policymakers, and stakeholders with the necessary insights for informed, responsible investment choices amidst global challenges.

The study's core goal is to dissect the interplay between ESGC scores and financial metrics, assessing their influence on financial risks. It will illustrate how ESGC scores can aid ethical investors in crafting resilient, sustainable portfolios, particularly focusing on the financial implications of environmental risks.

Through a detailed comparative analysis, the research will explore temporal changes and risk profiles of companies with varying ESGC scores. It aims to offer profound insights into the effects of ESGC factors on corporate performance and guide strategic, sustainable investment planning.

The study's novelty approach synthesizes a wide array of research on ethical investments, with a special focus on the energy sector. It employs advanced quantitative methods like clustering, violin plots, co-occurrence, and regression analyses to provide a thorough examination of the sector's financial performance over the past two decades, marking its novelty in the realm of sustainable and ethical investment research.

This study critically analyzes the financial performance and earnings quality of energy companies with and without ESGC scores, shedding light on the management of non-systematic risks within the sector. By examining 521 firms across 27 countries with a focus on the energy industry, it provides a nuanced understanding of the interplay between ESGC factors and financial metrics. The investigation's depth, covering a comprehensive temporal and geographical span, allows for a detailed exploration of trends and outliers, offering significant insights for a wide array of stakeholders.

The research goes beyond measuring ESGC's impact on financial performance by examining how these components are woven into the fabric of companies' risk management and sustainability strategies. Offering a fresh and profound perspective on sustainable finance and investment in the energy sector, the study paves the way for future exploration, aiming to guide investors, policymakers, and industry participants in navigating the complexities of ethical and sustainable investment. This meticulous approach ensures that the findings are well-informed, relevant, and actionable, contributing to a more sustainable and ethical future in the energy sector.

The ongoing parts of the study are aimed at comprehensively examining the origins and multifaceted dimensions of ethical investment. Under the title "Origins of Ethical Investment Behavior," the study thoroughly addresses the elements shaping the landscape of ethical investment. These include Impact Investments, Socially Responsible Investments (SRI), ESGC Investing, Sustinabile Investing, Faithful Investing and Culture. A "Systematic Literature Review" provides a rich synthesis of research, bridging historical and contemporary trends while identifying literature gaps. The "Materials and Methods" section outlines the empirical datasets, crucial for the study's depth and reliability.

Key analytical components like "Clustering Analysis" and "Violin Plot and Co-Occurrence Analysis" utilize advanced statistics to uncover patterns and correlations in ethical investment. "Lasso and Ridge Regressions" further the analytical rigor, focusing on predicting ethical investment outcomes. The study culminates in "Conclusion" and "Policy Implications," synthesizing findings to guide policymakers, investors, and scholars, thereby informing ethical investment strategies. This comprehensive approach ensures actionable insights, fostering a future where investments are as ethically informed as they are financially prudent.

1.1. The Origins of Ethical Investing Behavior

Schwartz (2003) [53] characterizes ethical investment as an approach adding specific objectives and restrictions to traditional financial criteria in investment processes. Since the 1990s, there's been a surge in funds adhering to these principles. Ethical investment is noted for its emphasis on social impact, environmental stewardship, and religious adherence, balancing positive impacts against potential negative externalities in sectors like defense, nuclear energy, and substances like tobacco and alcohol.

Ethical investment spans various domains like Impact Investing, SRI, ESGC scores, Sustainable, Faith-Based and Culture Investing. While every investor primarily seeks profit through capital gains and dividends, their strategies and motivations vary. Traditional financial and portfolio theories focus on risk-return trade-offs, often through financial and price analyses. However, for those inclined towards ethical investment, decisions might extend beyond mere financial indicators due to market information asymmetries.

Investors focusing on ESGC aim to align investments with their values, seeking companies with policies compatible with their views on environmental and social responsibilities. They often support renewable and sustainable energy projects, particularly government-backed initiatives within the energy sector. Yet, they remain cautious about the aggressive growth strategies of ethical funds and firms, advocating for a more sustainable, healthy growth path in revenue and profitability.

This study explores both financial and non-financial indicators in the energy sector, analyzing how companies with and without ESGC scores perform across various metrics. It aims to provide a nuanced view of how ethical considerations impact financial performance, guiding investors towards more informed, value-aligned investment strategies.

1.2. Impact Investing

Impact investing, as a branch of ethical investing, aims to achieve both financial returns and positive, measurable social or environmental impacts. It involves investments in various sectors like sustainable agriculture, renewable energy, and accessible services such as housing and healthcare [11]. This approach is redefining pathways to economic growth and social development.

The core elements of impact investing are intentionality, expected returns, diverse asset classes, and impact measurement. Barber et al. (2021) [4] indicate investors may accept lower financial returns (2.5-3.7%) for assets with social impact, though willingness varies among investor types and regions, with some showing a higher propensity to invest in impact-driven assets.

Block et al. (2021) [7] suggest impact investors prioritize the authenticity of founding teams, the importance of the societal problem addressed, and the venture's financial sustainability. Notably, they value social impact criteria over business criteria, aligning with the notion that impact investors might accept lower returns for significant social outcomes.

Saltuk et al. (2010) [52] provide a detailed market analysis, indicating that most investors assess the impact of their investments regularly, with an average expected return for developed market equity investments at 19% IRR and 18% for emerging markets. Despite challenges like limited track records,

the market is growing and evolving, holding promises for investors and social ventures alike. This trend underscores the dynamic nature of impact investing, reflecting a shift towards more socially conscious investment strategies.

1.3. Socially Responsible Investing (SRI)

SRI blends ethical and social accountability into investing, seeking beyond just financial gains to create environmental and societal value. Various research examines SRI's dual impact on financial outcomes and social responsibility. Revelli and Viviani's (2015) [49] extensive meta-analysis of 190 studies finds no significant difference in financial performance between SRI and conventional investments, indicating that SRI neither costs more nor yields extra financial benefits. However, its financial performance may differ based on market dynamics and social ratings used in SRI portfolio construction.

Sparkes (2002) [56] highlights environmental factors as critical in SRI's social responsibility elements, promoting a holistic "people, planet, and profit" (3P) approach due to rising global challenges. Elkington (2018) [18] further advocates for this triple bottom line (TBL) approach, suggesting that success measures extend beyond financials to encompass global welfare and environmental health. Contrarily, Friedman (1970) [25] argued that free-market capitalism enhances social welfare, emphasizing that businesses' primary obligation is to shareholders.

Friedman (1970) [25] 's tenets provide a critical framework for SRI. They suggest that while businesses should primarily focus on profit maximization and shareholder interests, they should also consider social and environmental impacts within the free market's scope. SRI involves careful consideration of government roles, stakeholder relations, and ethical standards, balancing financial health with social and environmental responsibilities. Furthermore, innovation and long-term sustainability are integral to SRI strategies.

Inclusion and sustainability are central to SRI's ethos, addressing broader issues like income and gender inequality. Lydenberg et al. (2018) [40] recognize that institutional investors are increasingly aware of social injustices affecting portfolio returns. As a result, SRI is not only profit-driven but also committed to addressing complex global challenges, thereby guiding investors and policymakers in crafting more holistic and enduring investment strategies.

1.4. ESGC Scores

ESGC scores gauge a company's commitment to environmental, social, governance, and controversial aspects. Increasingly critical for energy firms, these scores assess the balance between operational, societal, and sustainability responsibilities. High ESGC scores are indicative of a firm's dedication to lessening environmental footprints, upholding strong governance, and engaging in social responsibility, thereby contributing to long-term viability. Investors, considering ESGC scores for potential growth, make them essential for energy firms seeking capital.

Kotsantonis et al. (2016) [35] address misconceptions about ESG and sustainable investing, suggesting that these considerations can bolster shareholder value and company performance. Contrary to the belief that ESG data is scarce and unreliable, the study demonstrates that companies with higher ESGC scores achieve operational efficiency and market expansion. Despite myths of reduced returns, firms committed to ESG often find competitive advantages, attracting more sustainable, long-term investors. Moreover, while many investors endorse responsible investment principles, full integration of ESGC into investment decisions remains limited.

Verheyden et al. (2016) [60] explore the impacts of ESG screening on investment returns, risks, and diversification, challenging notions that it limits returns or increases risk. Their findings suggest that ESG-integrated portfolios do not underperform conventional ones and contribute to diversification, underscoring ESG's value beyond ethical implications.

Zehir and Aybars (2020) [64] examine ESG-based portfolio performances, aligning with the Efficient Market Hypothesis that current prices reflect all information. Their study reveals that while top ESG and Governance portfolios don't outperform market excess returns, portfolios with lower ESG scores have shown better performance, attributed to size and value factors. The lack of significant impact on performance from 2004 to 2018 offers insights for future SRI and performance research.

In Figure 1, a word cloud analysis visualizes the components of ESGC scores. This graphical representation highlights the frequency or significance of terms associated with ESGC criteria, with larger and more prominent words indicating greater frequency or importance. The word cloud effectively identifies predominant focus areas, prevalent themes, and the relative weight of various ESGC aspects, offering a quick and intuitive understanding of the key components and priorities in ESGC analysis.

Figure 1. ESGC Scores (with its components) Word Clouds

The concept of ESGC underscores the growing importance of ethical and sustainability approaches in investment strategies. The historical development of ESGC gained momentum particularly in the early 2000s, with the integration of sustainability and corporate social responsibility (CSR) into financial decision-making. While the roots of ESGC can be traced back to CSR debates in the 1970s, pivotal moments include the publication of the "Who Cares Wins" report by the United Nations in 2004 and the establishment of the United Nations Principles for Responsible Investment (UNPRI) in 2006 [59].

Extensive literature has examined the relationship between ESG and financial performance. Friede et al. (2015) [24] conducted a meta-analysis that highlighted the positive long-term financial impact of sustainability practices, demonstrating that ESG factors are not only ethical considerations but also strategic tools enhancing business performance. Similarly, Berk and van Binsbergen (2021) [5] noted that ESG practices positively influence stock performance by improving operational efficiency and reputation, highlighting ESG's value-creating potential for investors.

The historical evolution of ESG shows that environmental factors were initially emphasized, followed by a growing focus on social responsibility and governance. Barber et al. (2021) [4] assessed the impact of ESG factors on investment returns and particularly underscored the role of governance in enhancing investor confidence, which in turn positively affects financial performance.

The importance of environmental and social components should not be overlooked. Fulton et al. (2012) [26] argued that sustainability practices can reduce a firm's financial risks and help maintain financial health. This is particularly relevant for high-risk sectors like energy, where ESGC scores play a critical role. Pedersen et al. (2021) [46] detailed how sustainability strategies in the energy sector provide long-term competitive advantage and mitigate sector-specific risks, positioning ESG as a risk management tool for investors.

1.5 Sustainable Investing

Sustainable investing transcends conventional financial analysis, anchoring in the triad of ESGC factors. It represents a paradigm shift, asserting that long-term profitability and ethical stewardship of

resources are mutually reinforcing. This approach recognizes the interconnectedness of business success, environmental stewardship, and social responsibility.

Fiscal implications of sustainable investing are the subject of robust debate. Traditional perspectives, epitomized by Milton Friedman, suggest corporate focus should be solely on maximizing shareholder wealth, with sustainability as a secondary concern if considered at all. This view posits that diverting resources to sustainability can dilute focus and erode competitive advantage by increasing costs. Conversely, proponents of sustainable investing argue for its centrality in corporate strategy, suggesting that ESG integration is essential for enduring value creation and can lead to strategic advantages, such as innovation, brand enhancement, and operational efficiency [47; 23; 6].

Sustainable investing sits alongside SRI and impact investing within the ethical investing framework. SRI often involves exclusionary tactics, avoiding investment in companies not aligning with certain ethical standards. Impact investing, on the other hand, is about generating positive social or environmental impacts alongside financial returns. Sustainable investing represents a holistic approach, integrating ESG factors into financial analysis to achieve balanced, sustainable outcomes.

Empirical research explores the synergy between sustainability and financial performance. Studies by Khan et al. (2016) [34] have shown that companies with strong sustainability practices outperform their less sustainable counterparts in the stock market, suggesting that material ESG considerations are crucial to shareholder value. Rodriguez-Fernandez (2016) [50] supports this, demonstrating that good corporate governance and social responsibility can enhance financial performance and align with Global Reporting Inıtiatives (GRI) guidelines.

This evolution reflects a growing recognition that sustainable practices are not just ancillary but central to long-term corporate success and shareholder value. As empirical evidence mounts, sustainable investing is increasingly seen as both a prudent and forward-thinking approach, offering a compelling model for future investment strategies that harmonize ethical imperatives with financial returns.

1.6. Faith Based Investing

Faith-based investing is a unique subset of ethical investing, where religious beliefs guide financial decisions, aiming for positive social impacts while seeking financial returns [44]. Despite its value alignment and risk management benefits, challenges include limited sector exposure and the complexity of adhering to strict ethical and religious criteria, which may affect returns and diversification [2].

Religious beliefs significantly shape financial behaviors, influencing risk aversion, ethical corporate governance, and a preference for socially responsible norms [57]. This approach is manifested in practices like Islamic finance, which prohibits interest and speculative trades, and Christian investing, which varies from ethical discretion to active stewardship [30; 48]. While restrictive, faith-based funds have shown resilience and competitive market performance, suggesting that ethical alignment does not preclude financial success [38].

Faith-based investing is increasingly intersecting with broader ethical strategies like ESG and SRI, reflecting a collective shift towards incorporating non-financial factors into investment decisions. It offers a harmonious blend of moral adherence and financial objectives, growing in appeal as investors seek value-driven portfolios. As part of the broader ethical investing movement, it stands as a testament to the feasibility of integrating personal convictions with financial endeavors.

1.7. Culture

Finally, a positive and supportive culture is crucial for energy firms that seek to attract and retain top talent, enhance productivity, and foster innovation. By prioritizing values such as inclusivity, transparency, and ethical behavior, companies can create a culture that enhances their brand reputation and contributes to long-term success. Moreover, a positive culture can lead to increased employee engagement, lower turnover, and better productivity, all of which are critical for energy firms seeking to maintain a competitive advantage [8; 29; 12].

1.8. Key Financial Ratios and Their Relations with ESGC Score

In the financial landscape, key financial ratios serve as vital indicators for evaluating an energy company's financial health, stability, and growth potential. Ratios like return on investment,

debt-to-equity, and current ratio inform investors about a company's operational efficiency, leverage, and liquidity, thereby shaping investment decisions crucial for the sector's volatile and regulated environment.

Earnings Quality Scores (EQS) and its components (see Figure 2) and ESGC scores are pivotal in assessing a company's sustainability and ethical operations. High ESGC scores typically indicate robust practices in environmental, social, and governance aspects, which can lead to sustainable risk management and operational efficiency, positively impacting earnings quality and profitability. Sustainable practices, good governance, and social responsibility are not just ethical choices but strategic ones too, often leading to cost reductions, improved brand value, and customer loyalty.

Controversies in ESGC matters, such as environmental incidents or ethical breaches, can significantly tarnish a company's reputation, leading to decreased sales, stock value, and increased operational costs. These controversies can result in direct financial losses from fines and cleanup costs and indirect losses from operational disruptions, legal challenges, and increased borrowing costs. The long-term sustainability of a company can be jeopardized, affecting its competitive edge and growth potential.

For energy companies, high fixed assets and debt, sensitivity to energy price fluctuations, and environmental and regulatory exposure make the impact of ESGC controversies particularly pronounced. These impacts can manifest across various financial metrics, affecting gross and operational margins, liquidity, leverage, and operational efficiency. For instance, an increase in controversies can inflate operational costs, strain liquidity, increase financing costs, and disrupt asset utilization and revenue streams.

Understanding and integrating financial ratios, ESGC scores, and the implications of ESGC controversies are crucial for energy firms to navigate the complexities of sustainable investment, manage risks effectively, and harness opportunities for long-term growth and stability. These considerations are essential for investors and companies alike to foster a responsible and profitable energy sector.

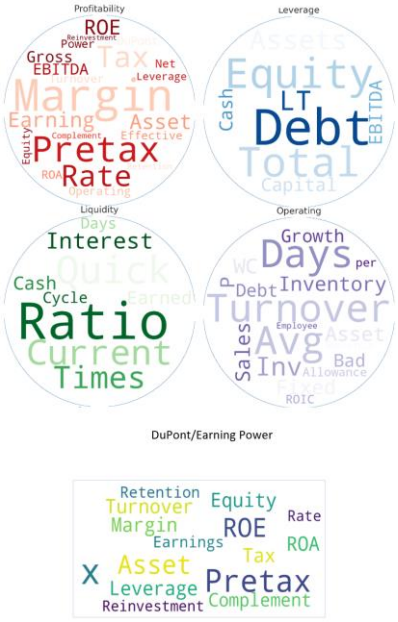


Figure 2. Earning Quality Score Components (Profitability, Leverage, Liquidty, Operating, DuPont/Earning Quality)

Here's how ESGC factors might interact with various EQS and its financial components:

Earnings Quality Score: Governance factors, like board composition, audit committee strength, and transparency, could interact with the earnings quality score. High governance standards might lead to higher earnings quality by ensuring more accurate and reliable financial reporting.

