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Comparative Analysis of ESG-Focused DeFi Protocols and Traditional ESG Funds: Financial Performance, Transparency, and Impact Assessment

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ABSTRACT
The intersection of Environmental, Social, and Governance (ESG) investing and decentralized finance (DeFi) introduces innovative pathways for integrating sustainability into financial markets. This study conducts a comparative analysis of ESG-focused DeFi protocols, such as KlimaDAO and Regen Network, and traditional ESG investment funds, including the Vanguard ESG U.S. Stock ETF and BlackRock Sustainable Advantage Large Cap Core Fund. Using data from March 2021 to March 2023 and quantitative methods such as ordinary least squares (OLS) regression, the study evaluates financial performance, transparency, and impact assessment. Results indicate that ESG-focused DeFi protocols provide enhanced transparency and potential for higher returns but are hindered by greater volatility and regulatory uncertainty. Conversely, traditional ESG funds offer stability and robust governance frameworks but lack the real-time transparency inherent to DeFi platforms. The findings underscore the need for standardized ESG reporting and offer actionable insights for investors aiming to align sustainability goals with financial performance

I. INTRODUCTION

This section provides the background for the study, establishing the context and setting the stage for the research.

1.1 Background of the study

The concept of sustainable and responsible investment has gained prominence over the past few years, driven by increased demand for transparency and ethical practices in the global financial sector. Environmental, Social, and Governance (ESG) funds, as traditional vehicles, have played a pivotal role in this shift, providing investors with avenues to align financial goals with sustainability objectives (Eccles &Stroehle, 2018). These funds assess corporate performance not only on financial returns but also on their environmental footprint, social responsibility, and governance integrity, contributing to their growing appeal (Bergman et al., 2020). As societal awareness of issues like climate change and social equity rises, ESG funds have become increasingly attractive to investors, pushing corporations to adopt more transparent and responsible business practices (Billio et al., 2020).

At the same time, decentralized finance (DeFi) has emerged as a transformative force, leveraging blockchain technology to bypass traditional financial intermediaries. This innovation in the financial space has led to the development of ESG-focused DeFi protocols, designed to incorporate ESG principles within decentralized financial ecosystems. These blockchain-based platforms offer enhanced transparency, accountability, and financial inclusion, appealing to a new class of socially conscious investors (Mahmood, 2020).

While both ESG funds and ESG-focused DeFi protocols aim to address the need for responsible investing, they operate on different models, each with its unique challenges and benefits. Traditional ESG funds offer established frameworks and lower-risk profiles, whereas ESG-focused DeFi protocols promise higher transparency but come with greater risks due to the volatility of decentralized markets (Cabolis et al., 2023). This study aims to compare the financial performance, transparency, and impact measurement of these two investment approaches, providing insights into their potential for long-term sustainability.

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1.2 Statement of the Problem

The increasing popularity of ESG (Environmental, Social, and Governance) investing has sparked significant interest in recent years, as both individual and institutional investors seek to align financial goals with ethical and sustainability values (Abate et al., 2021). However, challenges remain in assessing the true impact of ESG-focused investments due to inconsistent metrics and a lack of standardization across markets (Tosun, 2016). This inconsistency has raised concerns regarding the actual financial performance of ESG funds and whether they can outperform traditional investments during periods of economic uncertainty.

Furthermore, ESG-focused DeFi (decentralized finance) protocols, though promising, operate in an emerging, volatile market with untested regulatory frameworks (Mahmood, 2020). The research gap lies in understanding how ESG funds and DeFi protocols fare in terms of financial performance, transparency, and impact measurement, particularly in turbulent financial periods like the COVID-19 pandemic. This study aims to fill that gap by providing a comparative analysis of ESG-focused DeFi protocols and traditional ESG funds. This is essential for evaluating which offers better value for investors prioritizing sustainability while ensuring solid financial returns (Nofsinger& Varma, 2014).

