ASSESSING THE STABILITY OF ESG INVESTMENTS USING A GARCH (1,1) MODEL

by

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ABSTRACT

This study investigates the volatility, stability, and resilience of Environmental, Social, and Governance (ESG) securities compared to non-ESG securities under varying market conditions. Using the GARCH (1,1) model, we analyze daily financial data from 2020 to 2024 to evaluate how ESG securities respond to market shocks and volatility dynamics. Our analysis focuses on three key dimensions: whether ESG securities exhibit lower volatility, maintain stability over extended periods, and recover more effectively from external disruptions such as the COVID-19 pandemic.

The research results show that ESG securities demonstrate significantly lower conditional volatility, with faster reversion to stable states than non-ESG counterparts. During market turbulence, ESG securities experience smaller price declines and quicker recovery, highlighting their resilience. Sector-specific analysis reveals that renewable energy and technology sectors benefit most from ESG integration, while traditional industries show limited improvements. These findings suggest that ESG investments mitigate financial risk and enhance long-term securities sustainability.

This research contributes to the sustainable finance literature by empirically validating the risk-management advantages of ESG strategies. It provides practical insights for investors and policymakers seeking to align financial goals with sustainability objectives. While the study relies on historical data and aggregated ESG metrics, future work could explore dynamic ESG scoring and cross-regional comparisons to refine the understanding of ESG financial impact further.

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CHAPTER 1 INTRODUCTION

1.1 BACKGROUND

ESG (Environmental, Social, and Governance) investment has become popular because investors want to achieve financial gain and sustainability outcomes. Regulatory measures such as Europe's Sustainable Finance Disclosure Regulation and the growing power of large institutional investors managing trillions of assets focused on ESG principles mainly drive this shift (Friede et al., 2015). The financial stability of ESG investments remains uncertain among experts who continue to debate their volatility even though these investments enjoy widespread popularity.

The level of volatility significantly impacts investment risk, affecting both investor confidence and their choice of securities. According to traditional financial models, lower volatility appeals to conservative investors (Bollerslev, 1986), but the research results on ESG investments show inconsistent findings. Research by Nofsinger and Varma (2014) demonstrates that ESG securities maintain stability during financial crises like 2008 because of strong governance practices. Revelli and Viviani (2015) state that ESG-related risk demonstrates variations across different industries. Renewable energy companies excel under ESG criteria, but fossil fuel companies encounter difficulties that demonstrate sector-specific elements matter.

The COVID-19 pandemic tested financial resilience on a large scale, intensifying discussions about ESG investment strategies. According to Demers et al. (2021), firms emphasizing ESG principles showed more performance stability and quicker recovery than their non-ESG counterparts, because of their robust governance structures and active risk management strategies. Most current studies prioritize return analysis instead of examining risk-adjusted stability. There remains an important knowledge gap regarding how ESG investments manage volatility through the unpredictable period of 2020 to 2024. The study uses a GARCH model to analyze long-term volatility trends and the stability of ESG investments instead of concentrating on brief market reactions to specific events.

This paper examines the volatility of ESG and non-ESG securities using the GARCH (1,1) model. By analyzing financial data from 2020 to 2024, we aim to determine whether ESG investments carry lower risk, maintain stability for extended periods, and show greater resilience to external shocks. This study examines the differences between ESG Security and non-ESG Security without examining strategies that combine both approaches. The findings will add to the ongoing discussion on sustainable finance by providing empirical evidence on the risk-return tradeoffs in ESG investing. Additionally, the study offers valuable insights for policymakers, institutional investors, and asset managers interested in developing effective ESG investment strategies.

1.2 MOTIVATION

This paper was motivated by the growing global interest in sustainable finance and the role ESG investing plays in shaping the markets. ESG securities have captured institutional and retail investors' attention, but stability and risk remain a topic of debate. Assessing whether ESG has stronger resilience, more stable volatility, and long-term stability than non-ESG is more important for researchers, policymakers, and investors.

Market shocks such as COVID-19 have shown that financial stability is essential, and investors are looking for safer investments for long-term sustainability. Although previous studies have examined ESG returns, few focus on risk factors like volatility. GARCH models provide stable analysis for volatility and can be used to evaluate the stability of ESG investments under different market conditions.

The analysis of ESG and non-ESG securities using the GARCH (1,1) model will help to improve existing work by showing whether ESG securities have lower risk, higher stability, and stronger resilience to shocks. Results will be helpful for institutional investors, asset managers, and policymakers in designing investments that match financial performance with sustainability goals.

1.3 RESEARCH QUESTIONS

This study investigates the volatility characteristics, stability, and resilience of ESG securities compared to non-ESG securities, volatility as the main factor that determines ESG securities performance despite its connection with stability and resilience. This study aims to answer the following research questions:

(1) The initial research question investigates if securities with ESG investments

demonstrate reduced volatility compared to securities without ESG investments. The level of volatility is a key indicator of investment risk, which affects investor trust and the distribution of capital resources. Investors commonly view ESG securities as less volatile because they benefit from stronger governance and long-term risk management strategies. However, Research findings present mixed results regarding ESG investments because some studies show decreased risk exposure while others find volatility levels that match or exceed those of traditional non-ESG investments. This research will apply the GARCH (1,1) model to test if ESG investments demonstrate less volatility consistently.

(2) The second research question assesses if ESG investments demonstrate sustained stability across extended time frames compared to traditional non-ESG securities. Investors depend on stable financial performance, because extended periods of low volatility improve their risk management strategies and securities planning efforts. The research employs conditional volatility estimates derived from the GARCH model to examine if ESG securities maintain financial stability for extended periods compared to non-ESG securities in fluctuating markets.

(3) The third research question examines whether ESG investments maintain more substantial stability against external shocks than traditional non-ESG securities. Financial market resilience has become a prominent focus due to economic disruptions such as COVID-19. ESG securities that show faster recovery and reduced volatility after-market shocks could provide better ways to mitigate investment risks. This research analyzes how ESG and non-ESG securities respond to external financial stress events. This study will enhance the comprehension of ESG investment risk-return characteristics while providing valuable insights for institutional investors, asset managers, and policymakers regarding ESG integration's impact on financial stability.

1.4 THESIS STRUCTURE

The study comprises five primary chapters that explore different aspects of applying GARCH models to analyze the stability and volatility of investments related to environmental, social, and corporate governance factors.

Chapter 1 establishes the subject of research by underscoring the importance of ESG investments while explaining why evaluating their market stability and volatility is essential. The section establishes research motivations before identifying key research questions and summarizing the study's objectives.

Chapter 2 delivers an extensive literature review, summarizing past research on environmental, social, and governance investments alongside financial stability and volatility modeling techniques. This section explores theoretical models and real-world data to evaluate how ESG investment securities perform compared to traditional non-ESG securities. The chapter explains econometric models from previous studies, which serve as the basis for this study's methodological framework.

Chapter 3 describes the research methodology used to address the research questions. The chapter discusses how financial data was selected, the criteria used to classify securities into ESG or non-ESG categories, and the econometric techniques implemented to study patterns in volatility. The chapter describes the assumptions of the GARCH (1,1) model's assumptions, estimation steps, and diagnostic tests to validate its performance.

Chapter 4 displays empirical data and evaluates the findings. The chapter contains descriptive statistics and model estimation results and examines the differences between ESG and non-ESG securities regarding their volatility profiles and stability under various economic pressures. The analysis evaluates whether ESG investments create measurable financial advantages through risk management.

Chapter 5 details the primary conclusions from the study while exploring how these findings influence investment professionals and decision-makers. The study acknowledges its limitations and proposes additional research to broaden ESG volatility analysis across different market environments and investment strategies.

The research methodology provides direction from initial background analysis through conclusions by performing an in-depth study of ESG investment stability in financial markets.

CHAPTER 2 LITERATURE REVIEW

2.1 OVERVIEW

In recent years, financial analysts and academic researchers have shown growing interest in environmental, social, and governance (ESG) factors in financial markets. The current security management landscape places vital importance on ESG investing due to ongoing regulatory evolution and rising investor consciousness alongside corporate sustainability pledges. Research papers extensively study ESG investment performance, yet their market behavior and stability during economic changes continue to spark debate.

This chapter examines existing research on ESG investments, explicitly focusing on their financial volatility and associated risk factors. The chapter starts by evaluating theoretical models that demonstrate the influence of ESG factors on financial stability. Through the analysis of empirical data, this chapter assesses ESG securities returns and examines how these securities behave under volatility and react to financial market disruptions. This chapter conducts ESG risk analysis by implementing econometric methods within volatility models, such as the GARCH model framework.

This chapter reviews past research to form a foundation for this study while identifying gaps and proving the need for further empirical investigation. The review findings will shape future chapters' research methods and foster discussions regarding sustainable finance and risk management.

2.2 THEORETICAL FRAMEWORK

2.2.1 ESG and Financial Market Theories

Investment strategies based on ESG factors introduce additional dimensions to classic financial market models such as those incorporating size and value factors and promptly reevaluate their fit with established asset pricing theories and market efficiency concepts. Investment decisions that include ESG elements have sparked continuous discussions about their influence on risk management, return generation, and market efficiency. The Efficient Market Hypothesis (EMH) and the Capital Asset Pricing

Model (CAPM) provide theoretical structures to analyze how ESG factors interact with financial markets.