Profitability Margins: Environmental efficiency measures can reduce costs, potentially increasing Gross and EBITDA margins. Social factors, such as labor practices, can affect Operating and Pretax margins by influencing productivity and operational efficiency.

Asset Turnover: Companies with strong ESGC profiles may have better asset management practices, leading to higher asset turnover rates. For instance, environmental considerations can lead to more efficient use of assets to reduce waste.

Liquidity Ratios: Social controversies or governance issues may lead to reduced investor confidence, which could impact liquidity ratios by affecting the company's creditworthiness and market reputation.

Leverage: Environmental risks may affect the cost of capital and insurance premiums, influencing a company's leverage. Companies with better ESGC performance might have access to 'green financing' with more favorable terms.

Operating Metrics: Good governance practices can improve accounts receivable and inventory turnover by enforcing more disciplined and efficient operational processes.

ROIC: Companies that invest in ESGC initiatives might see long-term benefits that improve their ROIC. For example, investing in renewable energy can reduce long-term operational costs.

Revenue per Employee: Social factors, such as employee engagement and training, can increase productivity, potentially leading to higher revenue per employee.

Environmental Pillar Score: A higher score can suggest better management of environmental risks and opportunities, which can influence capital expenditures, operational costs, and compliance costs.

Social Pillar Score: This can interact with labor costs, turnover rates, and productivity, all of which are important components of financial performance.

Governance Pillar Score: Strong corporate governance can lower the risk of financial misstatements, fraud, and the associated costs of capital, which can have a direct impact on financial indicators like return on equity and overall market valuation.

2. Systematic Literature Review

The aim of the systematic literature review (Table 1) is to critically analyze and synthesize a diverse array of scholarly works that delve into the interplay between ESGC and corporate financial performance within the energy sector. The following table encapsulates a concise summary of the selected studies, outlining their scope, objectives, methodologies, key findings, and practical implications. This structured approach allows for a comprehensive understanding of the prevailing academic discourse, trends, challenges, and opportunities in aligning ethical investment strategies with financial outcomes. Through this review, the study endeavor to distill the nuanced complexities and glean insights that inform and advance the practice of sustainable and responsible investing.

Table 1. *Systematic Literature Review for Ethical Investing and Financial Metrics*

Authors & Year	Scope	Objectives	Methodology & Data	Main Findings	Impact on Practice
Barber, et al. 2021 [4]	Analysis of venture capital impact funds and their performance compared to traditional funds.	Assessing the trade-off between financial returns and social/environmental impacts in impact investing.	Empirical analysis using Preqin data, covering 24,000 VC and growth equity investments from 1995 to 2014. Discrete choice models for investor willingness.	Impact funds exhibit lower financial returns (IRR) than traditional funds. Certain investors are willing to accept lower returns for social/environmental benefits.	Shift in investment preferences towards social responsibility and sustainable investing, impacting investor behavior and fund management strategies.
Agrawal, and	A systematic review of	The objective is to under-	The review involved an	The study reveals the unique char-	Emphasizes the necessity

Hockerts, 2021 [1]	impact investing, critically analyzing the field's evolution and current status.	stand the terminological and definitional boundaries of impact investing, its current scope of scholarship, and future research possibilities.	analysis of 85 published articles and reports, using Harzing's publish or perish academic search engine and cross-checkin g with JSTOR and Web of Science.	acteristics of impact investing, the exploratory nature of most scholarship in the field, and a recent shift towards confirmatory studies. It also highlights the need for deeper exploration of concepts like the selection process, stakeholder management, and performance reporting.	for a more robust empirical foundation in impact investing research to guide practice, suggesting a move towards applied knowledge generation.
Berk and Binsbergen, 2021 [5]	Examines the effectiveness of divestiture strategies in impact investing, particularly focusing on their influence on the cost of capital and real investment decisions.	To evaluate the actual impact of divestiture strategies on cost of capital and whether they can meaningfully influence investment strategies of firms.	Theoretical modeling combined with empirical analysis using data on market capitalization, index fund holdings, and ESG classifications. The study assesses the cost of capital changes in relation to ESG investing activities.	The impact of ESG divestiture strategies on cost of capital is minimal, suggesting limited effectiveness in affecting corporate investment strategies.	Challenges the effectiveness of divestiture as a tool for impact investing, indicating the need for alternative strategies to achieve social and environmental goals.
de Jong and Rocco, 2022 [14]	A critical overview of ESG and impact investing, exploring their distinctions and intersections.	To clarify the differences between ESG and impact investing, addressing potential confusion in the investment community.	The authors conduct a literature review and analysis of various ESG and impact investing principles and practices.	The paper distinguishes between ESG investing and impact investing, emphasizing their unique features and the importance of clear definitions.	Highlights the need for investors and practitioners to accurately understand and differentiate between ESG and impact investing to make informed decisions.
Landier and Lovo, 2020 [37]	The study examines Socially Responsible	To explore the effectiveness of SRFs in balancing fi-	Theoretical modeling and empirical analysis of	The study suggests that SRFs can achieve positive social im-	Highlights the complexities of SRFs in impact invest-

	Funds (SRFs) and their potential to improve social welfare while maximizing assets under management.	nancial performance and social impact, particularly in terms of managing emissions.	SRF investment strategies, using general equilibrium models to understand the interplay between financial performance and social impact.	pacts, especially through strategies that influence supply chains, but their effectiveness varies based on investor types and market conditions.	ing, suggesting the need for nuanced investment strategies to balance financial returns and social impact effectively.
Erol, Unal and Coskun, 2023 [19]	This study investigates the empirical link between the social and financial performance of Real Estate Investment Trusts (REITs) using ESG metrics.	To explore the association between corporate social responsibility and market valuation of REITs.	Utilizes the PVAR-Granger causality model and fixed-effects panel data model, analyzing 234 ESG-rated REITs across five developed economies from 2003 to 2019.	Reveals that ESG investing components are priced differently by investors. Environmental and Social investing practices significantly impact REITs' financial performance, with a positive premium for S-investing.	Suggests that socially responsible investments can lead to higher returns and lower systematic risk, providing a competitive advantage for REITs.
Friede, et al. 2015 [24]	Comprehensive analysis of the relationship between Environmental, Social, and Governance (ESG) criteria and corporate financial performance (CFP).	To synthesize and generalize findings from over 2000 empirical studies to understand the financial effects of ESG criteria.	A second-order meta-analysis that aggregates findings from both vote-count studies and econometric review studies, encompassing over 2200 individual studies.	Approximately 90% of the studies find a nonnegative ESG-CFP relation, with a large majority reporting positive finding. The positive ESG impact on CFP appears stable over time.	Reinforces the business case for ESG investing, demonstrating its financial benefits and stability over time.
Fulton et al. 2012 [26]	The study examines sustainable investing, focusing on the evolution and integration of Environmental, Social, and Governance (ESG) factors	To explore how sustainable investing, particularly using ESG factors, affects long-term value creation and financial performance.	The study conducts a comprehensive analysis of academic research, reports, and meta-studies to evaluate the impact of sustainable investing on	The research identifies a positive correlation between sustainable investing and enhanced financial performance, demonstrating the value of integrating ESG factors in investment strategies.	Emphasizes the significance of ESG factors in investment decisions, suggesting that sustainable investing can lead to long-term value creation and

	in investment decisions.		financial performance.		improved financial performance.
Weston and Nnadi, 2023 [61]	This study investigates the impact of corporate sustainability and ESG policies on corporate finance performance.	To establish a link between Corporate Social Responsibility (CSR) and Corporate Financial Performance (CFP), and to explore how strategic management frameworks incorporating CSR and ESG principles influence investment decisions.	Analysis of iShares MSCI KLD 400 Social exchange-traded fund (ETF), iShares Core S&P 500 ETF, and firms following the Principles for Responsible Investing (PRI).	The study found no evidence that ethical ETFs outperform conventional ETFs, but PRI-following firms outperform those that do not follow the guidelines.	Suggests that ethical investment strategies and adherence to PRI guidelines can enhance corporate financial performance, informing strategic decision-making in corporate finance.
Pedersen et al. 2021 [46]	This study explores the concept of an ESG-efficient frontier in portfolio choice, integrating environmental, social, and governance (ESG) considerations.	To develop a framework that enables investors to choose portfolios based on both financial metrics and ESG scores.	Utilizes a theoretical model combined with empirical analysis, considering various ESG metrics and their impact on portfolio choice and asset pricing.	The study introduces the ESG-efficient frontier, a tool for investors to balance ESG preferences with financial returns and examines how ESG considerations can influence asset pricing.	Provides a practical approach for investors to incorporate ESG considerations into portfolio selection, contributing to the growing field of responsible investing.
Chen and Xie, 2022 [9]	The study explores the effect of ESG disclosure on corporate financial performance and the moderating role of ESG investors.	To examine how ESG disclosure impacts financial performance and to understand the influence of ESG investors in this relationship.	Uses a sample of non-financial listed companies from 2000 to 2020, applying the staggered difference-in-differences technique.	ESG disclosure positively impacts financial performance, and this effect is more pronounced in companies with ESG investors.	Highlights the importance of ESG disclosure in improving financial performance and suggests that ESG investors can play a vital role in this process.
Liu et al. 2022 [39]	The study explores the relationship between ESG disclosure	To analyze how different configurations of ESG pillars impact CFP	Longitudinal fsQCA of listed new energy companies in	Two configurations lead to high CFP, and four lead to low CFP. The social pillar is	Guides new energy companies in strengthening CSR practices

	and corporate financial performance (CFP), emphasizing the complexity and the differential impact of various ESG pillar combinations on CFP.	using the longitudinal fuzzy set qualitative comparative analysis (fsQCA) approach, focusing on listed new energy companies in China.	China from 2016 to 2020, identifying configurations that generate high and low CFP.	critical for high CFP outcomes, with consistent configuration over time.	and expands fsQCA application in longitudinal datasets.
Landi and Sciarelli, 2016 [36]	Examines the impact of Corporate Ethics Assessment on Financial Performance, particularly focusing on the influence of ESG ratings on the financial performance of Italian firms listed on the FTSE MIB Index.	To explore the relationship between socially responsible investment behaviors and market returns, particularly examining the statistical relationship between yearly ESG assessments and abnormal returns of companies.	Panel data analysis using a Fixed Effects Model, measuring abnormal returns via the Fama–French approach and yearly Jensen's Performance Index for each company.	Empirical results indicate a growing interest in CSR and sustainability by managers, but no significant positive impact of socially responsible investments in terms of market premium.	The study suggests that ethics is not yet a reliable fundraising tool for Italian-listed companies despite the growth rate of socially responsible investments.
Escrig-Olmedo, et al. 2010 [20]	Analyzes the evaluation criteria and methodologies used by sustainability indices and ESG rating and information provider agencies.	To define the standard evaluation criteria and methodologies of these organizations and their influence on SRI.	The study examined six sustainability indices and ten ESG agencies, focusing on their criteria for company evaluation, using both public information and questionnaires.	Identified the diversity and lack of standardization in the methods used by ESG agencies and sustainability indices, impacting their evaluations of CSR performance.	Highlights the need for more standardized and transparent criteria in SRI, influencing both companies and investors in the sector.

The current literature offers insights into how ESGC practices vary across different regions, highlighting both the similarities and divergences in approaches. For example, Landier and Lovo (2020) [37] emphasize the complexities involved in managing Socially Responsible Funds (SRFs) in

different market conditions, which suggests that the effectiveness of ESGC practices may depend significantly on regional factors like investor behavior, regulatory frameworks, and economic stability. Further expanding on these regional nuances would clarify how geographic contexts shape the application and success of ESGC strategies.

The reviewed studies suggest several actionable strategies that companies, particularly those in sectors like energy, can adopt to enhance their ESGC scores. For instance, Pedersen et al. (2021) [46] and Fulton et al. (2012) [26] highlight the importance of integrating sustainability strategies to minimize risks and improve long-term competitiveness. Expanding on such practical approaches and providing concrete examples of how firms could implement these strategies would make the discussion more relevant to practitioners.

3. Materials and Methods

3.1. Data

The data encompasses 27 countries and includes 640 variables related to ESGC and Financial ratios for 521 firms operating in the energy sector across these countries, covering the years 2000-2021 (see Table 2 and Table 3). The data for each company is collected from Thomson Reuters Refinitive Eikon.

The inclusion of 27 countries across continents ensures a comprehensive analysis that reflects different regulatory environments, market maturities, and cultural attitudes towards environmental and social issues. This diversity is crucial for understanding the universal applicability of ESGC principles and the variability in financial performance. The countries selected are significant players in the global energy sector, representing a range of energy markets and policies. This variety provides a rich dataset for understanding how different energy sectors respond to ESGC criteria. These firms have been chosen due to the availability of reliable and extensive data on firms' ESGC practices and financial performance. Consistency and comprehensiveness of data are vital for robust analysis.

Table 2. *Companies by Countries and Continental Over Time*

Continent	Country	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Africa	South Africa	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Asia	Hong Kong	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
	India	8	8	66	66	66	66	66	66	66	66	66	66	66	66	66	66	66	66	66	66	66	66
	Indonesia	5	6	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55
	Japan	7	7	377	377	377	377	377	377	377	377	377	377	377	377	377	377	377	377	377	377	377	377

	Kazakhstan	22	22	115	115	115	115	115	115	115	115	115	115	115	115	115	115	115	115	115	115	115	115	115
	Malaysia	66	66	334	334	334	334	334	334	334	334	334	334	334	334	334	334	334	334	334	334	334	334	334
	Saudi Arabia	11	11	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33	33
	Taiwan	11	11	117	117	117	117	117	117	117	117	117	117	117	117	117	117	117	117	117	117	117	117	117
	Thailand	12	12	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30	30
	Austria	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22
	Denmark	33	33	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55	55
	Finland	11	11	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22	22
	France	99	99	221	221	221	221	221	221	221	221	221	221	221	221	221	221	221	221	221	221	221	221	221
	Greece	22	22	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44
Europe	Hungary	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11	11
	Italy	87	87	122	122	122	122	122	122	122	122	122	122	122	122	122	122	122	122	122	122	122	122	122
	Netherlands	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44	44
	Poland	55	55	115	115	115	115	115	115	115	115	115	115	115	115	115	115	115	115	115	115	115	115	115

	Portugal	0	0	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18	18
	Roma-nia	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Russia	9	9	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60	60
	Spain	5	5	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
	Turkey	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
North America	Mexico	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
South America	Brazil	8	8	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14	14
	Colom-bia	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2

Table 3. *Continents by Country*

Continent	Included Countries	Total Company Count
Africa	South Africa	1
Asia	Hong Kong, India, Indonesia, Japan, Malaysia, Saudi Arabia, Kazakhstan, Taiwan, Thailand	345
Europe	Austria, Denmark, Finland, France, Greece, Hungary, Italy, Netherlands, Poland, Portugal, Romania, Russia, Spain, Türkiye	158
South America	Brazil, Colombia	16
North America	Mexico	1

The energy sector is pivotal in global economic stability and growth, and it's under increasing scrutiny for its environmental and social impacts. Analyzing this sector provides valuable insights into how energy companies are adapting to ESGC criteria, which is crucial given the industry's significant environmental footprint.

The energy sector offers a unique case for studying the integration of ESGC due to its varying levels of adoption across different types of energy (e.g., oil, gas, renewable energy) and across regions. The period from 2000 to 2021 encompasses various economic cycles, including booms, busts, and periods of stability. This timeframe allows for the examination of how ESGC factors and financial performance interact over different market conditions. Over these two decades, there has been significant development in ESGC awareness, regulation, and strategies. Starting from the early 2000s provides a historical perspective on the evolution and increasing importance of these criteria in corporate governance and investment decision-making.

Due to the large number of companies in the data, the analyses have been conducted over country and continental clusters. For ethical investing, descriptive and inferential statistics related to ESGC scores, which are associated with financial indicators, will be examined based on this grouping for ease of analysis.