The study's overall objective is to evaluate the financial performance, transparency, and impact assessment of ESG-focused DeFi protocols compared to traditional ESG investment funds. Specifically, the study will assess how both models measure and report their ESG impacts, compare financial performance, and evaluate transparency.

1.2 Research Question

In the evolving landscape of sustainable investing, two prominent approaches have emerged: traditional Environmental, Social, and Governance (ESG) funds, which have long provided a structured way for investors to align financial objectives with sustainability goals, and ESG-focused decentralized finance (DeFi) protocols, which leverage blockchain technology to enhance transparency and financial inclusion. However, these two investment models operate under vastly different frameworks, with varying degrees of risk, regulatory oversight, and operational transparency.

As the demand for responsible investing grows, understanding the strengths and limitations of each model is essential for investors looking to balance financial returns with sustainability objectives. In this context, this research seeks to answer the following question:

"How do ESG-focused DeFi protocols compare to traditional ESG funds in terms of financial performance, transparency, and impact assessment?"

This comparison is critical for evaluating the future of ESG investments, as DeFi protocols promise higher transparency and efficiency, while traditional ESG funds offer more established governance structures and risk mitigation strategies. By addressing this question, the study aims to provide insights for investors, regulators, and financial institutions seeking to navigate the intersection of sustainability and technological innovation in finance.

II. LITERATURE REVIEW

This section provides the conceptual definitions of variables, their logical relationships, the theoretical framework, and the current state of knowledge.

2.1 Conceptual Review

2.1.1 ESG and CSR

Integrating Environmental, Social, and Governance (ESG) criteria into investment decisions reflects a growing focus on corporate sustainability and societal impact. Studies show that companies with strong Corporate Social Responsibility (CSR) practices tend to achieve higher sales growth and returns on assets, highlighting the importance of ESG factors in evaluating financial performance.

Corporate Social Responsibility involves integrating social and environmental considerations into business operations (Cheng et al., 2014). Marrewijk and Werre (2003) found that CSR engagement varies among companies and should be classified accordingly. They noted that effective CSR requires clear internal and external goals aligned with a firm's economic strategy and emphasized the importance of governance aspects like transparency.

The concept of ESG became prominent with the rise of sustainable business practices, which are defined as "meeting the needs of the present without compromising future generations" (Nielsen & Villadsen, 2023). Initially focused on environmental issues, ESG now also addresses social inequalities, poverty, and health. Nielsen & Villadsen (2023) highlight that sustainability has evolved from a branding exercise to a core business strategy and is now integrated into a unified system that includes ESG dimensions.

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The relationship between ESG performance and financial outcomes is well-documented. Ameer & Othman (2012) found that companies with CSR strategies had higher sales growth and return on assets compared to those without.

Historically, ESG began as a way for institutional investors to integrate ethical and sustainability considerations into investment decisions. The concept evolved from socially responsible investing (SRI), which primarily focused on excluding companies based on ethical criteria, to a more comprehensive approach that includes environmental impact, social responsibility, and governance practices (Eccles &Stroehle, 2018). The movement toward responsible investing mirrors growing global concerns about climate change, income inequality, and corporate transparency.

With the rise of DeFi, these principles are facing new tests as the decentralized model of finance often lacks the established governance mechanisms and regulatory oversight that support ESG initiatives in traditional finance. In the decentralized world, aligning financial and sustainability objectives is more complex but also presents unique opportunities, such as reducing transaction costs and enabling global participation (Mahmood, 2020).

2.1.2 ESG Rating

ESG ratings are crucial for evaluating investment opportunities, providing a standardized measure of a company's environmental and social performance. However, discrepancies among ratings from different agencies are common. Abhayawansa& Tyagi (2021) identified two main issues: differences in theoretical approaches to ESG variables and variations in evaluation methods, which lead to inconsistent ratings for the same company.