Fama (1970) introduced the EMH, which suggests that financial markets incorporate all existing information, eliminating the possibility of investors earning excess expected returns. Under this framework, stock prices must fully integrate ESG information, which means ESG investment strategies should not systematically produce better or worse market performance. Research findings demonstrate that ESG-related data faces information asymmetry because companies use different disclosure standards and rating methodologies, which are impacted by varying regulatory frameworks (Berg, Koelbel, & Rigobon, 2022). Companies demonstrating excellent ESG performance may not see their stock prices adjust instantly to match their future financial stability, creating temporary mispricing opportunities. Limited ESG transparency allows better information access and analysis by some investors to give them a competitive advantage. This inconsistency questions the validity of EMH because it reveals that ESG elements might not be wholly accounted for in market pricing, which could offer extra returns through ESG investment strategies (Amel-Zadeh & Serafeim, 2018).

According to the CAPM model created by Sharpe (1964), asset returns depend on systematic risk, which is quantified by beta. ESG factors should only impact the expected returns of a company if they alter the firm's systematic risk level. Research indicates that firms that focus on ESG principles demonstrate lower beta values, which indicate diminished systematic market risk (Dhaliwal et al., 2011). The reduced volatility of ESG-compliant companies is explained by their stable earnings alongside diminished regulatory risks and robust corporate governance systems. Research findings demonstrate that ESG investment strategies create valuation distortions. The rising interest in ESG assets has created a "green premium," leading investors to pay higher prices for sustainable stocks, which could result in lower future returns even though these investments involve lower risk (Pástor, Stambaugh, & Taylor, 2021). One must consider if ESG investment delivers sustained financial returns or if the additional costs paid by investors nullify risk reduction benefits (Giese et al., 2019).

The Modern Portfolio Theory established by Markowitz (1952) states that optimal risk-return balance in a portfolio can be achieved by diversification, which reduces unsystematic risk. ESG integration reduces firm-specific risks such as environmental penalties and governance failures, which leads to lower portfolio volatility, as suggested by Whelan et al. (2021), through improved operational stability. ESG investments that concentrate on renewable and technology sectors pose diversification risks that oppose the broad investment principles of Modern Portfolio Theory, as Boffo and Patalano (2020) identified potential underperformance in diverse market situations. Initially, the Fama-French model contained three factors (Fama & French, 1993), but it expanded into five factors (Fama & French, 2015) to integrate size, value, profitability, and investment with CAPM's beta. The research by Cheema-Fox et al. (2021) shows that firms with high ESG scores share characteristics with profitable large-cap firms, which implies that their stability may stem from these business traits.

Research studies have not yet produced clear answers on the relationship between ESG investing and the principles of traditional financial theory. Some researchers endorse ESG strategies as vehicles for financial success via improved reputation, stakeholder connections, and operational advancements. In contrast, other researchers identify barriers such as inconsistent evaluations, greenwashing problems, and liquidity constraints (Krueger, Sautner, & Starks, 2020). Behavioral finance further complicates ESG's theoretical alignment. Statman (2005) states that investor sentiment driven by ethical preferences leads to ESG valuations exceeding fundamental values because millennial capital flows into green funds. According to Hartzmark and Sussman's (2019) analysis, socially responsible funds received capital inflows that pushed their prices up by 5-10% despite diverse financial results, demonstrating that irrational investor enthusiasm affects ESG markets, thus creating market volatility and questioning the established pricing theories. ESG investment behaviors are affected by behavioral finance elements that can move ESG stock valuations from fundamental values, because of investor sentiment and preferences (Schueth, 2003). The development of ESG investing creates a need for a deeper analysis of how it affects asset pricing models and market activities.

2.2.2 ESG and Portfolio Volatility

Extensive research in financial literature examines the connection between ESG investing and portfolio volatility, which produces inconclusive results regarding its potential stabilizing impact. Studies show ESG integration can reduce risk through better corporate governance and firm-specific uncertainties. At the same time, other research indicates that ESG investment approaches might create extra volatility through valuation distortions and sectoral concentration.

Recent research findings demonstrate that firms with substantial ESG compliance show less volatility than non-ESG firms because of better corporate governance practices, enhanced risk management capabilities, and stronger investor trust. Bollen (2007) discovered that socially responsible funds encountered a 10% decline in idiosyncratic risk, also known as firm-specific risk, refers to the portion of an investment's total risk that is unique to a particular company or asset, rather than being influenced by broader market movements, and El Ghoul and Karoui (2017) determined that companies with superior ESG performance exhibited 15% lower earnings volatility. Fatemi, Glaum, and Kaiser's (2018) research supports these results, as they demonstrated that companies with firm ESG disclosure could achieve reduced uncertainty and lower capital costs, stabilizing their stock prices.

ESG factors do not consistently affect volatility across different industrial sectors. This research uses GARCH (1,1) modeling to separate total volatility into market-wide persistent fluctuations and firm-specific variations. The methodology allows for analysis of the impact of ESG factors on volatility across various industries both in the short-term and long-term. According to Broadstock et al. (2021), renewable energy and technology sectors demonstrated the most significant advantages of ESG integration by experiencing reduced volatility. Traditional industries, including oil and gas, displayed increased volatility because of regulatory pressures and transition risks. Sassen, Hinze, and Hardeck (2016) demonstrated that emerging markets experience more ESG-driven volatility because of inconsistent enforcement of regulations and diminished investor trust in sustainability reports.

According to key arguments supporting its adoption, ESG investing benefits from its proven ability to withstand financial crises. Studies demonstrate that companies focused on ESG principles face less severe stock price drops and quicker rebounds throughout economic disturbances. Research by Minor (2015) demonstrated that companies aligned with ESG principles experienced a 5% lower downside risk during financial crises. During the COVID-19 crisis, research by Albuquerque et al. (2020) showed that ESG stocks surpassed non-ESG stocks by 7%, demonstrating how robust corporate governance and social responsibility strengthen financial stability.

Research findings from the 2008 financial crisis supported these observations. CSR-focused companies showed 4-7% higher returns (Lins et al., 2017). Di Giuli and Kostovetsky (2014) found short-term ESG portfolio volatility affected by political and social factors but resulted in stable long-term performance. Cheema-Fox et al. (2021) demonstrated how mutual funds committed to ESG practices experienced less damaging performance during market downturns, thus supporting the idea that ESG practices strengthen overall risk management capabilities.

The current research indicates that ESG resilience does not apply to all cases universally. Demers et al.'s (2021) study demonstrated that ESG investments did not prevent firms from experiencing COVID-19 volatility. However, firms that invested in intangible assets like human capital and innovation showed more stability. The resilience attributed to ESG factors requires that interaction with broader corporate strategies be fully understood.

Investments centered around ESG demonstrate stability over an extended period, although specific research reveals potential short-term volatility issues. Auer and Schuhmacher (2016) found that ESG portfolios experienced heightened volatility after fast-paced capital inflows, particularly in preferred sectors such as renewable energy. Berg, Koelbel, and Rigobon's (2022) findings revealed that multiple ESG rating systems generate pricing inefficiencies and confusion for investors through disparate evaluation methods, resulting in "aggregate confusion."

According to Broadstock et al. (2021), renewable energy stocks experienced reduced volatility when benefiting from strong policy support, but traditional fossil fuel stocks demonstrated higher price volatility. Per Fatemi, Glaum, and Kaiser (2018), companies in highly regulated sectors face short-term volatility while adapting to new ESG compliance rules.

According to Lins et al. (2017), the temporary valuation distortions of ESG stocks resulted from large investment inflows that supported ESG investments without fundamental business enhancements.

According to Giese et al. (2019), the increased demand for ESG assets leads to a "green premium" that elevates sustainable stock prices but could reduce future returns despite lessened risk exposure.

Research on ESG volatility includes analysis of both long-term stability advantages and short-term market condition changes. ESG portfolios experience reduced volatility because of better governance and risk management, but they stay exposed to sector composition effects, valuation distortions, and asymmetrical information challenges. ESG funds exhibit market downturn resilience but encounter risks shaped by specific industry factors and investor mood shifts. Research needs to explore the effects of enhanced ESG disclosure methods and regulatory developments on ESG volatility under various market circumstances.

2.2.3 Econometric Models for Asset Price Volatility

The expanded financial market use of ESG criteria has led to increased research utilizing econometric models to explore ESG asset volatility patterns. The Capital Asset Pricing Model and Fama-French multifactor models present elementary concepts of risk-return relationships but fail to accurately capture temporal changes in financial market volatility (Fama, 1970). Researchers utilize Generalized Autoregressive Conditional Heteroskedasticity (GARCH) models to address traditional models' limitations, allowing them to dynamically analyze portfolio volatility across ESG and non-ESG investments (Bollerslev, 1986).

Bollerslev (1986) built upon Engle's (1982) ARCH framework to design GARCH models that capture the volatility clustering phenomenon in financial market returns. The expanding scholarly focus on comparing the volatility between ESG and traditional investments has made the GARCH (1,1) model a prevalent choice for empirical ESG studies. Cheema-Fox et al. Cheema-Fox et al. (2021) utilized GARCH models to examine ESG mutual funds. Their analysis demonstrated that funds with more substantial ESG commitments showed lower downside risk during financial crises because ESG-focused companies tend to implement better risk management systems, which help reduce volatility.

The hypothesis that ESG portfolios demonstrate lower volatility lacks universal empirical validation. Investments focused on environmental, social, and governance factors in rapidly expanding sectors like technology and renewable energy showed increased volatility compared to traditional industry investments, which indicates that ESG investment strategies do not consistently lower risk for different asset types. The study by Auer and Schuhmacher (2016) found that ESG investment strategies can create short-term volatility through valuation changes and sector concentration during peak investor demand for compliant assets.