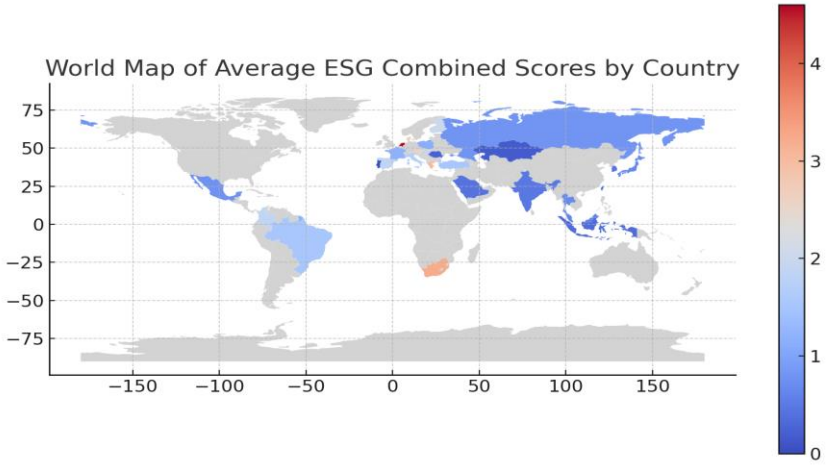


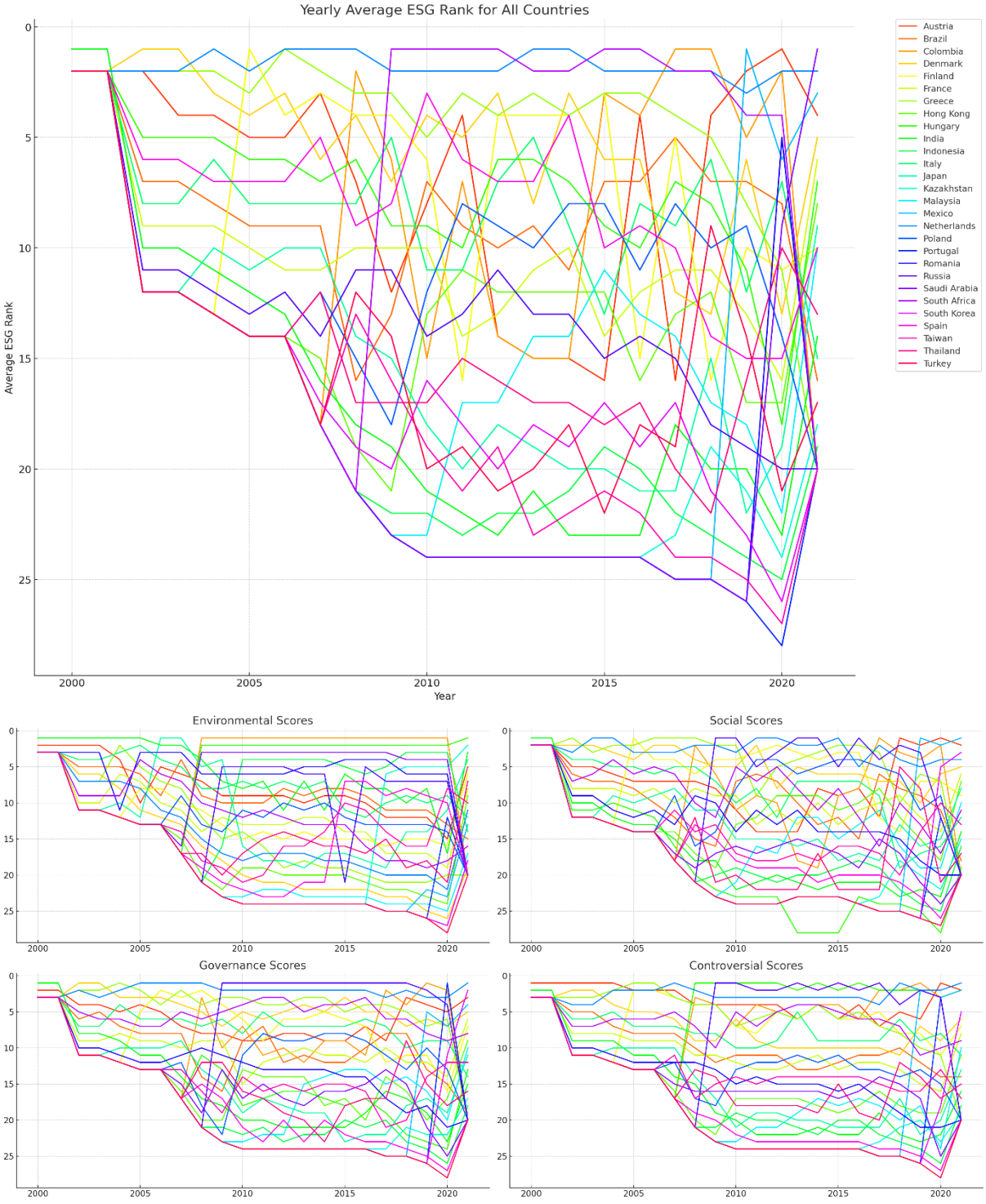
Figure 3. World Map of Average ESG Combined Scores By Country

The ESGC world map (see Figure 3) presents a visual representation of average ESGC scores across different countries. Countries with higher ESGC scores are depicted in darker red shades, suggesting a stronger emphasis on sustainability and governance practices. This trend is more pronounced in regions with developed economies and stringent regulatory frameworks, particularly in Europe and North America. In contrast, lighter shades in other regions, such as parts of Asia, Africa, and South America, indicate lower average ESGC scores. This could be reflective of less stringent sustainability regulations, emerging financial markets, or different prioritization of ESGC factors. The map underscores significant regional differences in ESGC adoption. Higher ESGC scores in Europe and North America might be attributed to robust regulatory environments and a mature investor base that values sustainability. Regions with lower ESGC scores may face challenges in attracting ESGC-focused investments, which could have broader economic implications, especially in the context of global efforts to promote sustainable development.

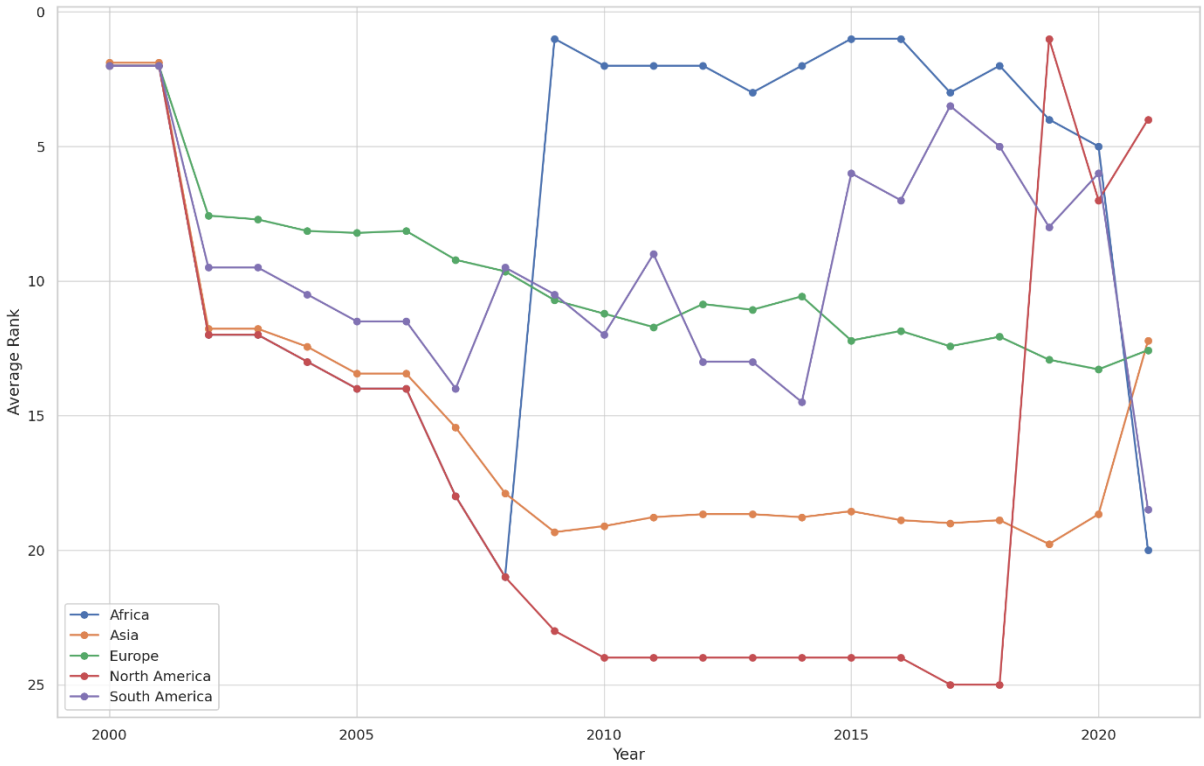
Graph 1 includes firms that initially had zero ESG scores but subsequently began generating such scores, as observed over the years across the 27 countries. For each year, the average values of the ESGC scores and their components for the firms were calculated. This data was used to rank each country annually within the set of 27 countries, and the results are depicted in the graph using parallel pipeline graphics. The aggregated ESGC ranking by country and the positioning of components will provide a crucial starting point for ethical investors. It will offer insightful guidance before conducting financial ratio analysis, illuminating the landscape of ethical investing across these nations.

Graph 1. ESGC (with their components) Rank Changes Over Time by (a) All Countries and (b) Continents

(a)



(b)



In the ranking pipeline, countries are evaluated based on ESGC scores, with rankings reflecting their average scores or the components of the ESGC score for all the firms within them for a given year. These rankings provide insights into a country's progress or consistency in ESGC areas over time. Shifts in rankings may indicate new policies, market changes, or global events, guiding investors and stakeholders in making informed decisions.

Austria, with a leading environmental position and rising trends in social and governance, showcases strong capabilities in managing controversies, marking it suitable for ethical investment. Brazil, despite volatility, indicates potential through upward environmental trends and controversy management. Colombia's notable environmental rise, along with fluctuating but steady controversial approaches, presents a positive investment profile. Denmark, Finland, and France lead in environmental efforts, with consistent or rising trends across all ESGC components, reflecting their ethical investment appeal. Greece and Hungary demonstrate considerable progress, especially in environmental and social governance, marking them as promising candidates.

Hong Kong, India, Saudi Arabia, and Italy show varying degrees of progress and commitment in ESGC areas, each with specific strengths and challenges but generally positive trajectories towards ethical investment. Spain and Malaysia's strengthened policies and consistent controversy management enhance their investment appeal. Poland and Romania, with marked environmental improvements and stable controversy handling, are emerging as considerable options. Kazakhstan and Mexico, despite initial challenges, exhibit growing commitments and gradual improvements, positioning them as consistent ethical investment choices.

Brazil and Indonesia display fluctuating performances but a general trend towards improvement, particularly in environmental commitments and controversy management. Türkiye and Russia show variability and face challenges, indicating the need for careful consideration but also potential for future improvement in ethical investment standings.

3.2. Clustering Analysis

Country profiles based on ESGC components have been thoroughly analyzed using rank pipeline graphics and advanced machine learning techniques, enhancing ethical investment guidance. This approach has combined annual financial performance metrics and ESGC scores, with a focus on the energy sector, allowing investors to track signals from firms' ESGC dimensions and assess financially quantifiable metrics. This facilitates the identification of outstanding characteristics for strategic investment decisions.

Key methods enhancing the analysis include:

K-Means Clustering (Elbow Method): Efficiently identifies natural groupings within countries based on ESGC scores and determines the optimal number of clusters, increasing clarity and relevance.

DBSCAN Clustering: Effective in identifying outliers and handling arbitrary shaped clusters, providing insights into the distribution and relationship of countries in the ESGC context.

Agglomerative Hierarchical Clustering: Offers a detailed visual snapshot of the clustering process, invaluable for understanding the hierarchical structure and grouping of countries.

Affinity Propagation Clustering: Adapts data to understand complex interrelations and affinities between countries regarding their ESGC profiles.

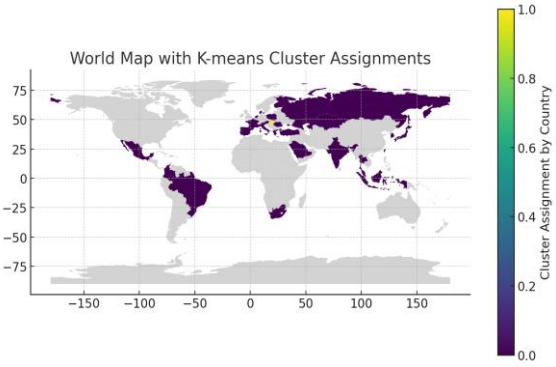
These advanced techniques provide a multifaceted view of countries' standings in ESGC analysis, offering valuable insights for ethical investing strategies. Incorporating ESG scores with financial metrics presents a dynamic landscape, empowering investors with a nuanced understanding of potential risks and opportunities in sustainable and ethical investments.

The K-means algorithm was used to identify natural groups in the dataset based on ESGC scores and financial performance metrics. K-means is effective in classifying observations into groups with similar characteristics, helping to identify differences in ESGC performance [41]. The clusters created based on ESGC scores helped determine whether countries or firms share similar ESGC characteristics, contributing to investment strategy development. Such group analysis is beneficial for identifying firms or countries with potential for improving sustainability performance [33].

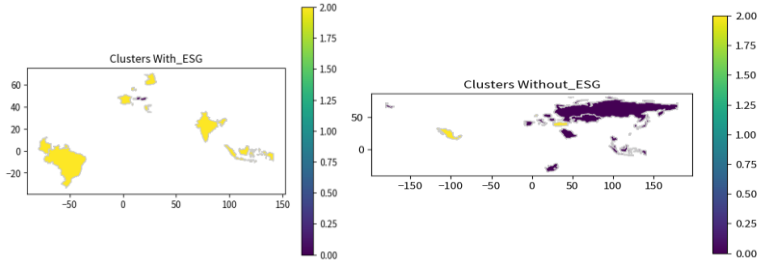
The DBSCAN algorithm was chosen to achieve density-based clustering and detect outliers. This feature is particularly useful for ESGC data, where different cluster shapes may exist [21]. This method helped identify density regions and anomalies in ESGC scores, assisting in determining unexpected trends in sustainability performance. This analysis reveals the potential risks of firms or countries exhibiting abnormal behavior, enabling investors to make more informed decisions [55].

The hierarchical clustering method was used to understand the similarities and differences in ESGC scores at a hierarchical level. This method provides a more detailed classification by presenting the data structure in subgroups [43]. This algorithm visually examines the similarities and differences of countries based on ESGC scores, offering valuable insights into developing sustainability strategies. Hierarchical structures help investors gain a deeper understanding of which countries share similar ESGC profiles [42].

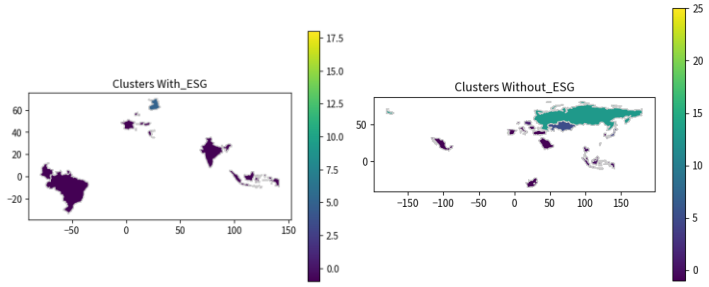
The Affinity Propagation algorithm was used to adapt itself to the data, providing insights into more complex relationships between ESGC profiles. This algorithm identifies exemplars within the data and clusters other points around them, providing valuable insights for ESGC analysis [22]. This method helped identify which countries lead in terms of ESGC and the complex relationships between these leaders and other countries. This analysis is useful for identifying best practices in ESG performance [22].


World Map with K-means Cluster Assignments
Cluster Assignment by Country

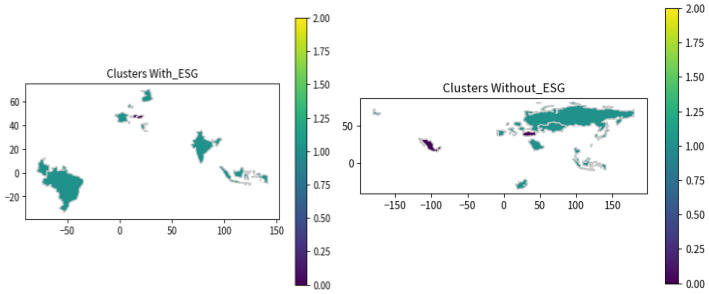
(a)


Clusters With_ESG
Clusters Without_ESG

(b)


Clusters With_ESG
Clusters Without_ESG

(c)


Clusters With_ESG
Clusters Without_ESG

(d)

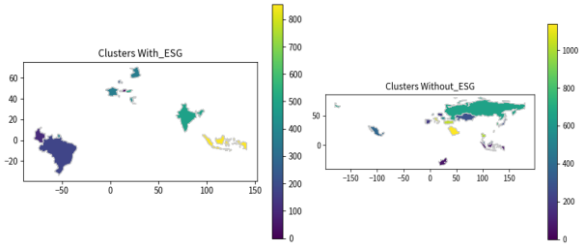


Figure 4. (a) K-Means (Elbow Methods) (b) DBSCAN Clustering (c) Agglomerative Hierarchical (d) Affinity Propogation Clustering For Countries (With and without ESGC Scores)

The clustering analysis in this study divides companies based on the presence or absence of ESG scores, allowing a comparative assessment of countries based on their firms' ESGC profiles. Each country undergoes clustering analysis according to the ESGC scores of its companies, comparing financial ratios and ESGC scores to understand the overall ethical and financial landscape.