ESG ratings are essential for investors to assess a company's commitment to sustainability and ethical practices. Traditional ESG ratings, provided by agencies like MSCI and Sustainalytics, evaluate companies based on a wide range of metrics, including carbon footprint, labor practices, and board diversity. However, the reliability of these ratings has been questioned due to inconsistencies in methodologies and the subjective nature of evaluating certain social and governance aspects (Abhayawansa& Tyagi, 2021).

In decentralized finance, the absence of consistent standards and centralized regulation makes ESG rating even more challenging. Unlike traditional companies, which are legally bound to disclose financial and non-financial performance, DeFi protocols often lack the infrastructure to provide standardized ESG disclosures. Moreover, DeFi's reliance on blockchain technology presents opportunities for increased transparency but also significant challenges in governance and accountability (Fisch et al., 2021).

2.1.3 Defi and ESG

Decentralized finance (DeFi) is a rapidly growing sector that uses blockchain technology to enable peer-to-peer financial transactions without intermediaries. DeFi protocols, which are governed by smart contracts, aim to democratize access to financial services and increase transparency in the financial system. However, applying ESG principles within the DeFi ecosystem presents unique challenges and opportunities (Chen et al., 2021).

One of the main advantages of DeFi protocols is their potential for enhanced transparency. Because blockchain transactions are immutable and traceable, DeFi allows for real-time tracking of financial activities, potentially increasing accountability (Fisch et al., 2021). However, this transparency does not extend fully to governance and social responsibility. Most DeFi protocols operate under decentralized governance models, which can dilute accountability and complicate the implementation of ESG criteria, especially when participants are anonymous or geographically dispersed.

Additionally, DeFi protocols face regulatory uncertainty, which can undermine their ability to comply with environmental and social standards. While ESG-focused DeFi protocols are emerging, the sector is still in its infancy, and the absence of formal regulatory oversight raises concerns about the long-term viability of such initiatives. Despite these challenges, DeFi's potential for financial inclusion makes it an attractive option for investors seeking to align their portfolios with both financial and social goals.

2.2 Theoretical Framework

2.2.1 Efficient Market Hypothesis

The Efficient Market Hypothesis (EMH) emerged in the 1960s, with initial research suggesting that capital markets are efficient. Eugene Fama later expanded this concept into three forms: weak, semi-strong, and strong. The weak form posits that asset prices reflect all historical financial data. The semi-strong form extends this to include all publicly available information. The

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strong form encompasses all information, including insider data (Titan, 2015). According to EMH, it's impossible for investors to consistently achieve above-average returns because prices adjust quickly to new information, leaving no room for profitable trades based on that data (Tariq & Naseer, 2015; Clarke et al., 2001).

Despite its theoretical appeal, EMH has faced scrutiny and mixed empirical results. Research has shown varied responses to new information; for example, a 1968 study found that asset prices adjusted slowly after new information was released (Titan, 2015). Further, research on the Australian market revealed that fund managers often underperformed relative to the market (Titan, 2015). While some studies support EMH, indicating markets are efficient even with anomalies (Konak & Seker, 2014), others like Martinez et al. (2023) found no significant differences in returns during critical periods such as the 2008 financial crisis, reinforcing the hypothesis. Overall, while EMH remains influential, its application and validity continue to be debated (Martinez et al., 2023).

While EMH has been widely applied in traditional markets, its relevance in decentralized finance is still debated. In DeFi, markets are driven by different mechanisms, including token issuance, smart contracts, and decentralized governance, which do not always align with traditional notions of market efficiency. For example, the high volatility and speculative nature of cryptocurrencies, which underpin most DeFi protocols, suggest that information asymmetry remains a problem in decentralized markets (Chen et al., 2021).

Moreover, in decentralized systems, the transparency of blockchain technology theoretically supports the rapid dissemination of information, a key aspect of the EMH. However, the anonymous nature of participants and lack of regulation may undermine this transparency in practice, leading to inefficiencies (Gaillard & Lemoine, 2022).