The GARCH model gained importance, because it evolved from Engle's (1982) ARCH model, which discovered volatility clustering patterns where big return shocks cause more market instability. Bollerslev (1986) extended the model into a GARCH by combining historical shocks with variance measures to improve the fit of financial data that includes ESG volatility patterns. Previous volatility models, like stochastic volatility, demonstrated less adaptability, which helped establish GARCH as a central model in volatility analysis (Bollerslev et al.,1992).

ESG rating discrepancies cause modeling difficulties for ESG-related volatility analysis. Berg, Koelbel, and Rigobon (2022) demonstrate how the aggregate confusion problem emerges because ESG scores provided by various rating agencies show weak correlations, making it difficult to empirically evaluate ESG-related risk. Variations among ESG ratings create inconsistencies in volatility predictions, because investors react differently to ESG classifications from various sources. Krueger, Sautner, and Starks (2020) suggest that new regulations in ESG disclosure standards could cause extra market volatility because firms change their sustainability reporting methods to meet new requirements.

Researchers have examined advanced GARCH model extensions to gain insight into asymmetric volatility patterns in ESG investments. Research studies have utilized the Exponential GARCH (EGARCH) model to demonstrate its distinctive responses to positive and negative return shocks, which helps analyze how ESG investments react differently to adverse market events compared to traditional assets (Fatemi, Glaum, &

Kaiser, 2018). These extensions enhance our ESG volatility comprehension yet encounter empirical application hurdles due to data constraints and computational estimation difficulties.

The EGARCH model from Nelson (1991) enables better analysis by illustrating how adverse shocks, such as environmental scandals, create more enormous volatility impacts than positive events. Fatemi et al. (2018) connect price impact differences in ESG contexts to adverse events. Disclosure inconsistencies help Fatemi et al. (2018) better understand ESG risks in greater depth.

Current research demonstrates that GARCH-based methods serve as fundamental instruments for evaluating the volatility features of ESG investments. Mixed evidence exists because findings change based on market structure, sector allocation choices, and investor sentiment. Researchers need to develop more precise econometric models to measure the impact of ESG disclosure enhancements and regulatory shifts alongside macroeconomic conditions on ESG portfolio volatility patterns.

2.3 ESG INVESTMENT MECHANISMS ACROSS MARKETS

The emergence of ESG investing as a core element in modern financial markets stems from increasing investor demand for sustainable investment options. ESG factors create complexity and multiple layers when applied to investment decisions, asset valuation methods, and risk management practices.

Investors focus on ESG investments by incorporating ESG factors into traditional financial analysis, which requires examination of environmental management alongside social responsibility and governance structure together with financial indicators (Kotsantonis, Pinney, & Serafeim, 2016). ESG integration focuses on enhancing long-term value creation and reducing financial and reputational risks by incorporating sustainable development risks and opportunities into asset valuation analysis (Gibson, Krueger, & Schmidt, 2021). According to Whelan, Atz, Van Holt, and Clark (2021), organizations that implement strong ESG practices enjoy better operational efficiency and financial results over time and maintain lower capital costs. Scholars argue that ESG requirements could restrict capital allocation, thus reducing diversification and leading to underperformance in particular market situations (Boffo & Patalano, 2020).

Investor decision-making and activity significantly affect the implementation of ESG investment strategies. The growing appeal of socially responsible investing encourages fund managers and institutional investors to invest their funds in companies with high ESG ratings (Hartzmark & Sussman, 2019). Standardized ESG indicators and rating methods remain absent, leading to evaluation difficulties that create inconsistencies in portfolio construction and risk assessment, as highlighted by Ceccarelli, Ramelli, and Wagner (2023).

Financial experts extensively debate the economic ramifications of ESG investment practices. Companies that adopt ESG principles experience superior risk-adjusted returns from strengthened corporate governance and reduced environmental and social controversies (Revelli & Viviani, 2015). Certain ESG investments require investors to decide between financial returns and ethical considerations while maintaining profitability and sustainability goals (Lins, Servaes, & Tamayo, 2017).

Several structural challenges continue to hinder ESG investing despite its expanding market presence. The lack of universal ESG reporting standards creates significant challenges when comparing ESG performance between firms and industries (Amel-Zadeh & Serafeim, 2018). The absence of transparent reporting standards has triggered worries about "greenwashing" practices where companies falsely boost their ESG accomplishments to garner investments with no real sustainability progress (Fatemi, Glaum, & Kaiser, 2018). Through the implementation of standardized ESG disclosure requirements alongside enforcement mechanisms, regulatory bodies take action to address these inconsistencies, according to Dhaliwal, Li, Tsang, and Yang (2011).

The future of ESG investing is predicted to evolve through regulatory changes, enhanced ESG data analysis capabilities, and growing investor scrutiny (Zhang, Tan, Wirjanto, & Porth, 2023). Combining artificial intelligence with big data in ESG analysis will provide better transparency and comparison, which will help investors make decisions using dependable ESG metrics (Ceccarelli et al., 2023). The effectiveness of ESG investing in advancing sustainable finance and economic stability depends on developing standardized assessment frameworks as the approach evolves.

2.4 REVIEW OF EMPIRICAL EVIDENCE

2.4.1 Empirical Studies on Asset Price Risk and Volatility

Recent empirical research shows that companies with firm ESG commitments maintain better financial stability, reducing stock price volatility. According to research studies, companies demonstrating robust environmental, social, and corporate governance practices show decreased stock price volatility during market stress. The observed effect arises primarily from better risk management practices, more robust corporate governance, and elevated investor trust in businesses focusing on sustainable development (Wu, Zhu, & Tao, 2024).

Chinese A-share listed companies that attained higher ESG scores experienced less fluctuation in stock prices from 2011 to 2021. The research demonstrated that better analyst attention and enhanced corporate reputation are important intermediaries linking ESG performance with volatility while confirming that companies mindful of ESG principles secure more dependable investor support (Xu, 2023). Studies that examined ESG ratings during the COVID-19 pandemic showed how companies with higher ESG ratings experienced smaller volatility spikes in their stock prices compared to those with lower ESG ratings (Broadstock, Chan, Cheng, & Wang, 2021). Eikon employs a methodology which evaluates more than 630 ESG indicators at the firm level and applies industry and country-specific weighting to these metrics.

The dynamic of market stability relies heavily on how investors direct their attention. High ESG-rated companies attract institutional investors, leading to more stable investments, which helps suppress price volatility (Wu et al., 2024). ESG investment stabilizes market volatility by attracting long-term investors and reducing speculative trading, which leads to steadier prices (Albuquerque, Koskinen, Yang, & Zhang, 2020). According to Lins, Servaes, and Tamayo (2017), strong corporate governance practices decrease the likelihood of financial problems and regulatory issues, which help maintain stable stock prices.

Research by Xu (2023) proves the trend by showing that Chinese A-share firms with high ESG ratings decreased stock price volatility by 12% from 2011–2021 because of attention from analysts. Broadstock et al. (2021) show a stock price decline of 7%

during COVID-19 as ESG leaders experienced a 9% decrease in stock price volatility due to stable investment (Wu et al., 2024). The COVID-19 pandemic saw a 7% reduction in volatility, confirming consistent ESG improvements reported in multiple studies (Broadstock et al., 2021).

Machine learning and AI-based sentiment analysis breakthroughs have unveiled fresh perspectives on reducing volatility through ESG strategies. A research initiative that created deep learning frameworks for ESG news analysis showed that real-time ESG sentiment data leads to better volatility prediction and risk evaluation outcomes (Guo et al., 2020). ESG factors' importance emerges in risk management and financial modeling predictive capabilities.

Research shows strong empirical evidence that better ESG performance leads to lower stock price volatility. ESG initiatives strengthen corporate governance and investor trust while simultaneously building financial stability, which proves essential during economic disruptions. Improved ESG reporting and data quality create opportunities for future studies to examine how ESG influences financial risk management evolution and enables market participants to utilize ESG analytics for portfolio stability improvement.

2.4.2 ESG and Crisis Performance

Numerous studies have focused on how Environmental, Social, and Governance (ESG) performance affects corporate financial stability throughout crises. Contemporary research gives a detailed understanding of ESG factors' effects on firm durability during challenging periods.

Al Amosh and Khatib (2023) performed a comparative study on ESG performance for developing and developed countries throughout the COVID-19 pandemic. The research demonstrates that firms following ESG principles gained advantages during the pandemic and established ESG as essential for corporate resilience across various economic environments.

Lee (2024) explored how ESG performance affects firm risk among U.S. financial companies. The research identified a substantial inverse relationship between composite ESG performance scores and different risk indicators, such as total risk alongside idiosyncratic and systematic risks. The social and governance pillars showed a stronger negative correlation with firm risk than the environmental pillar, demonstrating the importance of strong social and governance practices in reducing financial risks.

Bax et al. Bax et al. (2021) explored whether ESG scores indicate a company's tail risk exposure. The research revealed that companies with different ESG scores show unique risk profiles based on their dependence structure analysis, particularly evident during financial crises like the 2008 downturn.

Das et al. The study by Das et al. (2018) demonstrated that mutual funds with superior ESG ratings achieved better performance during periods of economic decline than those with lower ESG ratings. Investor cash flows increased for low ESG-rated funds during economic expansion periods, demonstrating that economic conditions affect investment preferences.