All clustering analysis utilizes all dataset columns, grouping countries based on overall similarity across various metrics, including ESGC scores and financial performance. By visualizing these clusters on a world map, it is possible to gain insights into regional patterns and how countries are grouped together based on multidimensional factors like sustainability performance, financial health, and governance quality. This methodological approach aids in identifying trends, potential investment opportunities, and areas for improvement in terms of sustainable and ethical business practices globally (see Figure 4).

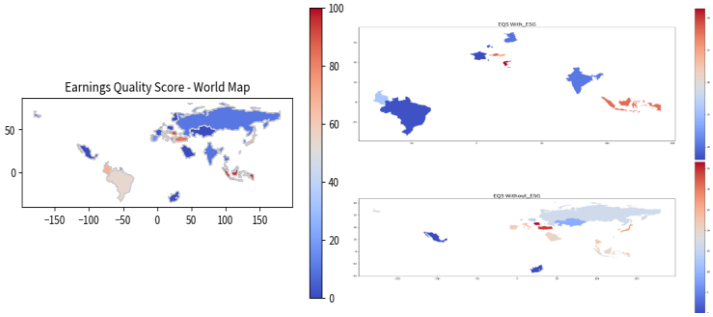


Figure 5. Earnings Quality Scores World Map

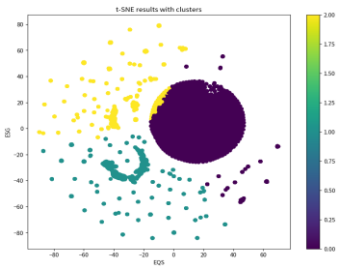


Figure 6. ESGC and Earning Quality Scores with t-SNE Clusters

Clustering analyses in the energy sector distinguish firms by Earning Quality and ESGC scores, offering insights for ethical investing. Initially, firms' annual Earning Quality Scores are compared

across countries and continents, considering the presence or absence of ESGC scores. Using algorithms like K-Means and DBSCAN, firms are grouped by performance, highlighting potential investment targets and risks. Agglomerative Hierarchical clustering provides a visual hierarchy of firm groupings by ESGC engagement, while Affinity Propagation identifies exemplary firms within clusters. This layered approach helps investors discern global patterns of ESGC engagement and align portfolios with ethical standards (see Figure 5 and Figure 6).

High Performers: Firms located in countries like Denmark and Finland stand out with perfect scores across all ESGC metrics, indicating exemplary performance and positioning them as potentially ideal candidates for ethical investment. These firms may be leading in sustainability and social responsibility.

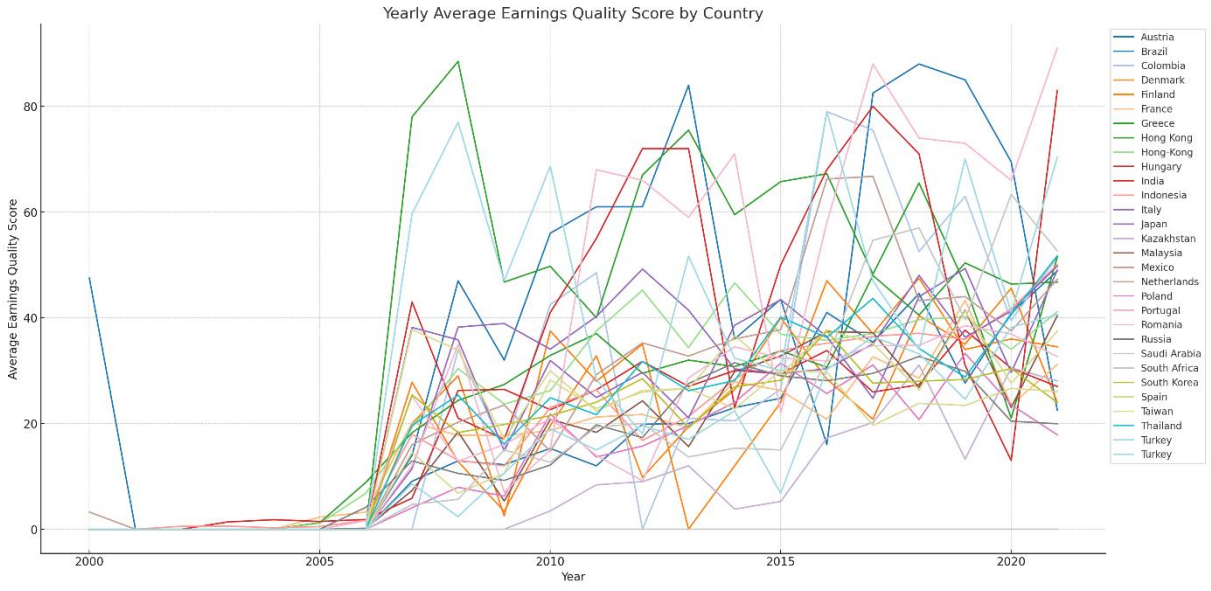
Solid Performers: Firms in Austria, with an overall score of 4.50, and France, with 4.25, are also strong contenders in the ethical investment landscape, showing strength in environmental and controversial issue management.

Steady Performers: Firms in countries such as Colombia, Hungary, India, Saudi Arabia, Italy, Spain, Malaysia, Poland, and Romania all have consistent scores of 4.00 across the board, suggesting a reliable and balanced approach to ESGC factors. These firms may be demonstrating a stable performance in ESG areas.

Improvement Potential: Firms in countries like Brazil, Kazakhstan, Mexico, Indonesia, and Türkiye, each with an overall score of 3.00, may have room for improvement in their ESGC practices but could represent emerging opportunities for investors focusing on progress and development in ESG criteria.

Low Performers: Russian firms, with the lowest score of 2.00, may be considered a high-risk country for ethical investors, reflecting significant challenges across all ESGC aspects. These firms might need serious improvements in ESGC areas.

Graph 2. Yearly Avarage Earnings Quality Score By (a) Country and (b) Continent



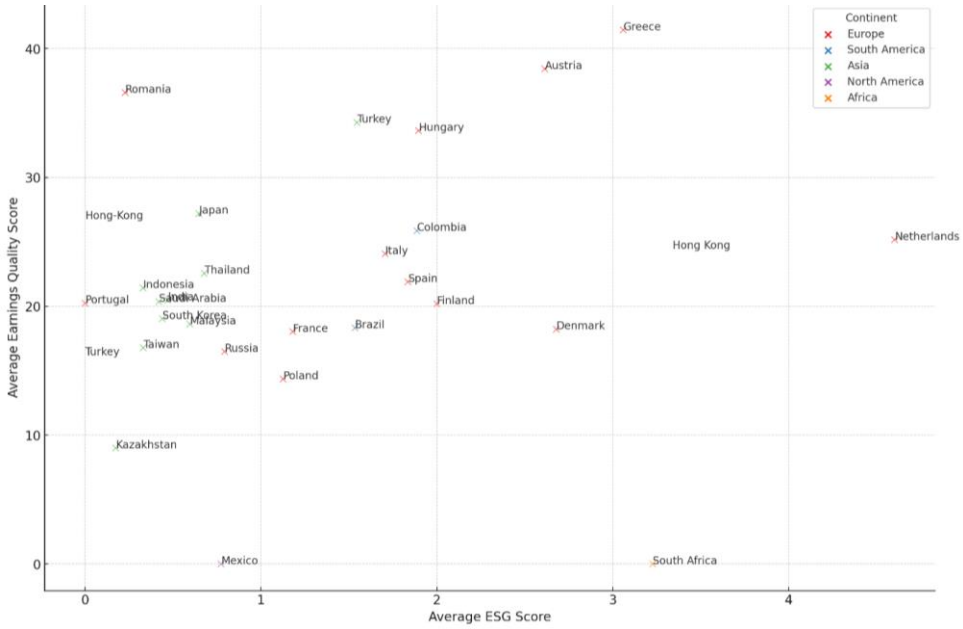
(a)

(b)

The cross-sectional analysis of EQS and ESGC scores over time reveals trends in financial integrity and ESG performance across countries and continents. The classification based on annual averages highlights the progression and regression in these scores, providing a crucial dataset for evaluating firms' financial and ethical standings. This analysis helps investors understand the nuanced relationship between financial reporting and ESG engagement, informing strategies for ethical and sustainable investment across different regions. It underscores the importance of integrating financial health and ESGC practices in investment decisions, reflecting the dynamic global investment landscape (see Graph 2).

The analysis of average EQS across 27 countries showcases a diverse range of financial reporting quality. Greece, Austria, and Romania emerge as leaders with superior financial health and transparency. Türkiye and Hungary also exhibit strong financial reporting, while Hong Kong represents Asia's commitment to robust financial standards. Variability in Asia is noted with Japan, South Korea, and varying scores in Thailand, India, and Malaysia, reflecting different financial reporting standards. European countries such as the Netherlands, Italy, Spain, and France show varying degrees of earnings quality, influenced by regional economic conditions and sectoral strengths. Nordic countries, including Finland and Denmark, maintain good quality, aligning with their strong governance reputation. Colombia and Brazil represent South America with potential for improvement, contrasting with North America's unexpected lower ranking for Mexico. At the lower end, Taiwan and Poland suggest average quality with room for enhancement. This analysis provides a comprehensive picture of financial reporting quality globally, essential for impact investors prioritizing financial integrity and ESGC practices.

Graph 3. Comparision of Avarage ESGC Scores and Earning Quality Scores by Country



Such detailed scatter plot analyses can inform investment strategies, highlighting where firms are not only excelling in financial reporting quality but also in their commitment to ESGC principles. This comprehensive approach allows for a multifaceted evaluation of potential investments, ensuring that ethical and impact investment portfolios are constructed with a balance of financial stability and social responsibility (see Graph 3). Higher points on the scatter plot, indicating better financial health, are not uniformly aligned with higher ESGC scores. This suggests that the correlation between ESGC practices and financial performance is complex and influenced by multiple factors.

3.2.1. Country-Specific Trends and Anomalies

Outliers in the scatter plot, where countries exhibit high ESGC scores but lower financial performance (or vice versa), are particularly insightful. These anomalies might reflect unique national circumstances, such as industry composition, economic stability, or governance quality. Such insights are crucial in understanding the multifaceted nature of the relationship between ESGC practices and financial health at the country level.

For sustainable and ethical investors, this analysis is particularly valuable. The plot underscores the complexity and regional specificity of these relationships, providing valuable insights for a range of policymakers, ethical investors, and businesses.

Romania, Hungary, and Türkiye show high EQS but more moderate ESGC scores. This suggests that while firms in these countries have reliable financial reporting, there may be room for improvement in their ESGC practices. Hong Kong shows high Earnings Quality Scores, reflecting the region's strong regulatory environment and financial transparency.

Countries like Japan, Italy, Spain, and Brazil show moderate scores in both ESGC and EQS. This indicates a balanced approach to both financial reporting and ESGC concerns, with neither aspect significantly outperforming the other.

Kazakhstan and Mexico are positioned lower on the plot, indicating lower scores in both ESGC and Earnings Quality. This suggests that firms in these countries might have significant room for improvement in terms of financial transparency and ESGC engagement. South Africa shows a low ESGC score in the dataset but is known for high EQS, which could imply a focus on financial performance over ESGC factors, or it could be indicative of data collection inconsistencies.

Poland and Russia have reasonable EQS but lower ESGC scores, suggesting that while the financial reporting might be up to standard, these countries could focus more on enhancing their ESGC practices. Denmark, known for high ESGC standards, shows a surprisingly moderate ESGC score in the plot, which may call for a closer examination of the sectors or firms evaluated.

3.2.2. Violin Plot and Co-ocuurance Analysis

Expanding upon the previous analyses, the study delves deeper into the intricate relationships between countries based on the aggregated annual data of firms' EQS and the components of ESGC scores. To unravel these complexities, the study employs violin plot and co-occurrence analysis methodologies.

Violin plots were used to visualize the distribution of ESGC components over annual data, highlighting variability in ESG performance [31]. Co-occurrence analyses were preferred to identify similarities in ESGC performance across countries. Violin plots show the distribution and variation of specific ESGC components across different countries, indicating which countries perform consistently in sustainability. This analysis helps in understanding variations in ESGC performance, which can influence investment decisions [31].

Expanding upon the previous analyses, the study examines the intricate relationships between countries based on the aggregated annual data of firms' EQS and the components of ESGC scores. To unravel these complexities, the study employs violin plot and co-occurrence analysis methodologies. Some more specific observations that could be drawn from violin plots might include:

Consistency: Countries with tall, narrow violins for a particular pillar may have more consistent policies and practices across their firms in that area.

Variability: Countries with wide violins may have a diverse set of practices, indicating that some firms perform well while others do not.

Potential for Improvement: Countries with violins that extend towards the lower end of the score range might have room for improvement in that ESGC component.

Violin plots analyses are essential tools for investors and policymakers to understand where firms (and countries) stand in terms of ESGC practices and where they may need to direct attention to improve their global ESGC standings. They can also help identify which countries exhibit best practices in each ESGC component, potentially guiding investment decisions towards more responsible and sustainable firms.

Co-occurrence Analysis

This approach complements *Violin Plots* by examining the frequency of countries sharing similar rankings in the relevant metrics when aggregated firm data is considered. It provides insights into the clustering patterns and affinities between countries, reinforcing findings from previous clustering and scatter plot analyses. It investigates how often countries share similar or identical ranks in financial and ESGC metrics, aiming to visualize the proximity of countries' performances in these areas.

The co-occurrence relationship between two countries stems from their shared rankings in financial and ESGC metrics. In essence, when two countries exhibit similar performance levels, they are linked in this analysis, creating a network of interconnected performance indicators.

The objective is to illuminate the similarities and differences in countries' performances regarding financial and ESGC metrics, using this information to better understand their positions within the global economic and social structures.

In constructing the graph, a Graph Neural Network (GNN) was utilized to visually represent these relationships and similarities among countries. This method allows for the exploration of more complex connections and patterns, offering valuable insights for investors, policymakers, or researchers looking to understand the intertwined nature of financial performance and ESGC commitments.

For the period 2000-2021, an average ranking for each country's financial ratios (Profitability, Liquidty, Leverage, DuPont/Earning Power, Operating) and ESGC metrics was calculated. The resulting co-occurrence graph illustrates the interrelationships that represent similar ranking profiles

between countries. An edge in this graph signifies that two countries share similar average rankings across any of the metrics, which can be leveraged to visualize overall trends and connections.

According to the analysis, the countries and years showing the most frequent co-occurrences (the nodes with the most connections) are highlighted, signifying that these nodes are pivotal in understanding the broader patterns of financial and ESGC performance. These findings can be instrumental in crafting investment strategies that not only seek financial returns but also align with ethical and sustainable practices, reflecting a shift towards responsible investing in the global marketplace.

In co-occurrence analyses, centrality indicates the position and significance of nodes (countries, in this case) within the network. A country's centrality implies a high degree of similarity with many other countries in terms of shared characteristics or rankings. Scientifically, a few interpretations can be drawn:

Similar Policies and Practices: Central countries are more frequently associated with others that have similar values in financial and sustainability metrics like ESGC scores and liquidity ratios, indicating analogous economic structures, policies, or market dynamics. For instance, a cluster of countries with similar approaches to ESGC practices or sharing comparable economic conditions may reflect these similarities in their rankings and thus in the co-occurrence network.

Information Flow and Interaction: Central countries can play a more active role in the network's information flow and interactions. From the perspective of social network analysis and diffusion theory, central nodes (countries) can act as pivotal points in the dissemination of innovations, trends, or policy shifts. If a country exhibits similarities with many others across various ESGC metrics or financial ratios, it suggests a central role in the diffusion of related knowledge and practices.

Network Resilience and Risk Management: In network theory, central nodes present both opportunities and challenges for network resilience. Central countries are potentially more sensitive to changes or shocks, as alterations in these countries might rapidly propagate throughout the network. This centrality suggests a need for careful risk management and policymaking, as the impact and spread of changes can be significant due to the interconnected nature of the network.