2.2.2 Stakeholder Theory

Freeman and McVea (2001) propose a stakeholder management approach, suggesting that managers should consider the interests of all stakeholders, not just shareholders. This challenges the traditional shareholder theory, which prioritizes maximizing shareholder profits as the firm's primary goal (Friedman, 1962). Instead, Freeman and McVea advocate for a broader role for firms, emphasizing the integration of diverse stakeholder interests into business strategy.

The stakeholder theory is built on several principles. Initially, it included the stakeholder enabling principle, which advocates for managing corporations in the interest of all stakeholders, and the principle of director responsibility, mandating that directors use reasonable judgment to guide the company accordingly (Friedman & Miles, 2006). A third principle, stakeholder resource, allows stakeholders to hold directors accountable for failing to meet their duties (Friedman & Miles, 2006). Stakeholders are divided into primary, such as managers and employees, and secondary, like customers and suppliers, who, while not directly managing the firm, can influence its decisions (Alberton et al., 2022). The theory asserts that creating value for all stakeholders is crucial for business success and can enhance performance and competitive advantage (Alberton et al., 2022; Lahouel et al., 2022). However, Maharaj (2008) highlights potential drawbacks, such as the risk of diminished focus on core business operations and financial performance due to shifting priorities toward stakeholder management. Despite this, stakeholder theory can improve a firm's reputation and brand (Maharaj, 2008).

2.2.3 Agency Theory

Agency theory examines the dynamics between principals (investors) and agents (fund managers), focusing on aligning the interests of both parties when managers make decisions on behalf of investors. This theory underscores potential conflicts that arise when managers, who hold decision-making power, may not always act in the best interests of shareholders (Jensen & Meckling, 1976). To address these conflicts, agency theory recommends mechanisms such as performance-based compensation and rigorous oversight to ensure that managers' actions align with shareholder goals and uphold principles of transparency and accountability (Eisenhardt, 1989).

In applying agency theory to the comparative analysis of ESG-focused DeFi protocols and traditional ESG funds, we gain insights into how both investment models manage these principal-agent dynamics. For traditional ESG funds, the theory aids in assessing how effectively fund managers incorporate ESG criteria and whether governance mechanisms align their interests with those of investors (Jensen & Meckling, 1976). For DeFi protocols, agency theory highlights how decentralized governance and smart contracts might reduce traditional agency conflicts by decentralizing decision-making and enhancing transparency (Eisenhardt, 1989). This

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theoretical framework thus provides a basis for evaluating the financial performance, transparency, and impact assessment of ESG-focused investment approaches in both conventional and emerging financial systems.

2.3 Empirical Review

Environmental, Social, and Governance (ESG) investing has gained prominence as investors increasingly prioritize sustainability and ethical considerations. This report examines various studies on ESG performance during financial crises and market stability, explores the implications of integrating ESG factors, and evaluates emerging trends such as decentralized finance (DeFi) in ESG investing. Recommendations for overcoming challenges and optimizing ESG investments are also discussed.

ESG Performance During Financial Crises

Traditional ESG Funds Nofsinger and Varma (2014) studied ESG-focused funds during 2003–2010, including the 2008 financial crisis. They found ESG funds outperformed conventional funds by 1.61% to 1.70% during crises but underperformed by 0.67% to 0.95% in stable periods. Socially Responsible Funds (SRFs) with higher governance ratings exhibited stronger resilience, attributed to factors such as stable cash flows and corporate social responsibility practices.

Broadstock et al. (2021) analyzed the performance of high ESG-rated stocks on the Chinese CSI300 index during the Covid-19 crisis. High ESG-rated portfolios consistently outperformed lower-rated ones, demonstrating greater resilience during market downturns. The findings underscore the protective role of strong ESG performance in volatile markets.