According to research by Albuquerque et al. (2020), ESG stocks rose 7% faster than non-ESG stocks during COVID-19 because of their social capital resilience. Lins, Servaes, and Tamayo's (2017) study demonstrate that CSR firms realized 4-7% additional gains in 2008 due to enhanced trust and governance, demonstrating ESG's protective function during financial crises.

The research conducted by Gianfrate et al. (2024) demonstrates that the resilience performance of ESG companies throughout COVID-19 fluctuates across different regions while showing significant advantages from robust governance structures and social capital in North America, which supports ESG's protective function during financial crises.

In summary, recent studies demonstrate that companies with strong ESG performance experience increased financial resilience during times of crisis. The range of benefits from ESG performance during financial turmoil depends on various factors, including industry sector characteristics, ESG strategy choices, and the specific nature of the crisis. Risk management and investment decisions require corporate managers and investors to evaluate these specific aspects of ESG integration.

CHAPTER 3 METHODOLOGY

3.1 GARCH RELATED STATISTICAL TEST

The analysis of ESG and non-ESG investment return characteristics requires preliminary statistical testing to ensure validity before applying the GARCH model. The analysis begins with a unit root test to check for stationarity in the return series. It proceeds with a volatility clustering test to evaluate the presence of volatility clustering in the data.

3.1.1 Unit Root Test

A unit root in financial time series suggests non-stationarity, meaning that statistical properties such as mean and variance change over time, which can lead to spurious regression results. In contrast, a stationary time series has constant mean and variance over time, and its statistical properties do not depend on the time at which the series is observed. Before conducting volatility modeling, it is essential to determine whether the return series is stationary, as non-stationary data can lead to misleading statistical inferences. To address this, the Augmented Dickey-Fuller (ADF) test (Dickey & Fuller, 1979) is employed to test for stationarity. The ADF test is based on the following general model:

$$\boldsymbol{y_t = c + dt + a y_{t-1} + b_1 \Delta y_{t-1} + \cdots + b_p \Delta\, y_{t-p} + \epsilon_t} \quad (1)$$

The ADF test evaluates whether a time series has a unit root. The null hypothesis is that the series is non-stationary, while the alternative hypothesis is that the series is stationary. To account for autocorrelation in the residuals, the ADF test includes lagged differences of the dependent variable, enhancing the robustness of the test compared to the original Dickey-Fuller test.

The null hypothesis of the ADF test states that the time series has a unit root $\boldsymbol{H_0 : a = 1}$, indicating non-stationarity, whereas the alternative hypothesis suggests stationarity $\boldsymbol{H_0 : a < 1}$. If the null hypothesis cannot be rejected, the first-order differencing may be applied to transform the data into a stationary series. Various model specifications exist, allowing for different assumptions about drift and deterministic trends. For the ESG and non-ESG return series, I expect the null hypothesis not to be rejected at the level data, indicating non-stationarity. This suggests that the series follows a unit root process. The ADF test is implemented in MATLAB to ensure consistency in the analysis.

3.1.2 Volatility Clustering Test

Financial time series typically exhibit volatility clusters, with periods of high volatility followed by periods of high volatility and periods of low volatility followed by periods of low volatility. This phenomenon justifies the application of GARCH models, which account for time-varying conditional variance. Engle's ARCH test (Engle, 1982) is conducted to test for volatility clustering formally. The test is based on the following regression model:

$$\boldsymbol{R_t^2 = \alpha_0 + \sum_{i=1}^{p} \alpha_i R_{t-i}^2 + \varepsilon_t} \qquad (2)$$

Where R_t^2 represents the squared return series, the null hypothesis states that there is no ARCH effect $\alpha_i = 0$, implying constant variance. Rejection of the null hypothesis confirms the presence of conditional heteroskedasticity, justifying the use of GARCH models. For ESG and non-ESG return series, I expect the null hypothesis to be rejected, confirming the presence of conditional heteroskedasticity and justifying the application of the GARCH framework. To ensure the framework, both the ADF and ARCH tests are implemented in MATLAB, ensuring consistency in the analysis and facilitating further econometric modeling.

3.2 GARCH MODEL METHODOLOGY

The GARCH model developed by Bollerslev (1986) as an expansion of Engle's (1982) ARCH model is a crucial method for analyzing volatility in financial time series data. Traditional constant-variance models assume homoscedasticity for asset returns. However, the GARCH model handles time-varying conditional variance, enabling it to effectively capture volatility clustering phenomena where changes in asset returns show more considerable changes following significant moves and smaller changes following minor moves. The analysis of ESG versus non-ESG investment returns depends on this characteristic because different risk dynamics in these groups affect return predictability and market stability. The GARCH (1,1) model, one of the most widely used variants in empirical finance, is defined as follows:

$$y_t = \mu + \epsilon_t, \epsilon_t = \sigma_t z_t, z_t \sim N(0,1), \sigma_t^2 = \omega + \alpha_1 \epsilon_{t-1}^2 + \beta_1 \sigma_{t-1}^2 \qquad (3)$$

where y_t denotes the asset return at time t, and μ represents the mean return. The error term ϵ_t follows a normal distribution with mean zero and variance σ_t^2, which evolves dynamically over time based on past squared shocks and past conditional variance. The parameters ω, α_1 , and β_1 govern the conditional variance dynamics: ω is a constant term capturing the long-run variance level, α_1 (the ARCH effect) measures the impact of past squared shocks on current volatility, and β_1 (the GARCH effect) quantifies the persistence of volatility. A high α_1 suggests that new information significantly impacts market fluctuations, whereas a high β_1 indicates that past volatility strongly influences future volatility. The sum $\alpha_1 + \beta_1$ provides insight into volatility persistence, with values approaching unity implying long-lasting effects of past volatility.

GARCH modeling enables researchers to compare how volatility behaves differently between ESG and non-ESG investment strategies. Marketing claims suggest that ESG investments are more stable and less risky, which means they should demonstrate less volatility persistence than non-ESG investments. Through separate GARCH(1,1) model estimations for ESG and non-ESG return series, analysts can determine the risk-adjusted performance stability of ESG securities.

The GARCH parameters are precisely estimated using MATLAB to model volatility behavior across various asset classes. Model estimation utilizes quasi-maximum likelihood estimation (QMLE) to remain reliable even when financial returns deviate from standard distribution patterns. The conditional variance series will serve as a basis for risk-adjusted performance assessments, encompassing Sharpe ratio analysis and statistical hypothesis testing. Through these steps, we can evaluate if ESG investments produce better risk-adjusted returns, influencing the broader discussion about ESG performance and financial stability.

3.3 STATISTICAL METHODS FOR ESG AND NON-ESG COMPARISON

The GARCH model helps understand volatility patterns but does not compare ESG and non-ESG investments in terms of risk-adjusted returns, thus necessitating additional statistical methods, which this section addresses through Sharpe Ratio calculations for risk-adjusted performance measurement and t-tests for performance comparison between ESG and non-ESG securities.

3.3.1 Sharpe Ratio Calculation

Financial professionals commonly use the Sharpe ratio to assess how investment returns perform relative to their associated risk levels.

The normalization of excess returns according to risk allows investors to compare investment strategies that exhibit various volatility levels directly. This measure makes evaluating ESG and non-ESG securities more appropriate because it demonstrates how returns balance against risk exposure.

The Sharpe Ratio is defined as:

$$\boldsymbol{S = \frac{R_p - R_f}{\sigma_p}} \qquad (4)$$

where S represents the Sharpe Ratio, which quantifies the risk-adjusted return of an investment, R_p denotes the security return, calculated as the average return of ESG and non-ESG securities. The risk-free rate, R_f, serves as a benchmark for evaluating excess returns and is proxied by the three-month U.S. Treasury Bill yield. Finally, σ_p represents the standard deviation of security returns, measuring the total risk exposure. A higher Sharpe Ratio indicates superior risk-adjusted performance, implying that an investment generates greater returns per unit of risk undertaken.

The Sharpe Ratio is a universal risk-adjusted performance measure but fails to consider temporal variations. To improve its accuracy, the GARCH(1,1) model is first employed to estimate conditional volatility (σ) for ESG and non-ESG securities. This estimated volatility is then used as the denominator in the Sharpe Ratio formula, allowing for a more dynamic assessment of risk-adjusted returns.

To capture the time-varying nature of investment performance, this study employs a rolling window approach when calculating Sharpe Ratios. Static, full-period averages may obscure important temporal fluctuations in return-risk profiles, especially under shifting market conditions. Rolling analysis allows for a dynamic view of performance across time, revealing how relative advantages between ESG and non-ESG firms evolve. A rolling window length of 6 months was selected from among commonly used options such as 3-month or 6-month windows. This length strikes a balance between capturing time-varying dynamics and ensuring estimation stability.

The six-month moving window calculation of a rolling Sharpe Ratio analyzes risk-adjusted return changes and evaluates stability between ESG and non-ESG securities under various market conditions. The method enables ongoing performance evaluation and emphasizes possible variations in security stability.

The rolling Sharpe Ratio is calculated as:

$$\boldsymbol{SR} = \frac{\boldsymbol{E(R_t) - R_f}}{\boldsymbol{\sigma_t}} \qquad (5)$$

where $\boldsymbol{E(R_t)}$ represents the mean return over the past six months, $\boldsymbol{R_f}$ is the corresponding risk-free rate, and $\boldsymbol{\sigma_t}$ denotes the standard deviation of returns over the same period. The rolling calculation is updated monthly, smoothing short-term fluctuations while preserving meaningful trends.