Graph 4. ESGC Scores (with its components "Environmental Pillar Score (Weight 34.5%)", "Social Pillar Score (Weight 42.0%)", "Governance Pillar Score (Weight 23.5%)", "ESG Controversies Score")

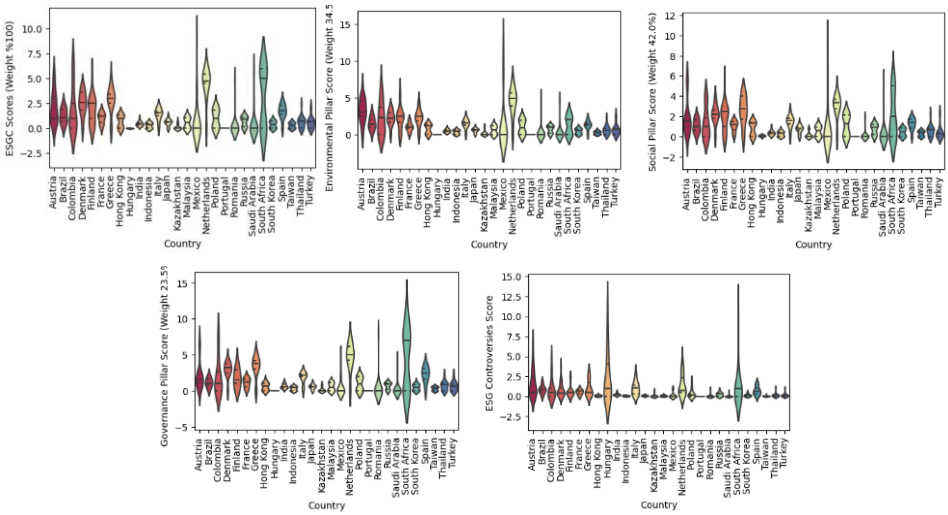


Table 4. *ESGC Score Distribution and Observations Table*

Score Type	Narrow Distributions	Wide Distributions	Significant Peaks	Key Observations
ESGC Overall Scores	Hungary, Japan, Portugal	Austria, Denmark	Mexico, Netherlands	Stability vs diversity in ESG practices across countries
Environmental Pillar	India, South Korea	Greece, Finland	Romania, Saudi Arabia	Consistency vs variability in environmental practices
Social Pillar	Kazakhstan, Taiwan	Brazil, South Africa	Mexico, Saudi Arabia	Uniformity vs diversity in social engagement
Governance Pillar	Hong-Kong, Malaysia	Netherlands, Spain	Colombia, Romania	Consistent vs varied corporate governance
Controversies Pillar	Japan, Thailand	Italy, Netherlands	Hungary, South Africa	Stable vs diverse public perception and management of ESG issues

Score Type: The specific ESGC component and financial ratios being analyzed, such as overall scores, environmental, social, governance, or controversies scores.

Narrow Distributions: Refers to countries that have shown a relatively tight range of scores for a particular ESGC component and financial ratios. This indicates a level of consistency or uniformity among the firms within these countries. Narrow distributions suggest that firms are mostly aligned in their practices or performances concerning the specific ESGC and financial ratios aspect.

Wide Distributions: Represents countries with a broad range of scores for a particular ESGC component. This indicates a high degree of variability and diversity in how firms within these countries approach or perform in the specific ESGC aspect and financial ratios. Wide distributions suggest that firms within these countries may be implementing a wide array of strategies, or they might be at different stages of ESG and financial ratios and adoption or performance.

Significant Peaks: Indicates countries where a particular score or range of scores is prominently represented among firms for a specific ESGC component and financial ratios. This could suggest that there is a prevalent practice, regulation, or condition in these countries that leads to a concentration of firms around certain ESGC performance and financial ratio levels. Significant peaks can highlight areas where firms are excelling or, conversely, where they may face common challenges.

Key Observations: Summarizes the essential insights or trends derived from the distribution patterns of ESGC scores and financial ratios. This column provides a brief narrative or commentary on

what the distributions might imply about the firms' approaches, performance, and strategies in relation to ESGC components in different countries (see Graph 4 and Table 4).

Graph 5. Violin Plots for Profitability Metrics (with its components "Gross Margin", "EBITDA Margin", "Operating Margin", "Pretax Margin", "Effective Tax Rate", "Net Margin") by Country and Year

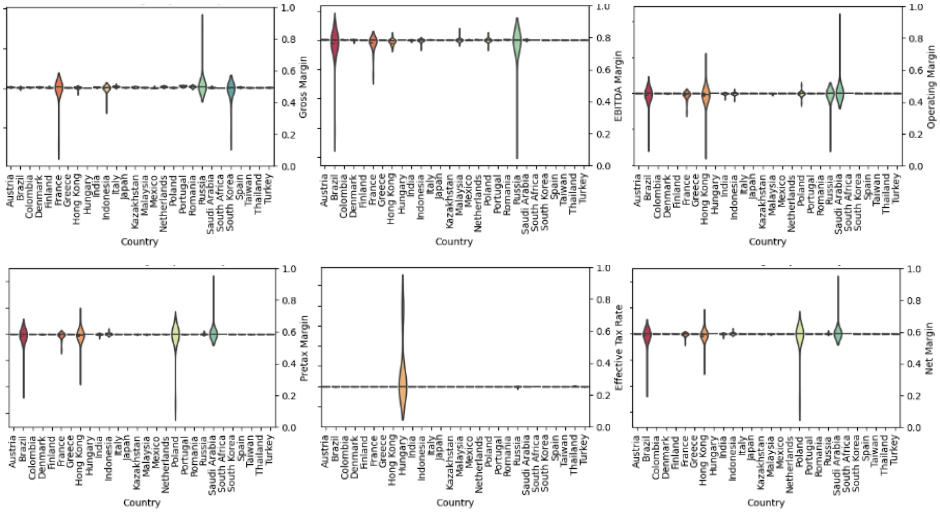


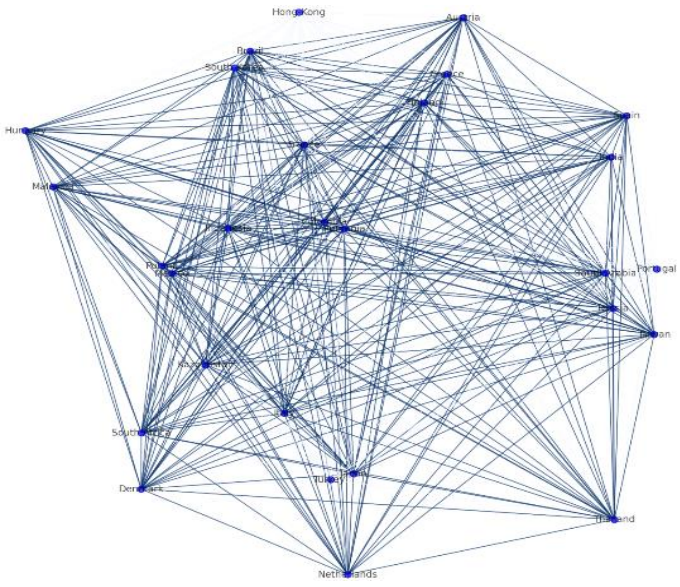
Table 5. *Profitability Metrics Distribution and Key Observations*

Score Type	Narrow Distributions	Wide Distributions	Key Observations
Gross Margin	Austria, Denmark, Greece (Consistent margins)	France, Indonesia, Russia (Diverse margins)	Gross margin variability indicates different levels of market competitiveness and cost structures.
EBITDA Margin	Austria, Colombia, Denmark (Uniform profitability)	Brazil, France, Hong-Kong (Diverse operational efficiency)	EBITDA margin variations highlight differences in operational leverage and management efficiency.
Operating Margin	Austria, Colombia, Denmark (Consistent performance)	Brazil, France, Hong-Kong (Diverse operational performance)	Operating margin consistency or variability reflects operational cost management and profit generation.
Pretax Margin	Austria, Colombia, Denmark (Uniform	Brazil, France, Hong-Kong (Varied	Pretax margin distributions show the degree of homogeneity or

	profitability before tax)	market conditions)	diversity in overall profitability before taxes.
Effective Tax Rate	Various (Similar tax rates)	Hungary (Diverse strategies)	Effective tax rate variations reveal the complexity of tax environments and strategies employed by firms.
Net Margin	Austria, Colombia, Denmark (Consistent net profitability)	Brazil, France, Hong-Kong (Significant disparity in net profitability)	Net margin variations underscore final profitability and impact of overall efficiency and strategy.

Table 5 summarizes the distributions and key observations for various profitability metrics as analyzed through violin plots for different countries (see Graph 5). The "Narrow Distributions" column highlights countries with consistent performance in a profitability component metric, suggesting homogeneity or effective management. "Wide Distributions" indicates a broad range of performance, reflecting diversity in strategies or market conditions. "Significant Peaks" refers to notable extremes in the data that may suggest prevalent industry practices or outlier performances. Finally, "Key Observations" provides insights into what these distributions might imply about operational efficiency, market conditions, and financial strategies of firms in the analyzed countries.

Graph 6. World Co-Occurance Ranks Profitability (with its components “Gross Margin”, “EBITDA Margin”, “Operating Margin”, “Pretax Margin”, “Effective Tax Rate”, “Net Margin”) Metrics and ESGC Component Scores



The co-occurrence network map (see Graph 6) reveals a complex web of interconnections among countries, reflecting their alignment in financial and ESG performance metrics. Indonesia, Belgium, and Colombia and centrality in the network underscores its role as a pivotal financial hub, interfacing with a multitude of countries. European nations such as Austria, Denmark, Sweden, and the Netherlands are also nodes with substantial linkages, suggesting their conformance to global trends in both financial benchmarks and ESGC adherence. In contrast, countries with sparser connections, such as Türkiye, exhibit a blend of commonalities and distinctive characteristics, indicating nuanced financial and ESGC profiles that diverge from the more interconnected nodes. The network's overall density signifies a considerable degree of shared performance rankings, yet each country retains unique aspects of its economic and social fabric. This map serves as a crucial analytical tool for investors and policymakers to decipher the intricate tapestry of global economic and social structures, providing insights into the collective and individual country performances within the international arena.

Graph 7. Violin Plots for Du/Pont Earning Power Metrics (with its components "Asset Turnover", "x Pretax Margin", "Pretax ROA", "x Leverage (Assets/Equity)", "Pretax ROE", "x Tax Complement", "ROE", "x Earnings Retention", "Reinvestment Rate") by Country and Year

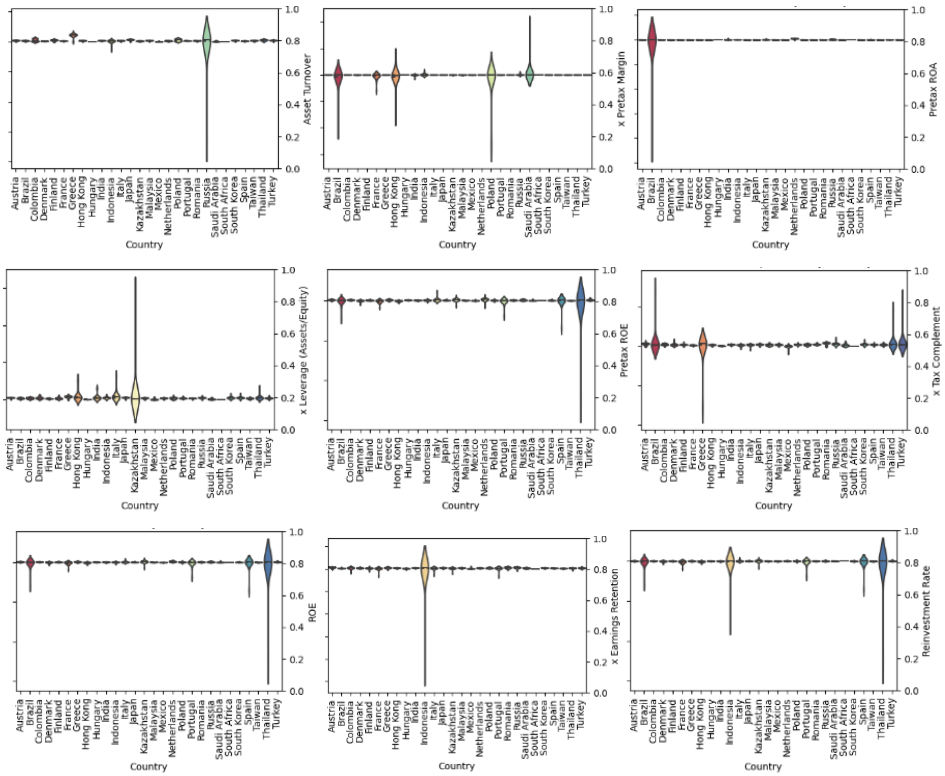


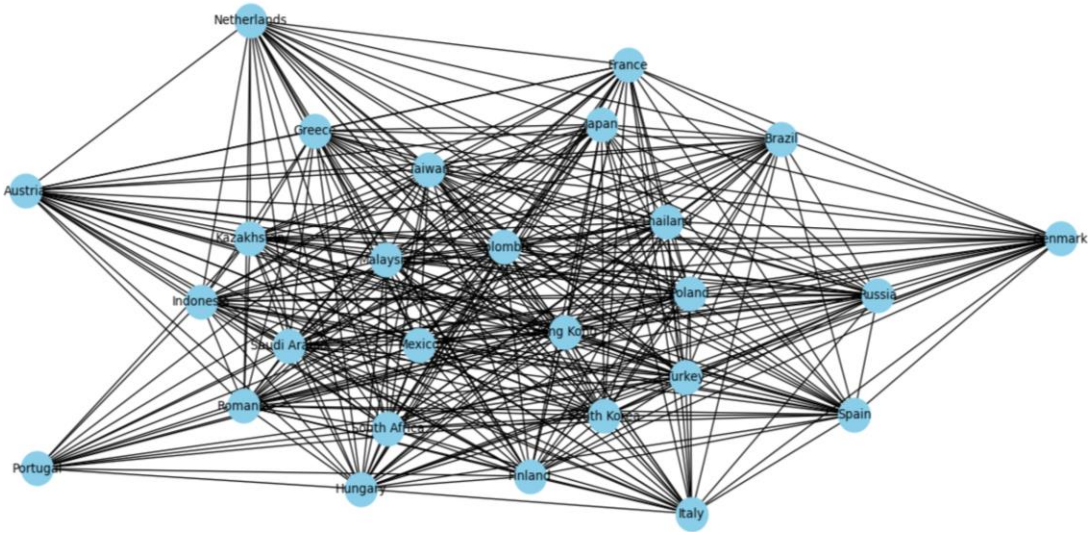
Table 6. *DuPont/Earning Power Metrics Distribution and Key Observations*

Score Type	Narrow Distributions	Wide Distributions	Significant Peaks	Key Observations
Asset Turnover	Colombia, Greece, Indonesia (Homogenous asset efficiency)	Brazil, India, Russia (Diverse efficiency in asset use)	Austria, Mexico, Türkiye (Concentrated around specific values)	Asset turnover variability reflects differences in operational practices and asset utilization efficiency.
Pretax Margin	Austria, Japan, Spain (Uniform pretax profitability)	France, Hong-Kong, Saudi Arabia (Diverse pretax profitability)	Brazil, South Africa (Peaked distribution indicating common profitability level)	Pretax margin diversity indicates varying market conditions and financial strategies.
Pretax ROA	Most countries except Brazil (Consistent asset profitability)	Brazil, Russia, India (Varied effectiveness in profit generation from assets)	Not specified	Pretax ROA distributions reflect consistency or variability in how assets generate profits.
Leverage (Assets/Equity)	Austria, Japan, Spain (Uniform leverage practices)	Hong-Kong, India, Italy (Significant variability in leverage)	Not specified	Leverage distributions indicate the degree of financial risk and capital structure homogeneity.
Pretax ROE	Austria, Mexico,	Brazil, France,	Not specified	Pretax ROE varia-

	Taiwan (Consistent returns on equity)	Thailand (Diverse return on equity performance)	tions signal different levels of firm efficiency in using equity to generate profits.

Table 6 organizes the DuPont/Earning Power Metrics into categories based on their distribution characteristics—narrow, wide, and significant peaks (see Graph 7)—along with key observations that reflect the implications of these distributions for the firms' financial management practices and operational efficiency. Each metric offers insights into different aspects of firms' earning power and financial strategies, helping stakeholders understand the nuances of financial performance across countries and industries.

Graph 8. World Co-Occurrence Ranks DuPont/Earning Power Metrics (with its components; Asset Turnover, x Pretax Margin, Pretax ROA, x Leverage (Assets/Equity), Pretax ROE, x Tax Complement ROE, x Earnings Retention, Reinvestment Rate) and ESGC Component Scores



Graph 8 the co-occurrence network map, which plots the similarity in DuPont/Earning Power metrics and ESGC component scores across various countries, presents a rich tableau of interconnectedness based on financial performance and sustainability practices.