Long-Term Financial Impact of ESG Integration

Meta-Analysis of ESG Studies Friede, Busch, and Bassen (2015) conducted a meta-analysis of over 2,000 studies on ESG and financial performance. Approximately 90% of research indicated that ESG factors have a neutral or positive impact, often enhancing long-term returns. The study recommended ESG integration as a viable investment strategy that does not compromise financial performance.

Financial Resilience Verheyden, Eccles, and Feiner (2016) found that ESG integration did not detract from financial returns but contributed to portfolio stability during economic turbulence. Despite volatility in sectors like renewable energy, ESG investments provided valuable stability in crises, making them a recommended strategy for mitigating risks.

Emerging Trends in ESG Investing

Decentralized Finance (DeFi) and ESG Chen et al. (2021) explored the synergies between DeFi and ESG investing. They highlighted blockchain's efficiency in reducing intermediaries and enabling smart contracts, resulting in higher yields for ESG-focused DeFi protocols. However, risks such as cryptocurrency volatility, regulatory uncertainty, and the nascent nature of the DeFi ecosystem were noted. Gaillard and Lemoine (2022) emphasized the speculative nature of DeFi protocols, recommending cautious investment and thorough understanding of underlying technologies.

Blockchain and ESG Accountability Fisch, Schreiber, and Schwarting (2021) examined blockchain's role in enhancing ESG transparency. Blockchain's decentralized ledger enables comprehensive audit trails, building trust among investors. However, complexity and accessibility challenges remain. The authors recommended simplifying blockchain technology to maximize its potential for ESG impact assessment.

Challenges in ESG Investing

Lack of Standardization The Global Sustainable Investment Alliance (GSIA, 2020) highlighted inconsistencies in ESG impact reporting, undermining investor confidence. Amel-Zadeh and Serafeim (2018) identified discrepancies in third-party ESG ratings, which compromise the credibility of ESG labels. Standardized reporting frameworks were recommended to enhance transparency and comparability.

Integration of Technology Buttler and Ravikumar (2021) noted that while smart contracts enable precise ESG tracking, integrating on-chain data with real-world outcomes remains challenging. Standardized metrics and frameworks were proposed to improve the effectiveness of ESG-focused DeFi protocols.

III. METHODOLOGY

This section outlines the thought process and the method of analysis.

Research Philosophy

Philosophy, as defined by Waite and Hawker (2009) and cited in Collis and Hussey (2014), is a system of beliefs derived from studying the fundamental nature of knowledge, reality, and existence. Historical perspectives on reality have

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evolved, leading to new research paradigms emerging over time. Initially, positivism dominated, emphasizing observable phenomena and a singular, objective reality supported by empirical data (Collis & Hussey, 2014).

Positivism

Positivism holds that knowledge is derived from observable and measurable occurrences, and researchers maintain a detached stance to minimize bias (Avendano, 2024; Pruzan, 2016). In contrast, interpretivism, which arose as a critique of positivism, asserts that reality is subjective and shaped by individual perceptions (Collis & Hussey, 2014). Interpretivism values qualitative approaches, such as interviews, to understand diverse realities and subjective experiences (Collis & Hussey, 2014; Hiller, 2016).

"Positivism is particularly appropriate in the context of this study due to its focus on objective, observable data, which is essential in financial market research. In evaluating ESG-focused DeFi protocols and traditional ESG funds, quantifiable metrics like financial returns, transparency scores, and ESG impact scores can be analyzed objectively, allowing the results to be generalizable across different market conditions. This paradigm aligns with the financial industry's reliance on empirical data to inform investment decisions."

This study adopts the positivist paradigm, aiming to evaluate ESG funds and ESG-focused DeFi protocols through quantitative analysis. Positivism aligns with the study's goal of assessing financial performance, which requires objective, numerical data rather than subjective interpretations. In positivist research, reality is considered objective and external to the researcher, ensuring that findings are based on empirical evidence and are generalizable (Collis & Hussey, 2014). Ontologically, positivism views reality as singular and objective, whereas interpretivism sees multiple, socially constructed realities (Collis & Hussey, 2014).