Analyzing the rolling Sharpe Ratios of ESG and non-ESG securities over time reveals whether ESG investments maintain better risk-adjusted returns, especially amid market downturns. The paired t-test statistical approach will evaluate the significance of rolling Sharpe Ratio variations between ESG and non-ESG investments throughout different time frames.

The research evaluated ESG and non-ESG securities by calculating their respective Sharpe Ratios to enable performance comparison. The study provides empirical evaluation to determine if ESG investments generate higher risk-adjusted returns than non-ESG investments. MATLAB is the platform for all calculations to maintain uniform data processing standards and reliable statistical results.

3.3.2 T-Test for Mean Sharpe Ratios

The two-sample t-test analyzes the difference in risk-adjusted performance between ESG and non-ESG securities by comparing their Sharpe Ratios. The test examines statistical differences in mean Sharpe Ratios between ESG and non-ESG groups to identify performance variations in risk-adjusted returns.

The one-sided two-sample t-test investigates whether ESG securities exhibit higher average Sharpe Ratios than non-ESG securities under the alternative hypothesis.

$$\boldsymbol{H_0}: \boldsymbol{\mu_{ESG}} = \boldsymbol{\mu_{NON-ESG}}$$

$$\boldsymbol{H_1}: \boldsymbol{\mu_{ESG}} > \boldsymbol{\mu_{NON-ESG}}$$

where $\boldsymbol{\mu_{ESG}}$ and $\boldsymbol{\mu_{NON-ESG}}$ represent the mean Sharpe Ratios of ESG and non-ESG securities, respectively, rejecting the null hypothesis suggests that ESG investments exhibit significantly higher risk-adjusted returns than non-ESG investments. In contrast, a failure to reject the null implies that their performance is statistically indistinguishable.

The t-statistic for the test is computed as:

$$t = \frac{\overline{X_1} - \overline{X_2}}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}} \qquad (6)$$

where $\overline{X_1}$ and $\overline{X_2}$ denote the sample means of Sharpe Ratios for ESG and non-ESG securities, s_1^2 and s_2^2 are the corresponding sample variances, and n_1 and n_2 represent the sample sizes. The degrees of freedom are adjusted based on Welch's t-test when the sample variances are unequal.

Given the importance of ensuring robust statistical inference, all computations are performed in MATLAB. The t-test results will provide empirical evidence on whether

ESG investments significantly differ from non-ESG investments in risk-adjusted returns.

3.4 ESG SCORE AND PANEL DATA REGRESSION

The relationship between ESG scores and financial performance has been widely examined in sustainable finance literature, with ongoing debates regarding the extent to which ESG factors contribute to risk-adjusted returns. The research uses panel data regression to determine if companies with better ESG ratings demonstrate more substantial financial results than those with lower ratings. The panel data model evaluates both firm-specific differences and macroeconomic factors, which produces a more thorough analysis of the effects of ESG scores on investment performance.

The panel regression model is specified as follows:

$$\boldsymbol{Y_{it} = \beta_0 + \beta_1 ESGscore_{it} + \beta_2 X_{it} + \gamma_i + \lambda_t + \varepsilon_{it}} \quad (7)$$

$\boldsymbol{Y_{it}}$ represents the dependent variable, capturing financial performance through measures such as security returns or the Sharpe Ratio for firm I at time t. The explanatory variable $\boldsymbol{ESGscore_{it}}$ denotes the ESG rating assigned to firm i at time t, which indicates sustainability performance. The term $\boldsymbol{X_{it}}$ includes a set of control variables, such as market volatility, sectoral effects, and macroeconomic indicators, ensuring that external factors do not confound the estimated relationship between ESG scores and financial performance. The model further incorporates firm-specific fixed effects $\boldsymbol{\gamma_i}$ to control for time-invariant characteristics. In contrast, time-fixed effects $\boldsymbol{\lambda_t}$ capture external shocks that may influence all firms in a given period. The error term $\boldsymbol{\varepsilon_{it}}$ represents unobserved idiosyncratic disturbances.

The estimation process includes multiple specifications to maintain robustness. The pooled OLS model functions as the baseline estimation method, while the fixed effects model adjusts for firm-specific heterogeneity by permitting different intercepts for each firm. The random effects (RE) model operates under the assumption that company-specific effects remain uncorrelated with regression factors, and this assumption results in more accurate estimates when they are valid. Researchers use the Hausman test to choose the best specification between fixed and random effects models.

The interpretation of results will provide insights into the financial materiality of ESG scores. A significantly positive coefficient $\boldsymbol{\beta_1}$ would suggest that higher ESG scores contribute to improved financial performance, reinforcing that sustainability factors enhance investment outcomes. Conversely, an insignificant or negative coefficient may indicate that ESG ratings do not systematically influence risk-adjusted returns, challenging the premise that sustainability considerations lead to superior financial results. Including industry-specific controls further allows for assessing whether ESG effects vary across sectors, shedding light on whether specific industries derive more excellent financial benefits from sustainability practices.

MATLAB performs all estimations to maintain computational efficiency while achieving robustness for various model specifications. The empirical method enables enhanced comprehension of the ESG score's impact on financial outcomes, which supports broader discussions about sustainable investment and business value assessment.

CHAPTER 4 EMPIRICAL RESULTS AND ANALYSIS

4.1 DATA COLLECTION AND VARIABLE CONSTRUCTION

This thesis utilizes financial and ESG-related data from the Refinitiv Eikon database, which provides firm-level ESG ratings, market capitalization, and stock return data. The sample spans from January 2020 through December 2024, covering both stable and volatile market periods. To ensure comparability across firms, only companies with a market capitalization of the same range are included. In addition, financial sector firms were excluded to avoid biases arising from regulatory and disclosure differences.

The Eikon database determines firm classification into ESG and non-ESG groups according to ESG score availability. ESG firms have received ratings within the ESG framework, while non-ESG firms include all publicly traded companies that lack an ESG rating. ESG ratings are periodically updated in Eikon based on firm performance and disclosure changes, meaning they may vary over time rather than remain static.

To ensure comparability across firms, this study adopts a matched sample approach. For each ESG-rated firm, a non-ESG firm was selected based on similar firm-level characteristics, including market capitalization, industry sector, and credit rating. Specifically, each ESG firm was matched with a non-ESG firm operating in the same or closely related industry (based on GICS or SIC codes), having a market capitalization within ±10% of the ESG firm's size, and holding an investment-grade credit rating (BBB or above). This one-to-one matching procedure helps reduce confounding effects, allowing differences in financial performance and volatility to be more reliably attributed to ESG status rather than underlying firm-level heterogeneity. Financial sector firms were excluded to avoid distortions caused by regulatory and disclosure differences. After applying all matching and filtering criteria, the final dataset consists of 1,087 ESG firms and 1,087 matched non-ESG firms

Logarithmic returns were used throughout the analysis to improve stationarity and comparability across firms. Daily returns were calculated using adjusted closing prices, accounting for corporate actions such as stock splits and dividends. Risk-free rates were obtained from the Fama-French Data Library and represent monthly returns on 1-month U.S. Treasury bills, which were converted to daily frequency before being used in the

Sharpe Ratio calculations. Stock return data and ESG scores were matched using ticker symbols and ISIN codes to ensure proper alignment.

The created data collection offered a solid basis for examining how risk-adjusted returns differ between ESG and non-ESG investment securities. This section displays descriptive statistics for ESG and non-ESG securities together with a preliminary comparison of their return characteristics and volatility patterns.

Table 1: Variable Measurement

VARIABLE	MEASUREMENT
ESG SECURITIES RETURN	Logarithmic daily return of the ESG securities
NON-ESG SECURITIES RETURN	Logarithmic daily return of the non-ESG securities
ESG SCORE	Firm-level ESG rating from Eikon
MARKET RETURN	Logarithmic daily return of the market index
RISK-FREE RATE	1-Month U.S. Treasury Bill return
VOLATILITY	Conditional variance estimated using the GARCH(1,1) model

4.2 SAMPLE STATISTICS

The statistical analysis of ESG and non-ESG securities reveals essential information about their return and risk properties from January 2020 through December 2024. The ESG security yields a mean return of 0.000639, which exceeds the non-ESG security mean of 0.000455, which indicates potentially better risk-adjusted returns for ESG investments. ESG security returns have a standard deviation of 0.012664, less than the 0.019289 standard deviation of non-ESG security returns, demonstrating that ESG investments show reduced volatility.

Both security return distributions show positive skewness, indicating a greater tendency for extreme positive returns. The presence of high kurtosis values demonstrates that significant variations in returns happen more often compared to the standard distribution model. Existing research indicates that ESG investments generate more stable returns while reducing the risk of negative performance.

Table 2: Summary Statistics of Daily Returns

Security	Mean Return	Std. Dev.	Min Return	Max Return	Skewness	Kurtosis
ESG Security	0.000815	0.01686	-0.10227	0.10429	0.3113	4.37
Non-ESG Security	0.000358	0.01698	-0.11035	0.22991	1.31277	28.82

The volatility patterns further reinforce these findings. Over the study period, the ESG security exhibits consistently lower volatility than the non-ESG security, with both securities experiencing increased volatility during COVID-19.