Central to this network are countries like Colombia, Mexico, Hong-Kong Malaysia, and Taiwan which exhibit numerous connections, suggesting that these nations have companies with financial and ESGC metrics that often rank similarly to those in many other countries. This could indicate that firms in these countries are closely aligned with global market practices and sustainability standards, or that they share economic characteristics with a broad array of countries.

Some peripheral countries appear as a particularly interconnected node, suggesting its companies' financial practices and ESGC performance are representative of a larger trend within the network. This could imply that peripheral countries' corporate strategies are reflective of wider, perhaps regionally influenced, business practices that resonate across multiple countries.

On the other end of the spectrum, countries like Denmark, Austria, and Netherlands which are less densely connected, may reflect unique national circumstances that affect company performance metrics differently from global patterns. These could be due to distinctive industry structures, local economic policies, or varying stages of development in ESGC practices.

Peripheral nodes in the network, which include countries with fewer connections such as Russia, could indicate more isolated economic behaviors or alternative business practices that do not co-occur frequently with the majority. The specifics of these connections could reveal insights into how certain national policies or industry-specific factors are shaping financial and ESGC performance distinctly from the global norms.

Clusters within the network—subsets of countries with dense interconnections—might suggest regional similarities or shared economic and regulatory environments. For example, if European countries form a tight cluster, this could reflect the influence of European Union regulations and market dynamics that standardize financial and ESGC practices across member states.

Graph 9. Violin Plots for Liquidity Metrics (with its components "Quick Ratio", "Current Ratio", "Times Interest Earned", "Cash Cycle (Days)") by Country and Year

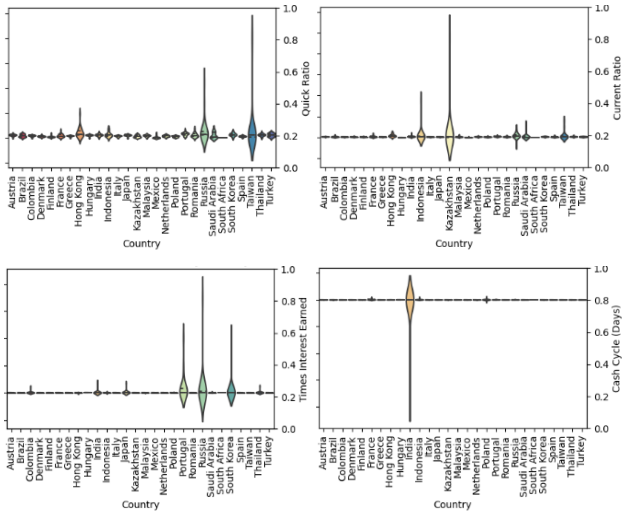


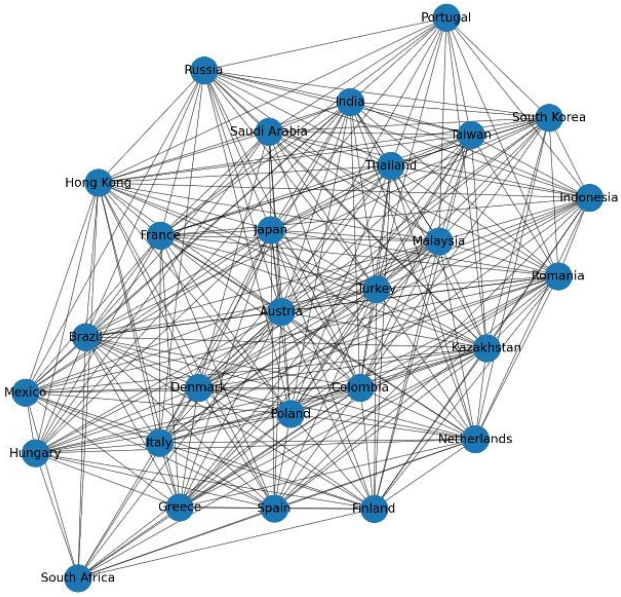
Table 7. *Liquidity Metrics Distribution and Key Observations*

Score Type	Narrow Distributions	Wide Distributions	Significant Peaks	Key Observations
Quick Ratio	Austria, Colombia, Denmark (Con-	Hong-Kong, Indonesia, Russia (Variable	Hong-Kong, Taiwan (Con-	Quick ratio variability reflects differences in

	sistent liquidity management)	liquid asset management)	centration around specific values)	short-term asset management and liquidity strategies.
Current Ratio	Austria, Colombia, Denmark (Uniform working capital management)	Saudi Arabia, Hong-Kong, India (Diverse approaches to working capital)	Indonesia, Kazakhstan, Russia (Common liquidity levels)	Current ratio distributions show consistency or diversity in firms' short-term financial health and operational efficiency.
Times Interest Earned	Austria, Colombia, Denmark (Consistent debt servicing capacity)	Thailand, Russia (Varied ability to cover interest expenses)	Portugal, Russia, South Korea (Standardized financial capacity)	Times Interest Earned variability highlights differences in firms' profitability and debt management strategies.
Cash Cycle (Days)	Austria, Colombia, Denmark (Similar cash conversion cycles)	India (Variable cash conversion efficiency)	Not specified	Cash cycle distributions reflect operational efficiency and how quickly firms convert operations into cash.

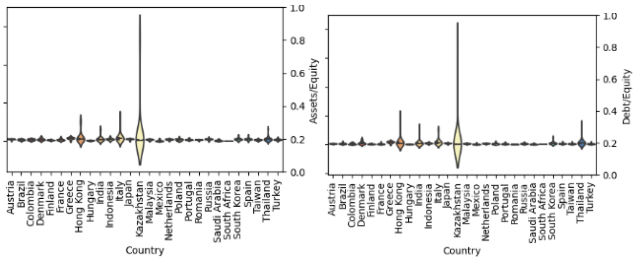
Table 7 organizes the Liquidity Metrics into categories based on their distribution characteristics—narrow, wide, and significant peaks (see Graph 9)—along with key observations that reflect the implications of these distributions for the firms' liquidity management and short-term financial strategies. Each metric offers insights into different aspects of firms' liquidity, helping stakeholders understand the nuances of financial health and cash flow management across countries and industries.

Graph 10. World Co-Occurrence Ranks Liquidity (with its components "Quick Ratio", "Current Ratio", "Times Interest Earned", "Cash Cycle (Days)") Metrics and ESGC Component Scores



The co-occurrence network graph (see Graph 10) portrays Italy and South Korea as central hubs, indicating that these countries' companies likely exhibit liquidity and ESGC metrics that are well-aligned with global patterns, suggesting they could serve as benchmarks for best practices. In contrast, nations like Russia and Indonesia, positioned more peripherally, might represent unique business environments with distinct liquidity management and ESGC strategies that diverge from the global norm. The network also hints at potential regional clusters, such as European countries, whose dense interlinkages could reflect uniformity in economic policies and ESGC regulations. Türkiye's specific positioning, with noticeable but not overly dense connections, might reflect a blend of practices that align with both central hubs and peripheral countries, indicating a diverse but integrated economic landscape. This graph thus offers a succinct visual summary of how countries compare in financial health and sustainability, providing valuable insights for international economic analysis and investment strategy development.

Graph 11. Violin Plots For Leverage Metrics (with its components "Assets/Equity", "Debt/Equity", "% LT Debt to Total Capital", "(Total Debt - Cash) / EBITDA") by Country and Year



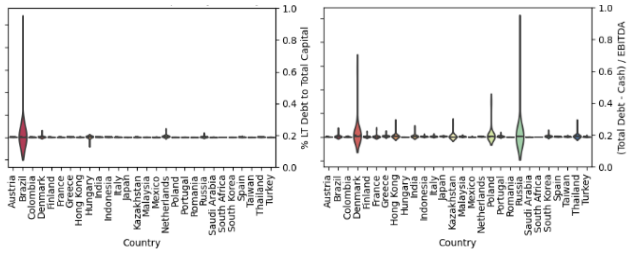


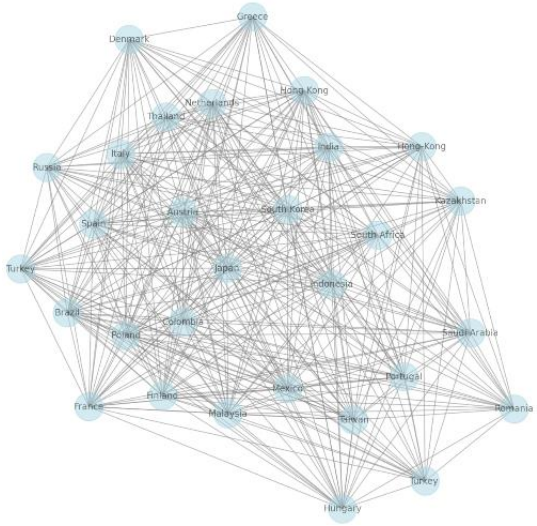
Table 8. *Leverage Metrics Distribution and Key Observations*

Score Type	Narrow Distributions	Wide Distributions	Significant Peaks	Key Observations
Assets/Equity	Germany, Japan, Switzerland (Consistent financial leverage)	Brazil, Russia (Significant variability in financing)	Not specified	Assets/Equity variability indicates different levels of financial risk and strategies.
Debt/Equity	Not specified	Not specified	Not specified	Debt/Equity distributions reflect how firms balance debt and equity in their capital structure.
% LT Debt to Total Capital	Not specified	Not specified	Not specified	Long-term debt distributions provide insights into firms' long-term financial stability and risk.
(Total Debt - Cash) / EBITDA	Not specified	Not specified	Not specified	This ratio indicates firms' ability to cover debt with operating earnings, reflecting financial health and risk.

Table 8 organizes the Leverage Metrics into categories based on their distribution characteristics—narrow, wide, and significant peaks—along with key observations that reflect the implications of these distributions for the firms' financial structure and risk management. Each metric offers insights

into different aspects of firms' financial leverage, helping stakeholders understand the nuances of capital structure and financial strategies across countries and industries (see Graph 11).

Graph 12. World Co-Occurrence Ranks Leverage (with its components “Assets/Equity”, “Debt/Equity”, “% LT Debt to Total Capital”, “(Total Debt - Cash) / EBITDA)”) Metrics and ESGC Component Scores



Central Nodes with Multiple Connections: Japan and South Korea: These two countries are central nodes with a high number of connections, indicating that they share similar financial leverage and ESGC rankings with many other countries. This could suggest that their corporate financial structures and ESGC practices are reflective of or influential in global trends.

Germany: Another central node with many connections, pointing to Germany's position as a country with financial and ESGC metrics that are like those of many other countries. This aligns with Germany's role as a major global economy with substantial influence in international financial standards and sustainability practices.

Dense Clusters with Strong Interconnections: European Cluster: Countries like France, Italy, and Spain show a dense interconnection, suggesting shared financial and ESGC profiles, likely due to similarities in European Union regulations and economic practices.

Asian Cluster: Hong Kong, Singapore, and Thailand appear to be closely connected, which may reflect shared economic dynamics in the Asian region, common market practices, or similar stages of economic development.

Sparse Connections Indicating Unique Profiles: Russia and Türkiye: These countries have fewer connections compared to central nodes, implying a more unique set of financial and ESGC characteristics that may not align as closely with the global average or may indicate differing economic or regulatory environments.

Countries with Specific Connections: Brazil: Connected to both European and Asian nodes, Brazil's position could indicate a diverse range of financial leverage practices or a varied ESGC profile that aligns with different global regions. Denmark and Sweden: These Nordic countries, while connected to the broader European cluster, also have specific connections that might highlight their leadership in certain ESGC practices or financial strategies (see Graph 12).

Graph 13. Violin Plots For Operating Metrics ((with its components “A/R Turnover”, “Avg. A/R Days”, “Inv Turnover”, “Avg. Inventory Days”, “Avg. A/P Days”, “Fixed Asset Turnover”, “WC / Sales Grow”, “Bad Debt Allowance (% of A/R)”, “ROIC”, “Revenue per Employee ($)”) by Country and Year

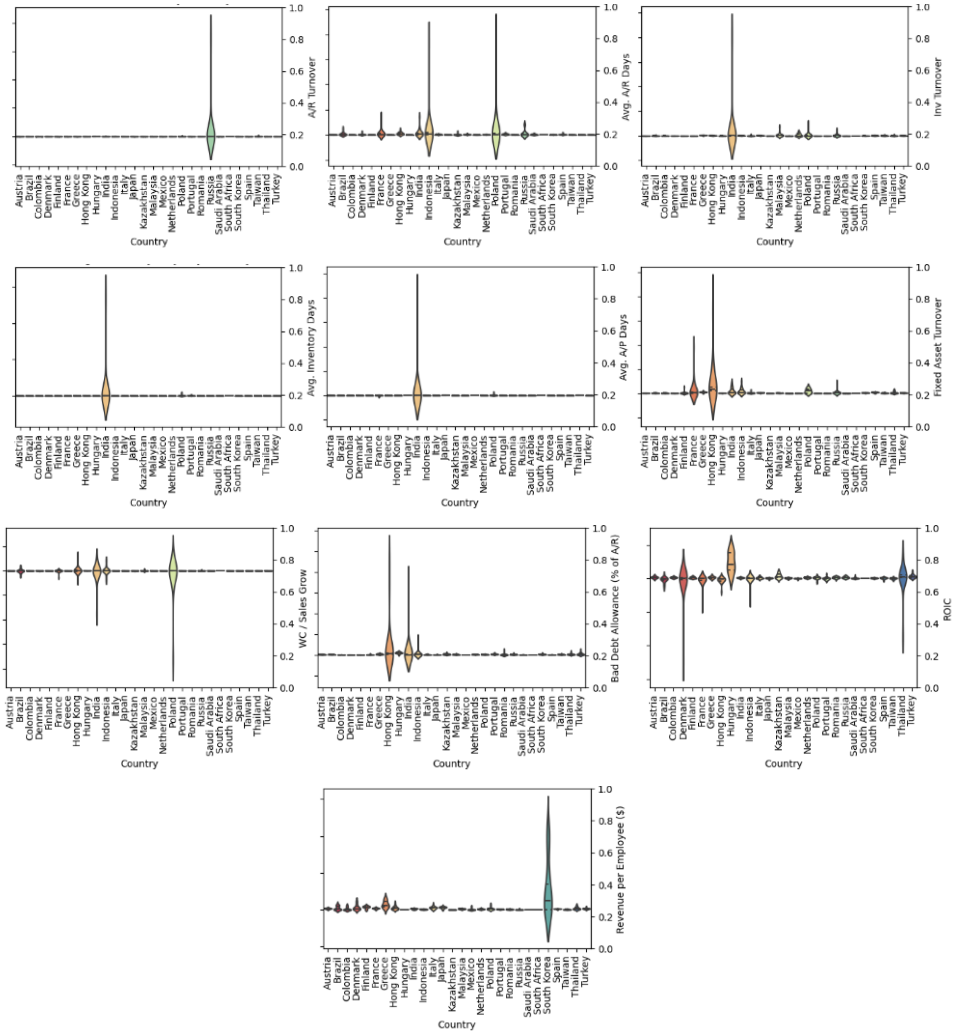


Table 9. *Operating Metrics Distribution and Key Observations*

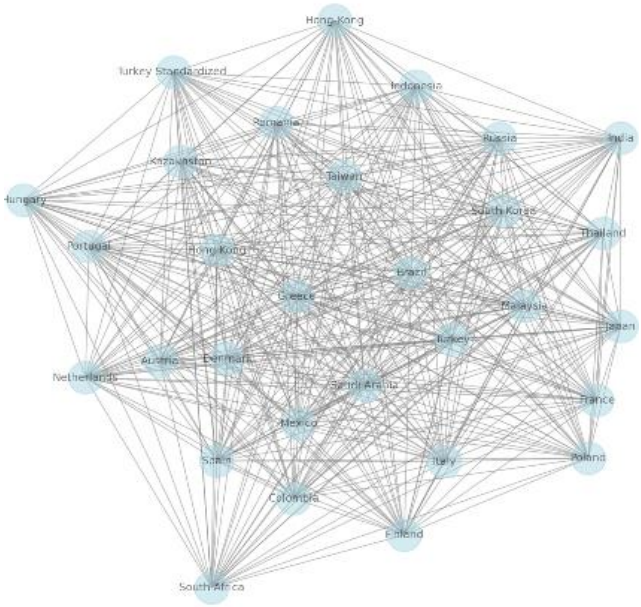
Score Type	Narrow Distributions	Wide Distributions	Significant Peaks	Key Observations
A/R Turnover	Austria, Denmark, Finland (Consistent receivables man-	Not specified	Not specified	A/R Turnover uniformity indicates consistent receivables collection effi-

	agement)			ciency.
Avg. A/R Days	Austria, Denmark, Japan (Uniform collection period)	Russia, Kazakhstan (Varied collection days)	France, Poland (Concentrated collection days)	Avg. A/R Days variability reflects differences in credit terms and collection efficiency.
Inv Turnover	Austria, Denmark, France (Consistent inventory management)	Malaysia, Netherlands (Diverse inventory strategies)	Not specified	Inventory Turnover uniformity indicates consistent sales and inventory efficiency.
Avg. Inventory Days	Austria, Denmark (Uniform holding period)	Poland (Varied holding days)	India (Concentrated holding days)	Avg. Inventory Days variability suggests differences in stock management and operational efficiency.
Avg. A/P Days	Austria, Denmark (Consistent payment period)	Brazil, France (Varied payment days)	India (Concentrated payment days)	Avg. A/P Days variability indicates differences in payment strategies and cash management.
Fixed Asset Turnover	Austria, Denmark, Japan (Consistent asset utilization)	Finland, Greece (Diverse asset efficiency)	France, Hong-Kong (Concentrated asset turnover)	Fixed Asset Turnover uniformity reflects stable asset utilization and operational efficiency.
WC / Sales Grow	Austria, Denmark, Italy (Consistent capital usage)	Brazil, France (Varied growth strategies)	Hong-Kong, India (Concentrated	WC / Sales Grow variability indicates different approaches to managing

			growth rates)	working capital and growth.
Bad Debt Allowance (% of A/R)	Austria, Brazil, Denmark (Uniform credit risk management)	Greece, Türkiye (Diverse bad debt expectations)	Hong-Kong, India (Concentrated allowances)	Bad Debt Allowance variability reflects differences in credit risk assessment and management.
ROIC	Not specified	Not specified	Kazakhstan, Malaysia (Common ROIC levels)	ROIC distributions reflect variations in capital efficiency and return generation.
Revenue per Employee	Hungary, India, Portugal (Consistent revenue generation)	Brazil, France (Varied income distribution)	South Korea (Concentrated revenue per employee)	Revenue per Employee variability highlights differences in productivity and operational efficiency.