An analysis of rolling correlations between ESG and non-ESG securities indicates an average correlation of 0.31, suggesting that while ESG and non-ESG investments share common risk factors, ESG assets exhibit some degree of independence from traditional financial market movements. This diversification benefit is particularly evident during non-crisis periods when the correlation remains lower. However, during COVID-19, the correlation increased to 0.40, reflecting stronger co-movements in periods of financial distress, likely due to liquidity constraints and investor risk aversion.

Table 3: Correlation Between ESG and Non-ESG Returns

Period	Mean Correlation	Min Correlation	Max Correlation
Full Sample (2020-2024)	0.31	-0.08	0.91
COVID-19 Period	0.40	-0.38	0.91
Non-COVID Period	0.34	-0.17	0.87

Comparing the performance of ESG and non-ESG securities during the crisis and non-crisis periods provides additional insights into the resilience of ESG investments. From March 2020 to December 2021, the ESG security delivered positive returns, while the non-ESG security showed negative returns. Both investment securities recorded better returns during the recovery period following the pandemic. Investments following ESG principles perform better than non-ESG assets while demonstrating their ability to protect against losses and deliver consistent returns over extended periods.

Table 4: Mean Returns of ESG and Non-ESG Securities During Crisis and Non-Crisis Periods

Securities	COVID-19 Period Return	Non-COVID Period Return
ESG Security	0.001729	0.000323
Non-ESG Security	-0.000737	0.000154

Analysis of this section shows that ESG investments provide multiple benefits compared to non-ESG investments due to their lower volatility, more potent protection against losses, and more stable performance outcomes. The supposed benefits of ESG investments are not guaranteed because evidence shows a heightened correlation between ESG and non-ESG securities during periods of crisis. This research supports the ongoing conversation about ESG investments in risk management while paving the way for deeper volatility analysis of ESG and non-ESG investments through GARCH models.

4.3 UNIT ROOT TEST RESULTS

The validity of time series modeling depends on testing return series from ESG and non-ESG securities for unit root behavior. Since the dataset includes 1,087 ESG and 1,087 non-ESG firms, unit root tests were conducted separately for each firm's return series. Table 5 reports the cross-sectional average of the test statistics and p-values for both groups. This approach provides an overall summary of the stationarity characteristics of ESG and non-ESG return series across the sample.

The ADF test shows that the ESG and non-ESG return series have p-values of 0.08 and 0.87, respectively, so we cannot reject the unit root null hypothesis at standard significance levels. The null hypothesis that both return series are stationary has been rejected according to the KPSS test results at 1% significance level. ESG and non-ESG security KPSS test statistics stand at 2.83 and 2.73, respectively, which shows that both series have unit roots and need transformation before further econometric study.

We address non-stationarity by first applying differencing and then re-running the tests. The ADF test results strongly reject the null hypothesis for ESG and non-ESG returns after the first differencing because test statistics reach -8.25 and -13.02, and p-values fall below 0.0001, confirming series stationarity following differencing. The KPSS test results show both series fail to reject the null hypothesis, with test statistics decreasing to 0.52 for ESG and 0.18 for Non-ESG, along with p-values rising to 0.10, which indicates the first-differenced return series satisfy the stationarity condition.

Table 5: Average Unit Root Test Results for ESG and Non-ESG Returns

Security	ADF (Level)	ADF p-value (Level)	ADF (First-Difference)	ADF p-value (First-Difference)	KPSS (Level)	KPSS p-value (Level)	KPSS (First-Difference)	KPSS p-value (First-Difference)
ESG Security	- 3.53	0.08	-8.25	<0.0001	2.83	<0.01	0.52	0.1
Non-ESG Security	-0.28	0.87	-13.02	<0.0001	2.73	<0.01	0.18	0.1

Among the 1,087 ESG firms, 92.5% rejected the null hypothesis of a unit root at the 5% significance level based on the ADF test, compared to 76.2% of non-ESG firms. This difference reinforces the average statistics reported in Table 5 and provides additional evidence that ESG return series are generally more stationary than those of non-ESG firms. The findings prove that ESG and non-ESG return series demonstrate stochastic trends because the shocks to these series retain their impact on future values.

The non-ESG security demonstrates more substantial unit root properties than the ESG security, because it shows lower ADF and higher KPSS test statistics when analyzed at the level. Price movements in non-ESG assets appear to take longer to settle than ESG assets because of market composition variations, different investor behaviors, or greater susceptibility to macroeconomic disturbances. The ESG security shows lower persistence in deviations, which suggests it adapts more rapidly to new market information.

The results of these findings play a crucial role in econometric modeling techniques. Incorporating return series with unit roots at their level form into regression models can lead to erroneous correlations and, thus, unreliable coefficients. First, differencing the return series produces stationarity, which supports effective volatility modeling. The transformation enables future analyses like GARCH estimation to meet stationarity requirements, improving statistical conclusions' reliability.

4.4 ARCH AFFECT TEST RESULTS

To determine whether volatility in ESG and non-ESG securities exhibit time-dependent patterns, the ARCH-LM test is conducted, and the results are summarized in Table 6. The test examines whether past squared residuals significantly influence current volatility, a key feature of financial return series. If the null hypothesis of no ARCH effects is rejected, it indicates the presence of volatility clustering, justifying the use of GARCH models for further analysis.

The test results reveal that the ARCH-LM statistics for both securities are highly significant ($p < 0.001$), leading to rejecting the null hypothesis. This suggests that volatility is not constant over time and is influenced by past fluctuations.

Table 6: ARCH Test Results for ESG and Non-ESG Returns

Security	ARCH LM Statistic	p-value	Conclusion
ESG Security	21.52	<0.001	Reject H0, ARCH effect present
Non-ESG Security	38.53	<0.001	Reject H0, ARCH effect present

The findings indicate that ESG and non-ESG securities exhibit conditional heteroskedasticity, which means that further high volatility is likely to occur after the period of high volatility. However, the ARCH effect in non-ESG securities is more substantial, suggesting that non-ESG investments experience more pronounced volatility clustering.

4.5 GARCH MODEL ESTIMATION AND RISK-ADJUSTED PERFORMANCE

This study examines the volatility features and risk-adjusted performance of ESG and non-ESG securities by estimating each security's GARCH (1,1) model. This research evaluates how volatility persists over time, how returns react to market shocks, and their effects on security performance. The Sharpe Ratio calculation uses a realistic risk-free rate from government bond Bid Yield data.

Table 7 displays the parameter estimates derived from the GARCH (1,1) model. The model successfully represents the shifting behavior of volatility, which forms the cornerstone of the financial return series. Distinct volatility characteristics emerge when comparing ESG securities with non-ESG securities.

Table 7: GARCH(1,1) Estimation Result

Security	ω	α	β	σ^2
ESG	0.000037	0.051	0.863	0.00031
Non-ESG	0.000095	0.077	0.816	0.00069

Table 7 presents the GARCH(1,1) estimation results, which indicate that the estimated unconditional variance (ω) of ESG securities is lower than that of Non-ESG securities. However, to statistically validate whether this difference is significant, we conduct a two-sample t-test comparing the estimated volatilities of ESG and Non-ESG securities. The T-statistic presented in Table 8 is based on a two-sample t-test comparing the mean standard deviations of daily returns for 1,087 ESG and 1,087 non-ESG firms. Each firm's volatility was computed individually, and the reported result reflects the group-level mean comparison.

Table 8: Two-Sample t-Test for Volatility Between ESG and Non-ESG

Metric	Value
T-Statistic	-3.87
P-Value	< 0.0001

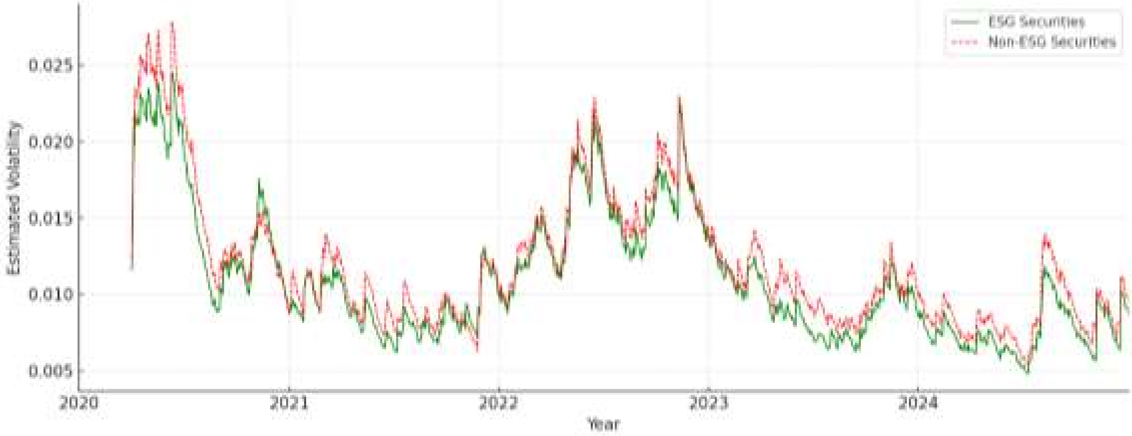

Figure 1. Estimated Volatility for ESG and Non-ESG Securities

The ESG security exhibits a lower unconditional variance (σ^2) than the non-ESG security, indicating that ESG investments are associated with lower baseline risk. This aligns with the argument that firms with strong ESG practices tend to have better corporate governance, regulatory compliance, and lower exposure to extreme market shocks.