Table 9 organizes the Operating Metrics into categories based on their distribution characteristics—narrow, wide, and significant peaks (see Graph 13)—along with key observations that reflect the implications of these distributions for the firms' operational efficiency and financial strategies. Each metric offers insights into different aspects of firms' operations, helping stakeholders understand the nuances of operational performance across countries and industries.

Graph 14. World Co-Occurrence Ranks Operating (with its components "A/R Turnover", "Avg. A/R Days", "Inv Turnover", "Avg. Inventory Days", "Avg. A/P Days", "Fixed Asset Turnover", "WC / Sales Grow", "Bad Debt Allowance (% of A/R)", "ROIC", "Revenue per Employee ($)") Metrics and ESGC Component Scores



Central Countries: These countries are typically located near the geometric center of the graph and have strong connections with many other countries. These connections reflect similarities in financial and ESGC performance. Moreover, they are often considered central players in the global economy or regional leaders. Examples include European countries like Greece, Denmark, and Austria.

Peripheral Countries: Peripheral countries are usually situated on the outer edges of the graph and have fewer connections. This indicates that their economic structures or ESGC performances may differ from other countries. For instance, examples can be found in countries like Japan, Thailand and some smaller European countries.

Dense Connections: Countries with dense connections are linked to each other with thick lines on the graph. This suggests that these countries have tight economic and social relationships and are likely part of similar economic blocs. For example, the dense connections observed around Germany indicate strong economic ties with many other countries.

Weak Connections: Countries with weak connections have not established direct links with many other countries. These countries often exhibit unique economic structures or differ in ESGC performance from others. For example, some Asian countries may fall into this category and have fewer connections (see Graph 14).

To more strikingly present the outcomes of violin plot analyses, below are the comparative analyses of averages. These analyses serve to highlight the distribution and density of data points for various financial indicators, providing a vivid depiction of how ESGC scores influence company financial metrics. By comparing the means, the analysis underscores the distinct financial patterns and trends between companies with and without ESGC scores, offering a clear visual and statistical representation of the relationship between ESGC commitment and financial performance. Before moving on

to regression analyses, key ratios that are significant for both professional and individual investors have been compared in terms of averages, and significant differences have been identified based on the presence or absence of ESGC scores. These findings are reported in Table 10.

Table 10. *The Impact of ESGC Performance on Financial Indicators: Comparative Analysis of Companies with and without ESGC Scores*

Indicator	General Average	Average of Those with ESGC Score	Average of Those Without ESGC Score
Earnings Quality Score	20.52	41.86	17.61
Exchange Rate	0.13	0.36	0.10
Profitability	-0.00	0.0103	-0.0102
Gross Margin	77	0.13	0.29	0.11
EBITDA Margin	-0.77	0.032	-0.88
Operating Margin	-1.11	-0.56	-1.19
Pre-Tax Margin	-0.81	-0.50	-0.85
Net Margin	-0.74	-0.49	-0.78

In the comparative analysis in Table 10 companies with ESGC scores generally demonstrate enhanced financial performance across various indicators compared to those without, with specific figures emphasizing the impact:

Earnings Quality Score: Companies with ESGC scores show a significant increase in earnings quality (41.86) compared to those without (17.61), indicating robust financial integrity and transparency.

Exchange Rate: Firms with ESGC scores experience higher exchange rate variability (0.36) versus those without (0.10), suggesting broader international exposure and operational scope.

Profitability: ESGC-engaged companies exhibit a positive average profitability of 0.0103, contrasting with a negative average of -0.0102 for their non-ESGC counterparts, reflecting the beneficial impact of ESGC practices on profitability.

Gross Margin: A noticeable increase in gross margin for ESGC firms (0.29) compared to those without ESGC scores (0.11), suggesting that ESGC investments may lead to more effective cost management and profitability.

EBITDA Margin: Companies with ESGC scores report a higher EBITDA margin (0.032) as opposed to a lower margin for non-ESGC companies (-0.88), indicating enhanced operational efficiency through ESGC practices.

Operating Margin: Although negative for both, companies with ESGC scores have a less negative operating margin (-0.56) compared to those without (-1.19), implying a more stable operational stance with ESG integration.

Pre-Tax Margin: Similarly, a less negative pre-tax margin is observed for ESGC firms (-0.50) versus non-ESGC firms (-0.85), suggesting a mitigated financial risk through sustainable practices.

Net Margin: The net margin for ESG companies (-0.49) is less negative than for their non-ESGC counterparts (-0.78), indicating a trend towards better net profitability with ESGC engagement.

Overall, these figures underline that companies with ESGC performance tend to have more favorable financial metrics, advocating for the integration of ESGC considerations into business and investment strategies for better financial outcomes.

3.3. Lasso ve Ridge Regression Results

Lasso and Ridge regressions are statistical methods used especially in complex datasets to manage features and prevent overfitting. In this study, Lasso and Ridge regression methods were used to examine the impact of ESGC scores on financial performance. These methods were selected to prevent overfitting and control multicollinearity [58; 32]. Lasso and Ridge regressions were used to identify the financial metrics that have the greatest impact on ESGC scores, providing valuable insights into understanding the effect of sustainability practices on financial returns [65]:

Lasso Regression (L1 Regularization):

Feature Selection: Effectively identifies and eliminates irrelevant features, simplifying the model.

Reduces Complexity: Helps in reducing overfitting, enhancing model generalizability.
Ideal for Numerous Features: Useful in scenarios with many potential predictors.

Ridge Regression (L2 Regularization):

Shrinks Coefficients: Reduces the impact of less important features without completely eliminating them.

Prevents Overfitting: Imposes a penalty on large coefficients, maintaining model performance on unseen data.

Handles Multicollinearity: Effectively distributes coefficients across correlated predictors.

Common Reasons for Applying Lasso and Ridge:

Feature Selection with Lasso: Useful for identifying relevant financial ratios related to targets like the "ESG Combined Score" in large datasets.

Preventing Overfitting: Both methods add regularization terms to penalize large coefficients, maintaining more robust and generalizable models.

Regulated Modeling: Control model complexity and enhance generalization performance.

Managing Multicollinearity: Financial ratios often correlate highly; Lasso and Ridge can manage these effectively.

Model Complexity and Overfitting: They mitigate the risk of overfitting in datasets with many features, improving generalization capabilities.

These tools are instrumental in refining models for better prediction and understanding, particularly in financial contexts [13; 45; 51; 62; 3; 27].

The Shapiro-Wilk Normality Distribution Test:

Particularly the Shapiro-Wilk test, is a cornerstone in data analysis for determining whether a dataset conforms to a normal distribution, which is a fundamental requirement for many statistical tests and modeling techniques.

Purpose: Assesses if a dataset follows a normal distribution.

Hypothesis Testing: Null hypothesis (H0) states data are normally distributed. A small p-value (<0.05) rejects H0, indicating non-normality.

Test Statistic (W): Measures how well data align with a normal distribution, ranging between 0 and 1, where values near 1 suggest normality.

Importance in Data Analysis:

Small Sample Suitability: Especially powerful for small samples, it remains effective for larger ones.

W Interpretation: A W value near 1 indicates a close approximation to normal distribution.

Regression Analysis: Useful in evaluating normality of residuals in regression models, where error term normality is a standard assumption.

Application in Regression:

Error Term Normality: Critical for the validity of inferential statistics and hypothesis testing in regression analysis.

Pre-Regression Analysis: Helps determine the need for data transformation or alternative modeling approaches to address non-normality, enhancing accuracy and reliability [63; 28; 16].

Table 11. *Shapiro-Wilk Normality Test Results for Financial Ratios (ESGC Present and ESGC Absent Companies)*

Financial Ratio	W (ESGC Present)	P-Value (ESGC Present)	W (ESGC Absent)	P-Value (ESGC Absent)
Earnings Quality Score	0.927764	5.799447e-24	0.666243	0.0
Period End FX Rate (D/USD)	0.684006	4.231921e-43	0.420670	0.0
Profitability	0.097146	0.0	0.004729	0.0
Gross Margin	0.863737	1.785859e-31	0.012682	0.0
EBITDA Margin	0.060180	0.0	0.008183	0.0
Operating Margin	0.021291	0.0	0.015303	0.0
Pretax Margin	0.023693	0.0	0.026346	0.0
Effective Tax Rate	0.033054	0.0	0.005973	0.0
Net Margin	0.025452	0.0	0.026809	0.0
DuPont/Earning Power	0.138202	0.0	0.054860	0.0
Asset Turnover	0.837409	9.296636e-34	0.005639	0.0
x Pretax Margin	0.023528	0.0	0.026287	0.0
Pretax ROA	0.292400	0.0	0.005149	0.0
x Leverage (Assets/Equity)	0.027238	0.0	0.034484	0.0
Pretax ROE	0.448807	0.0	0.011814	0.0

x Tax Complement	0.036580	0.0	0.047114	0.0
ROE	0.379588	0.0	0.009981	0.0
x Earnings Retention	0.211279	0.0	0.007938	0.0
Reinvestment Rate	0.283268	0.0	0.010421	0.0
Liquidity	0.140292	0.0	0.022594	0.0
Quick Ratio	0.727794	6.713060e-41	0.040495	0.0
Current Ratio	0.297211	0.0	0.018809	0.0
Times Interest Earned	0.017436	0.0	0.006780	0.0
Cash Cycle (Days)	0.094735	0.0	0.002307	0.0
Leverage	0.152835	0.0	0.038443	0.0
Assets/Equity	0.026486	0.0	0.034786	0.0
Debt/Equity	0.020995	0.0	0.024781	0.0
% LT Debt to Total Capital	0.199059	0.0	0.005665	0.0
(Total Debt - Cash) / EBITDA	0.072192	0.0	0.005544	0.0
Operating	0.140282	0.0	0.023068	0.0
A/R Turnover	0.430620	0.0	0.002161	0.0
Avg. A/R Days	0.144631	0.0	0.010888	0.0
Inv Turnover	0.266292	0.0	0.003237	0.0
Avg. Inventory Days	0.131476	0.0	0.002017	0.0
Avg. A/P Days	0.068950	0.0	0.002093	0.0
Fixed Asset Turnover	0.314299	0.0	0.022944	0.0
WC / Sales Grow	0.053371	0.0	0.015416	0.0
Bad Debt Allowance (% of A/R)	0.177236	0.0	0.008089	0.0
ROIC	0.556923	0.0	0.053769	0.0
Revenue per Employee ($)	0.055925	0.0	0.013569	0.0

Note: This table includes the 'W' values of the Shapiro-Wilk test, which test for normality in the data distribution, and the 'P-Value' associated with each 'W' value.

A P-Value close to zero suggests that the null hypothesis of normality is rejected for the distribution of that particular financial ratio.

Earnings Quality Score: Both ESGC present and absent companies show a deviation from normality, but it is more pronounced in companies with ESGC presence. This may indicate that ESG-related activities could be associated with more complex earnings patterns.

Period End FX Rate (D/USD): This shows a significant deviation from normality for both groups, with a lower W value for ESGC absent companies, suggesting exchange rates impact these companies differently, perhaps due to their varying exposure to international markets.

Profitability Metrics (Profitability, Gross Margin, EBITDA Margin, etc.): Across these metrics, the W values are very low, especially for ESGC absent companies, indicating a strong rejection of normality. This could imply that profitability measures are highly skewed or have heavy tails, which could be attributed to outlier firms or sector-specific characteristics.

Margin Ratios (Operating Margin, Pretax Margin, Net Margin, etc.): Similar to profitability, these ratios are far from normally distributed. For companies without ESGC, the deviation is severe, which could reflect a more heterogeneous group with differing operational efficiencies.

Asset Turnover and Related Ratios: These ratios also show a significant departure from normality. Asset efficiency might vary widely across firms, which could be due to different investment strategies or industry characteristics.

Leverage Ratios (Leverage, Debt/Equity, etc.): The very low W values, particularly for ESGC absent companies, suggest that leverage metrics are not normally distributed. This can be due to different capital structures and risk profiles between firms.

Liquidity Ratios (Quick Ratio, Current Ratio): The departure from normality is noted here as well, which might be influenced by industry-specific cash and asset management practices.

Activity Ratios (A/R Turnover, Inventory Turnover, etc.): These ratios are also not normally distributed, particularly for ESGC absent companies. This might be due to different management practices and operational efficiencies.

ROE and ROIC: Both ratios are key measures of financial performance, and they show a significant deviation from normality, especially for companies without ESGC. This could be due to a variety of factors including different industry risks, company sizes, and financial policies.

Revenue per Employee: This ratio also deviates from a normal distribution, which could be because firms vary greatly in how labor-intensive they are, or in their use of automation and outsourcing (see Table 11).

Lasso and Ridge regressions do not require the independent variables (features) to be normally distributed. They are primarily concerned with regularization — adding a penalty to the model to prevent overfitting and to handle multicollinearity, rather than relying on the distribution of the variables. Both Lasso (L1 regularization) and Ridge (L2 regularization) are particularly useful in preventing overfitting and addressing multicollinearity, common issues in regression analyses with many predictors. This is beneficial regardless of the predictors' distribution. In the context of regression analysis, while the normality assumption is typically about the error terms (residuals) rather than the predictors themselves, Lasso and Ridge can still be valuable. They don't rely on the normality assumption for the error terms and instead focus on producing a more robust and generalized model. Both methods effectively reduce model complexity by penalizing the size of coefficients. Lasso can even set some coefficients exactly to zero, effectively performing feature selection.

Table 12. *Lasso and Ridge Regression Results for ESGC Combined Score and Financial Ratios*

Financial Ratio	Lasso Coefficient	Ridge Coefficient
Profitability	0.00	0.00
Gross Margin	0.00	0.01
EBITDA Margin	-0.20	-0.30

Operating Margin	-1.13	-1.23
Pretax Margin	-1.09	-1.18
Net Margin	-0.97	-1.06
Quick Ratio	0.08	0.18
Current Ratio	0.20	0.30
Debt/Equity	0.86	0.95
A/R Turnover	-0.05	-0.15
Fixed Asset Turnover	-0.44	-0.54

The Lasso and Ridge Coefficients indeed provide valuable insights into how different financial ratios relate to the ESGC Combined Score, reflecting the company's sustainability and social responsibility performance (see Table 12).

3.3.1. Lasso Coefficients

Zeroing Out Some Coefficients: Lasso regression's capability to reduce some coefficients to zero is a form of feature selection. This indicates that certain financial ratios might not be significant predictors of the ESGC Combined Score. For instance, if the Lasso coefficient for a specific ratio like Profitability or Gross Margin is zero, it suggests that these variables might not be crucial in predicting or are not reliably related to ESGC performance under the model.

Simplifying the Model: By eliminating less relevant predictors, Lasso helps in simplifying the model, making it easier to interpret and reducing the risk of overfitting.

3.3.2. Ridge Coefficients

Shrinking Coefficients: While Ridge also reduces the magnitude of coefficients, it does not set them to zero. This suggests that all included financial ratios contribute some information to the model, but their impact is regulated to prevent overfitting and manage multicollinearity.

Continued Inclusion of Features: All variables stay in the model, providing a comprehensive view of the data's structure and how each variable, to a lesser or greater extent, relates to the ESGC Combined Score.

Here's a detailed look into what these coefficients imply and how they shape the understanding of the relationship between financial ratios and ESGC scores:

Profitability and Gross Margin

Lasso Coefficients at Zero: Suggests that Profitability and Gross Margin might not be significant predictors of the ESGC score in the Lasso model, indicating a potential lack of direct association or variability explained by these metrics.

Positive Ridge Coefficients: Indicates that while these ratios don't have the strongest predictive power (as suggested by Lasso), they still maintain a positive relationship with ESGC scores according to Ridge regression. This could imply that while not the most critical factors, Profitability and Gross Margin do reflect some aspects of financial performance affected by sustainable practices.

EBITDA Margin, Operating Margin, and Pretax Margin

Negative Coefficients: Both Lasso and Ridge indicate a negative relationship between these margins and ESGC scores. This could suggest that higher operational costs or investments associated with maintaining or achieving high ESGC standards may initially impact these profitability measures. It reflects the potential short-term financial sacrifices companies might make for long-term sustainability and ethical operations.

Net Margin

Negative Coefficients: Indicates a potential negative relationship between Net Margin and high ESGC scores, possibly due to the initial costs or investments in sustainable practices impacting the bottom line. Companies might experience a decrease in net profitability as they invest in sustainable practices, which may not immediately translate into financial gains.

Quick Ratio and Current Ratio

Positive Coefficients: Suggests that companies with higher liquidity are better positioned to manage and invest in sustainability initiatives. It may reflect a financial health aspect that supports sustainable practices, indicating these companies might be more resilient or capable of maintaining operations while pursuing ESGC goals.

Debt/Equity

High Positive Coefficient: Indicates a possible positive correlation between leveraging and ESGC scores. Companies might be using debt financing to invest in ESGC initiatives, suggesting a strategic approach to funding sustainable growth. This highlights the importance of managing debt levels carefully, as they might reflect investment in long-term sustainability.

A/R Turnover and Fixed Asset Turnover

Negative Coefficients: Suggests an inverse relationship with ESGC performance. Lower A/R Turnover might indicate slower collection processes, and lower Fixed Asset Turnover might indicate less efficient use of assets. Both could potentially impact financial flexibility and capacity to invest in or maintain sustainable practices.

3.4. Implications for Ethical or Green Investment Perspective

Identifying Key Financial Ratios: The Lasso and Ridge results can guide investors and corporate managers by highlighting which financial ratios are more closely associated with higher ESGC scores. This could help focus on areas for improvement or investment that align with sustainability and social responsibility goals.

Informing Investment Decisions: As ESGC scores become increasingly crucial for investors, understanding the financial dimensions most affected by ESGC performance allows for more informed decision-making. Investors might prefer companies with certain financial characteristics known to correlate with higher ESGC scores.

Shaping Corporate Strategy: Companies looking to improve their ESGC scores might analyze these regression results to understand which financial aspects to focus on or adjust. Knowing how various financial ratios impact their ESGC scores can inform strategy and operations to align with ethical and green investment standards.

4. Conclusion

The study confirms a complex yet discernible relationship between ESGC scores and financial performance. Firms with higher ESGC scores generally exhibit more favorable financial indicators such as higher earnings quality, better profitability margins, and improved liquidity ratios, suggesting a positive correlation between responsible corporate behavior and financial health. This relationship is particularly pronounced in the energy sector, reflecting the critical importance of sustainability practices in this industry. These findings are consistent with the growing body of literature that suggests that sustainable practices and ethical operations contribute to enhanced financial performance, risk mitigation, and stock stability [24; 34]. The study's findings also complement the understanding that ESGC engagement can lead to better operational efficiencies, reputational gains, and access to capital [10; 17; 15].

Investors and fund managers are increasingly considering ESGC factors as integral to investment decisions. The study's findings support the notion that integrating ESGC considerations into portfolio management is not only a moral or regulatory compliance issue but also a strategic one that aligns with long-term value creation [54]. Ethical investing strategies that prioritize high ESGC scores may benefit from improved risk-adjusted returns, aligning investors' ethical stances with financial prudence. Companies with robust ESG practices not only contribute positively to social and environmental outcomes but also demonstrate strong financial performance, resilience, and potential for long-term growth.

Energy firms with high ESGC scores tend to manage risks more effectively, showing resilience in their stock performance. The research suggests that comprehensive ESGC strategies can mitigate various risks, including operational, reputational, and regulatory risks, thereby protecting and potentially enhancing shareholder value.

Firms are encouraged to balance short-term financial impacts with long-term ESGC goals. While initial investments in ESGC practices might strain financial ratios like EBITDA or operating margins, the long-term payoff in terms of reduced risks, better customer engagement, and regulatory compliance can lead to improved overall performance.

The energy sector, in particular, is shown to benefit significantly from ESGC practices. Companies in this sector are advised to integrate ESGC strategies into their core operations to manage industry-specific risks effectively and capitalize on emerging opportunities in the green economy.

The study finds a nuanced impact of ESGC scores on stock performance. While there is an initial indication of higher costs or lower margins due to ESGC investments, these are often offset by long-term benefits such as improved reputation, customer loyalty, and operational efficiencies. Consequently, energy firms with higher ESGC commitments might experience more stable and potentially superior stock performance over time.

In the intricate interplay between ESGC scores and financial performance, this study adds empirical weight to the burgeoning body of systematic literature advocating for ethical investing. Aligning

with the findings of Barber et al. (2021) [4] and Agrawal and Hockerts (2021) [1], this study underscores the positive correlation between robust ESGC practices and enhanced financial metrics, such as earnings quality and profitability. These correlations are not merely incidental but foundational to the philosophy that ethical practices are integral to sustainable business success and long-term value creation.

The empirical findings resonate with the assertions made by Berk and Binsbergen (2021) [5] and de Jong and Rocco (2022) [14], reinforcing the notion that ethical investing is not a trade-off between moral values and profitability but a synergistic strategy that leverages responsible practices for better financial outcomes. This synergy is particularly evident in the operational efficiencies and risk mitigation strategies observed in firms with higher ESGC scores, lending credence to the body of work by Friede et al. (2015) [24], and Fulton et al. (2012) [26].

The nuanced relationship between ESGC and financial performance highlighted in this study acknowledges the complexities and sector-specific impacts discussed in the works of Weston and Nnadi (2023) [61] and Pedersen et al. (2021) [46]. This aligns with the broader academic discourse that calls for a more refined understanding of how ESGC factors manifest in different corporate contexts and geographic regions, emphasizing the need for sophisticated, context-sensitive investment analyses.

In advocating for refined analytical tools and methodologies, this study echoes the sentiment of Chen and Xie (2022) [9] and Liu et al. (2022) [39], who emphasize the importance of advanced statistical methods and sector-specific insights in accurately assessing the impact of ESGC factors on financial performance. These methodological advancements are crucial in enabling investors to navigate the complexities of ethical investing and make informed decisions that align with both their financial objectives and ethical standards.

Enhanced Earnings Quality and Profitability: Firms with higher ESGC scores demonstrate a notable increase in earnings quality and profitability. This suggests that ethical practices and sustainable strategies contribute significantly to financial robustness, echoing the narratives of Barber et al. (2021) [4] and Agrawal and Hockerts (2021) [1].

Operational Efficiency: Companies engaged in responsible and ethical practices tend to show improved operational efficiencies, as indicated by higher gross and EBITDA margins. This aligns with the assertions made by Berk and Binsbergen (2021) [5] and de Jong and Rocco (2022) [14], who highlight the synergistic benefits of integrating ESGC considerations into business operations.

Risk Mitigation and Strategic Value: The findings resonate with the comprehensive analysis of Friede et al. (2015) [24] and Fulton et al. (2012) [26], emphasizing that ethical investing not only mitigates risks but also adds strategic value by aligning companies with future sustainability trends and regulations.

Sector-specific Impacts and Geographical Nuances: The study acknowledges the sector-specific impacts and geographical nuances of ESGC practices, suggesting that the benefits and challenges of ethical investing vary across industries and regions, a notion supported by Weston and Nnadi (2023) and Pedersen et al. (2021) [46].

The utilization of advanced statistical techniques, K-Means clustering, DBSCAN, Lasso, and Ridge regression provide deep insights into the nature of the relationship between ESGC scores and financial metrics. These methods reveal the nuanced ways in which different financial ratios are asso-

ciated with ESGC performance, allowing for more targeted and effective strategies for improving both financial and ESGC outcomes.

The study's findings, particularly through violin plots and co-occurrence analyses, offer investors robust tools for assessing the ESG and financial landscape of potential investments. By understanding the complex interactions between ESG factors and financial performance, investors can make more informed decisions aligned with both ethical standards and profitability goals.

5. Policy Implications and Regulatory Considerations:

In the realm of ethical investing, this comprehensive study dovetails with the growing body of systematic literature underscoring the multifaceted relationship between ESGC scores and financial performance. The convergence of empirical findings with prior research highlights the evolving narrative of ethical investing, not just as a niche strategy but as a robust approach that intertwines corporate responsibility with financial viability.

This analysis echoes the sentiments of studies indicating that firms with higher ESGC scores often exhibit superior financial metrics, such as enhanced earnings quality, operational efficiency, and profitability margins. This relationship underscores the fact that ethical practices and sustainable operations are not merely compliance obligations but are integral to fostering long-term corporate health and stakeholder value. These findings align with the broader trend of ethical investing gaining traction as a mainstream investment philosophy, driven by both moral imperatives and economic rationale.

The positive correlation between ESGC engagement and financial performance found in this study is corroborated by similar research, reinforcing the idea that sustainable business practices contribute to operational excellence and risk mitigation. As indicated in the literature, companies that invest in sustainable practices tend to benefit from reduced operational costs, enhanced brand reputation, and increased customer loyalty—all of which culminate in stronger financial performance.

As the global investment community continues to grapple with environmental challenges, social disparities, and governance issues, the impetus for ethical investing becomes increasingly compelling. This study, supported by a systematic review of the literature, reaffirms the pivotal role of ethical investing in steering the corporate world towards a more sustainable and equitable future. It calls for a concerted effort among investors, corporations, policymakers, and academics to foster a more sustainable financial ecosystem, where ethical considerations are seamlessly integrated into investment strategies and corporate practices.

Investors can use ESGC scores as a risk assessment tool to evaluate the long-term sustainability and risk management of companies in their portfolios. Companies with higher ESGC scores may carry lower operational and regulatory risks, making them attractive investments. ESGC metrics also help investors align their portfolios with environmental, social, and governance goals. The study advocates for the development and adoption of global ESGC standards to facilitate more accurate comparisons and assessments across firms and industries. This can enhance the reliability of ESGC metrics and further integrate sustainability into mainstream investment strategies.

Policymakers are urged to consider the findings of this study in shaping regulations and incentives. Promoting transparency and accountability in ESGC reporting can further enhance the positive impact of ESGC practices on financial performance and risk management.

Energy firms can enhance their ESGC scores by adopting strategies such as transitioning to renewable energy, investing in energy-efficient technologies, and prioritizing worker and community safety. Strengthening diversity and inclusion, ensuring transparency, and improving governance practices can also contribute to better ESGC performance.

While general recommendations for enhancing ESGC performance provide a strong foundation, this study emphasizes the importance of tailoring these strategies to the distinct characteristics of sub-sectors within the energy industry. Renewable energy firms, with their low carbon emissions and focus on environmental sustainability, are well-positioned for ESGC performance improvements. Key strategies include investing in innovative technologies like energy storage and improving grid integration to ensure reliable energy supply. Governments can accelerate growth through incentives such as low-interest loans, tax credits, and subsidies, as seen in the EU's Green Deal initiatives. Additionally, companies must prioritize transparent environmental impact assessments and engage with local communities to enhance project acceptance and social legitimacy, ensuring long-term sustainable growth.

To enhance ESGC performance, the fossil fuel sector must focus on reducing carbon emissions through strategic measures. Investing in carbon capture and storage (CCS) technologies and prioritizing cleaner fossil fuels like natural gas can aid the energy transition. Effective environmental risk management is crucial, requiring stricter regulations to prevent incidents like oil spills and gas leaks. Additionally, diversifying energy portfolios by investing in renewable projects can help fossil fuel firms lower their environmental impact and tap into new market opportunities. Governments could facilitate this shift by implementing targeted tax credits and financial incentives for firms that achieve measurable reductions in carbon emissions. By contrast, fossil fuel companies face distinct challenges, necessitating stricter environmental regulations and the implementation of carbon pricing mechanisms. Such policies could encourage a gradual transition towards cleaner energy sources while simultaneously addressing the sector's significant environmental impact. Furthermore, nuclear energy firms must prioritize transparency and safety in their ESGC strategies, given the sector's unique risks. Strengthening regulatory frameworks that mandate regular safety audits and the disclosure of waste management practices would not only enhance governance scores but also build public trust.

Nuclear energy offers low carbon emissions but faces significant environmental and social risks related to safety and waste management. Companies must enhance safety protocols, invest in innovative waste disposal technologies, and maintain transparent reporting to build public trust. Effective communication with local communities is key to addressing public concerns. Additionally, investing in research and development for next-generation reactors can improve safety and reduce waste, supporting long-term sustainability in the sector.

Beyond sector-specific strategies, the role of governments and regulatory bodies is paramount in creating a conducive environment for effective ESGC integration. A key recommendation of this study is the standardization of ESGC metrics across countries and industries, addressing the inconsistencies in scoring methodologies that can lead to information asymmetry and the risk of "greenwashing." Establishing a unified global framework for ESGC reporting would enhance comparability,

allowing investors to make more informed decisions. Collaborative efforts by international bodies, such as the United Nations and IFRS, could be instrumental in developing these standards, thus ensuring consistent and reliable disclosure practices. Moreover, governments can play a proactive role in promoting green financing instruments, like green bonds and sustainability-linked loans, which provide financial support to companies with strong ESGC performance. Introducing lower capital requirements for banks that issue green bonds could incentivize financial institutions to channel resources towards sustainable projects, thereby amplifying the positive impact of ESGC initiatives.

In conclusion, ESGC scores, sustainability practices, key financial ratios, worldwide governance indicators, and culture are essential for energy firms seeking to maintain and increase their competitive advantage, gain the trust of stakeholders, and achieve long-term success. By prioritizing these factors, companies can reduce their environmental impact, improve their financial health, enhance their reputation, attract investment, and attract and retain top talent. As sustainability and social responsibility become increasingly important to consumers and investors, energy firms that prioritize ESGC scores, sustainability practices, financial ratios, governance practices, and culture are more likely to succeed in the long run.

While the study covered a broad range of companies and countries, the availability and quality of ESGC data might still be limited, especially for firms in emerging markets or smaller enterprises. This limitation can affect the generalizability and depth of the findings. The study largely relies on static snapshots of financial ratios, which might not fully capture the dynamic and evolving nature of companies' operational and financial strategies influenced by ESGC factors. Future research should focus on longitudinal studies that track the ESGC and financial performance of companies over time. Such studies can provide more insight into the long-term impacts of ESGC initiatives and the evolution of corporate strategies. Given the diversity across sectors in terms of ESGC impact and financial performance, sector-specific studies could yield more nuanced insights. Understanding how ESGC factors play out in different industrial contexts can inform targeted investment strategies and policy measures. Incorporating alternative data sources, such as sentiment analysis from social media, detailed supply chain assessments, or climate impact models, could enrich the analysis and provide a more comprehensive view of a company's ESGC performance. As governments and international bodies implement new regulations or standards related to sustainability and corporate governance, future research should assess how these changes impact ESGC practices and financial performance across industries and regions. Understanding how the growing emphasis on ESGC factors shapes investor behavior, market dynamics, and company strategies can provide valuable insights for both practitioners and academics. This includes examining the role of ESGC in investment decisions, asset pricing, and market reactions to ESGC-related news.

Declaration of Interest Statement

The author declares no potential conflicts of interest with respect to the research, authorship, and/or publication of this article. The research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest. The author has not

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Furthermore, the author affirms that this manuscript is an original work and has not been published elsewhere in any form or language (partially or in full), nor is it currently under consideration for publication elsewhere. There are no relevant financial activities outside the submitted work. This statement also confirms that the manuscript reflects the author's own research and analysis in a truthful and complete manner.

Data Availability Statement

The data that support the findings of this study are available from Reuters Refinitiv Eikon. Restrictions apply to the availability of these data, which were used under license for this study. Data are available from the authors with the permission of Reuters Refinitiv Eikon.

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