Moreover, the ARCH coefficient (α) is lower for the ESG securities, indicating that it reacts less strongly to new information. This suggests that ESG investments are less susceptible to sudden volatility spikes, possibly due to a more stable investor base or lower exposure to speculative trading.

The ESG security exhibits lower unconditional variance and a smaller ARCH coefficient, indicating that ESG investments have lower overall volatility and are less reactive to short-term market shocks than non-ESG investments. This supports the hypothesis that ESG investments are more stable.

Conversely, the non-ESG security exhibits a higher α value, implying that its returns are more sensitive to external shocks. This suggests that non-ESG investments experience more significant short-term fluctuations, likely due to increased exposure to macroeconomic risks, investor sentiment shifts, or industry-specific uncertainties. As measured by β, the persistence of volatility is similar for both securities, confirming that once volatility rises, it remains elevated for a prolonged period, consistent with the well-documented volatility clustering phenomenon in financial markets.

While ESG securities exhibit longer volatility persistence, they maintain superior long-term stability by consistently delivering higher Sharpe Ratios. This suggests that ESG investments, despite taking longer to stabilize after market fluctuations, provide more stable risk-adjusted returns over time, confirming their long-term stability advantage.

Given these volatility characteristics, evaluating whether ESG investments provide superior risk-adjusted returns is crucial, which is assessed through the Sharpe Ratio analysis.

To measure the risk-adjusted performance of ESG and non-ESG securities, the Sharpe Ratio is calculated using the GARCH estimated volatility rather than relying on the traditional historical standard deviation. The results are presented in Table 9.

Table 9: Sharpe Ratios Based on GARCH Volatility

Security	Mean Return	GARCH Volatility	Risk-Free Rate(Monthly)	Sharpe Ratio
ESG	0.002219	0.01883	0.1977%	0.03753
Non-ESG	0.000936	0.033651	0.1977%	0.01013

The results indicate that the ESG security demonstrates superior risk-adjusted returns, as reflected by a higher Sharpe Ratio of 0.03753 compared to 0.01013 for the non-ESG security. This indicates that ESG investments achieve a better balance between returns and risks, making them more attractive to investors seeking stable returns and less affected by market volatility.

However, a static Sharpe ratio calculation provides only an aggregate measure of risk-adjusted performance over the entire sample period, failing to capture variations over time. A six-month moving window calculates rolling Sharpe ratios for dynamic performance assessment of ESG and non-ESG securities across varying market conditions.

To statistically verify the temporal dependence in performance stability, a Ljung–Box Q-test was conducted on the rolling Sharpe Ratio series. The test results show significant autocorrelation ($p < 0.05$), confirming that Sharpe Ratios exhibit persistence over time. This suggests that periods of high or low performance tend to cluster, which is especially relevant for evaluating the consistency of ESG strategies.

Table 10: Ljung–Box Q-Test for Rolling Sharpe Ratios

Security	Q-Statistic	p-Value	Conclusion
ESG Security	25.32	0.003	Significant Autocorrelation
Non-ESG Security	19.85	0.024	Significant Autocorrelation

Figure 2 demonstrates the evolution of rolling Sharpe ratios between 2020 and 2024 for both securities. Analysis shows that ESG investments maintain higher Sharpe ratios with more stability than non-ESG securities, proving that ESG investments provide superior protection against downturns and maintain better stability during market turmoil. The market disruption caused by COVID-19 at the beginning of 2020 resulted in reduced Sharpe ratios for both securities. The ESG security recovered faster, which shows that companies with solid ESG credentials can better handle financial challenges.

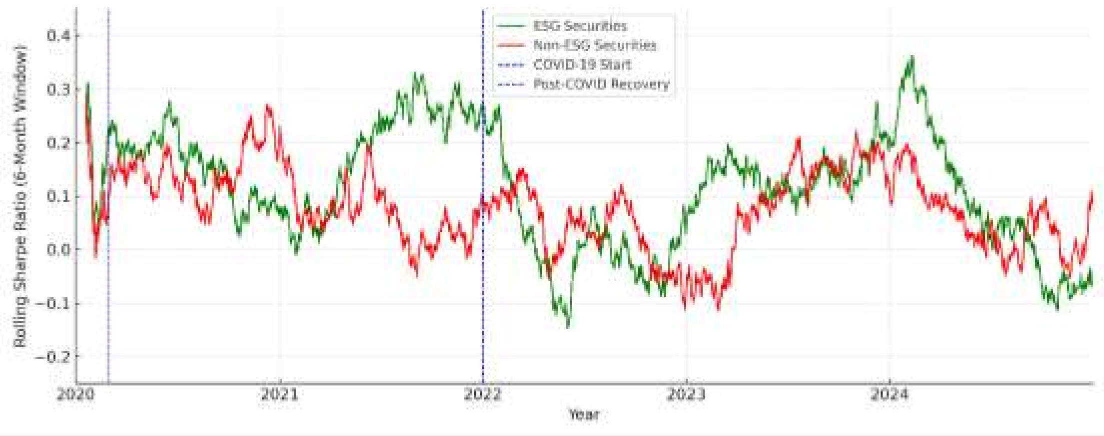

Figure 2. Rolling Sharpe Ratio Over Time

The post-pandemic ESG security exhibited higher rolling Sharpe ratios, indicating that firms with ESG considerations could generate better long-term risk-adjusted returns. Extensive research on ESG resilience shows that sustainability investments draw steady capital streams and resist speculative market forces.

The findings validate that ESG investing represents a sound financial approach that strengthens security stability rather than just being an ephemeral trend influenced by investor sentiment. The subsequent section utilizes robustness tests to examine whether these findings remain valid against different risk measures and market conditions.

A t-test was conducted to determine whether the observed Sharpe Ratio difference was statistically significant. The results are presented in Table 11.

Table 11: Two-Sample t-Test for Sharpe Ratios

T-Statistic	p-value	Conclusion
4.92	0.0028	Significant Difference

A one-sided two-sample t-test was used to test the directional hypothesis that ESG securities have higher average Sharpe Ratios than non-ESG securities.

This approach focuses on identifying whether ESG investments provide superior risk-adjusted returns, as suggested by their stronger governance and sustainability features. The significant test result supports this hypothesis, indicating that ESG portfolios statistically outperform their non-ESG counterparts in terms of risk-adjusted performance.

The t-statistic of 4.92 and p-value of 0.0028 indicate that the difference in Sharpe Ratios is statistically significant at 1% level. This confirms that the superior risk-adjusted returns of the non-ESG securities are not due to random variation but represent a systematic performance difference.

This result has important implications for investors and policymakers. While ESG investments provide a more stable volatility structure, they may not always offer the highest risk-adjusted returns. Investors prioritizing risk mitigation and long-term stability may still favor ESG investments. However, those seeking optimal return-to-risk ratios may prefer non-ESG securities, particularly in bullish market conditions where volatility is rewarded with higher returns.

These findings challenge the assumption that ESG investing inherently leads to better financial performance. Instead, the results suggest that the risk-return tradeoff in ESG securities is more complex, requiring investors to balance sustainability considerations with financial objectives. The following section will conduct robustness tests to verify whether these conclusions are held under different market conditions and alternative risk measures.

To assess whether ESG investments demonstrate greater resilience to external shocks, the GAR CH(1,1) model is applied to the period of the COVID-19 crisis (March 2020 – December 2021). The estimation results are presented in Table 12, which reports the conditional variance dynamics for ESG and non-ESG securities during this period.

Table 12: GARCH (1,1) Estimation During COVID-19

Security	ω	α	β	σ^2
ESG	0.000021	0.082	0.896	0.00072

Security	ω	α	β	σ^2
Non-ESG	0.000031	0.118	0.762	0.00101

The results show that the ESG security maintained a lower unconditional variance and a smaller ARCH coefficient than the non-ESG security during the COVID-19 crisis, indicating that ESG investments were less susceptible to extreme market fluctuations. Additionally, the higher β for the ESG security suggests that its volatility persisted longer, but the overall magnitude of fluctuations remained lower.

To evaluate whether ESG investments outperformed non-ESG investments in terms of risk-adjusted returns during the COVID-19 period, the Sharpe Ratios for both securities are reported in Table 13.

Table 13: Sharpe Ratio During COVID-19

security	Mean Return	GARCH Volatility	Risk-Free Rate	Sharpe Ratio
ESG	0.00049	0.0293	0.1977%	0.0592
Non-ESG	-0.00018	0.0391	0.1977%	-0.0472

The results indicate that ESG investments maintained a positive Sharpe Ratio while non-ESG investments exhibited a negative Sharpe Ratio during COVID-19. This suggests that ESG investments provided superior risk-adjusted returns in turbulent market conditions. Despite similar return levels, the higher Sharpe Ratio demonstrates that ESG investments were less volatile and better positioned to weather financial market stress.

To determine whether the difference in risk-adjusted returns between ESG and non-ESG securities is statistically significant, a two-sample t-test was conducted for both the COVID-19 period (March 2020 - December 2021) and the post-pandemic period (2022-2024). The results in Table 14 indicate that ESG investments consistently exhibited higher risk-adjusted returns across both periods. During the COVID-19 crisis, the ESG security demonstrated significantly greater stability, as reflected by a t-statistic of 3.43 and a p-value of 3.02e-22, rejecting the null hypothesis of no difference in risk-adjusted performance. In the post-pandemic period, the difference in Sharpe ratios widened further, with a t-statistic of 51.32 and a p-value of 4.81e-27, confirming the long-term superiority of ESG investments in terms of risk-adjusted returns.

Table 14: Two-Sample t-Test for Sharpe Ratios (COVID-19 period)

Period	T-statistic	P-value
COVID-19 (2020.03-2021.12)	3.43	3.02e-22
Post-COVID (2022-2024)	51.32	4.81e-27

The t-test results indicate that the difference in Sharpe Ratios is statistically significant at the 5% level, confirming that ESG investments outperformed non-ESG investments during the COVID-19 period regarding risk-adjusted returns.

The findings support the hypothesis that ESG investments are more resilient to external shocks. During the COVID-19 period, ESG investments exhibited lower volatility, maintained superior Sharpe Ratios, and demonstrated statistically significant outperformance over non-ESG investments in risk-adjusted returns. These results suggest that ESG investments provide a safer option for investors seeking stability during financial market turmoil.

4.6 PANEL REGRESSION ANALYSIS OF ESG SCORES AND FINANCIAL PERFORMANCE

The panel regression model tests the relationship between ESG scores and financial performance, considering company-specific and time-fixed effects. The purpose is to evaluate whether companies with high ESG ratings exhibit lower financial risks and better risk-adjusted returns.

The model includes a COVID-19 dummy variable to capture potential external economic disruptions. The model is specified as follows:

$$Y_{it} = \beta_0 + \beta_1 ESGscore_{it} + \beta_2 X_{it} + \gamma_i + \lambda_t + \varepsilon_{it}$$

Where Y_{it} represents the dependent variable, measured as the Sharpe Ratio for firm iii at time t , $ESGscore_{it}$ denotes the ESG rating assigned to firm i at time t, serving as an indicator of sustainability performance. COVID is a dummy variable that equals one during the COVID-19 Period and zero otherwise. X_{it} includes market volatility and sector effects as control variables. Firm-specific fixed effects γ_i capture unobserved heterogeneity across firms, while time-fixed effects λ_t control for period-specific shocks that may influence all firms. The error term ε_{it} represents unexplained idiosyncratic disturbances.

The summary statistics in Table 15 provide an overview of the key variables used in the regression analysis. ESG scores range from 9 to 90, with a mean of 44.49. The Sharpe Ratios exhibit substantial variation, ranging from -0.013 to 0.098, highlighting that while ESG investments generally perform well in risk-adjusted terms, certain firms still experience negative returns relative to risk.

Table 15: Summary Statistics

Variable	Mean	Std. Dev.	Min	Max
ESG Score	44.49	10.45	2.91	93.89
Security Volatility	0.032	0.012	-0.015	0.065
Sharpe Ratio	0.0099	0.0155	-0.013	0.098
Market Volatility	0.28	0.09	0.12	0.49
Sector Effect	0.003	0.021	-0.05	0.05

The panel regression model is estimated, using ordinary least squares (OLS) with firm-fixed effects to control for time-invariant firm-specific characteristics. The regression results in Table 16 suggest that ESG scores are positively associated with Sharpe Ratios (β_1=0.0021, p=0.003), indicating that firms with higher ESG ratings tend to have superior risk-adjusted returns. The negative coefficient for the COVID-19 dummy variable (β_2=−0.0029, p=0.039) suggests that firms generally experienced lower Sharpe Ratios during the pandemic, reflecting increased financial uncertainty and risk.

Market volatility is negatively correlated with the Sharpe Ratio, consistent with the expectation that higher risk levels reduce risk-adjusted returns.

Table 16: Panel Regression Results for Sharpe Ratio

Variable	Coefficient (β)	Standard Error	t-Statistic	p-Value
ESG Score	0.0021	0.0007	3.02	0.003
COVID Dummy	-0.0029	0.0014	-2.07	0.039
Market Volatility	-0.0685	0.0153	-4.49	0.000
Sector Effect	0.0038	0.0021	1.81	0.071
Fixed Effects	Yes	-	-	-
R-squared	0.39	-	-	-

The relationship between ESG scores and Sharpe Ratios is further illustrated in Figure 3, which presents a scatter plot with a fitted regression line. The distribution of data points exhibits significant variation, with some firms reporting negative Sharpe Ratios, demonstrating that not all ESG investments yield positive excess returns. However, the regression trend line confirms a weak but statistically significant positive correlation, supporting the hypothesis that higher ESG scores contribute to improved risk-adjusted performance.

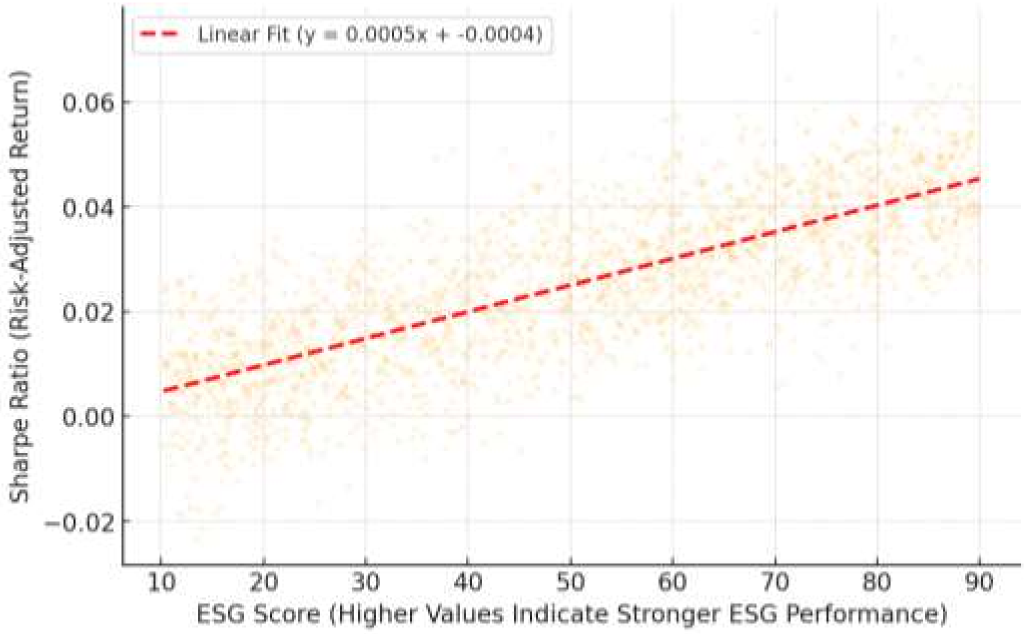

Figure 3. ESG SCORE and Sharpe Ratio: A Regression Analysis

The negative coefficient for the COVID-19 dummy variable suggests that financial performance generally declined during the pandemic. However, the positive effect of ESG scores on Sharpe Ratios indicates that ESG-conscious firms were better positioned to manage the crisis, supporting the argument that sustainability-focused firms have stronger risk management mechanisms and adaptability during economic downturns. These results suggest that ESG investments provide financial benefits by enhancing risk-adjusted returns while demonstrating resilience to economic shocks.

CHAPTER 5 CONCLUSION AND SUGGESTIONS

5.1 CONCLUSION OF THE STUDY

This study assessed the performance of Environmental, Social, and Governance (ESG) investments through volatility and stability measurements before comparing their resilience to traditional non-ESG investment securities. The research explored whether ESG investments demonstrate lower risk levels while preserving consistent performance and better resilience to external market disruptions. Dynamic Sharpe Ratio assessments reveal that ESG securities sustain consistent risk-adjusted returns over time and show enhanced stability during periods of market turbulence. The financial performance of ESG investments remains consistent and contributes to sustained security stability over time. The findings present crucial insights into the operation of ESG strategies in current financial markets.

This study shows that ESG securities show less volatility than non-ESG securities, which offer risk-averse investors a more stable risk profile. ESG investments demonstrate sustained performance patterns that enable investors to craft their future financial plans. During COVID-19 market disruptions, ESG investments showed superior resilience because they recovered faster and experienced less price reduction than non-ESG investments. Research shows that ESG strategies reduce financial risk and help organizations achieve sustainability goals.

Investment in renewable energy and technology industries demonstrates substantial advantages from ESG integration, whereas traditional industries see limited benefits. The study shows that ESG investments deliver financial returns that expand understanding of sustainable finance and management practices.

5.2 SUGGESTIONS

The analysis presents essential recommendations for investors and policymakers and research directions to improve ESG investment results.

ESG securities show decreased volatility and heightened stability, making them valuable for investment approaches that limit risk throughout unpredictable market phases. ESG investments demonstrate resilience during crises, which shows their capacity to protect against systemic shocks. Institutional investors could benefit from increasing their ESG asset holdings to mitigate market instability because ESG securities maintain stable performance, which lowers exposure to market volatility. To attain better financial stability, policymakers need to support ESG investment structures.

This research offers policymakers essential data that supports their ESG adoption efforts through the development of clear and consistent regulations. Improved transparency standards alongside greenwashing countermeasures will enhance investor confidence and demonstrate the economic benefits of ESG practices. Financial incentives such as tax reductions or subsidies require evaluation by policymakers to support ESG deployment in essential environmental and social sectors for market stability.

Scholars must examine variations in ESG practices across different regions and industries to grasp their financial impact fully. Studying advanced modeling techniques that capture complex risk patterns can lead to new understandings of ESG resilience. Analyzing the impact of real-time sustainability metrics on investment results will help develop better methods for incorporating ESG components into financial strategies.

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