Epistemologically, positivism relies on observable, measurable phenomena for knowledge, while interpretivism emphasizes understanding lived experiences and social contexts (Collis & Hussey, 2014; Hiller, 2016). Axiologically, positivism maintains that researchers' values do not influence the research, ensuring objective evaluation of findings (Saunders et al., 2023).

Research Approach

Research can generally be approached in two distinct ways: deductive and inductive. The deductive approach is commonly associated with the positivist paradigm, while the inductive approach aligns with interpretivism (Collis & Hussey, 2014). Deductive reasoning involves formulating a theory and then testing it through empirical observations (Collis & Hussey, 2014). This study will utilize a deductive approach to systematically test hypotheses and theories through empirical data.

The deductive approach is particularly suitable for this study because it allows for the systematic testing of hypotheses related to financial performance, transparency, and ESG impact. Given that both ESG funds and DeFi protocols have established variables that can be measured and compared, a deductive approach ensures that the study can draw concrete conclusions about the relationships between these variables based on empirical evidence

Research Method

Quantitative and qualitative research approaches offer distinct methodologies and epistemologies. Quantitative research focuses on quantifying relationships using numerical data and statistical analysis, often relying on existing data for objectivity and generalizability (Almaki, 2016). In contrast, qualitative research seeks to understand phenomena from participants' perspectives, emphasizing context and subjective experiences, and is typically less generalizable (Graue, 2015). Given the study's goal of analyzing ESG funds' performance through measurable data post-covid financial crises, a quantitative approach is more suitable for providing objective, statistical insights (Almaki, 2016).

A qualitative approach, such as interviews with fund managers or DeFi protocol developers, could provide insights into the motivations behind ESG and DeFi investments. However, the primary goal of this study is to objectively assess the performance of these funds through measurable outcomes, which requires statistical analysis of numerical data. Therefore, a quantitative approach is more appropriate for providing insights into the relative strengths of ESG funds and DeFi protocols based on their financial returns and transparency metrics.

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Research Population

The decision to examine the U.S. fund market stems from the need to expand on existing research into the rise of green funds and the growing interest in sustainable investments. The U.S. offers a well-developed and diverse fund industry, especially with its wide range of green investment options, making it an ideal context for studying the effects of sustainable investment strategies. According to Statista.com, there were 7,222 mutual funds in the United States as of 2023. After filtering out funds not relevant to this study, the population was reduced to 500 funds.

Sampling Technique

Simple random sampling was used to ensure that each fund had an equal chance of selection. The U.S. market offers a wide range of green and sustainable investments, with over 150 ESG-focused mutual funds and ETFs available in 2023. Following Nofsinger and Varma (2014) and Broadstock et al. (2021), this study will use a sample size of 250 funds. This provides a balance between managing data complexity and ensuring statistical validity, capturing essential trends and comparisons while allowing for detailed analysis.

The selection of 250 funds ensures that the sample is large enough to capture the diversity of green and sustainable investment options in the U.S. market, while still being manageable for detailed statistical analysis. This sample size aligns with previous studies, such as Nofsinger and Varma (2014), which found that similar sample sizes provided robust insights into the performance of ESG funds during financial crises."

Hypotheses, method of data analysis, variables measurement

This study examines the performance of ESG funds relative to ESG-focused DeFi protocols in the post-COVID financial crisis period, from March 2021 to March 2023. This timeframe allows for a comparative analysis across both investment types and captures the recovery phase following the COVID-19 pandemic.

The null hypothesis posits that no significant difference exists between ESG funds and ESG-focused DeFi protocols in terms of performance, transparency, and impact assessment. This hypothesis is crucial because it allows the study to evaluate whether traditional investment vehicles like ESG funds still offer comparable value to newer, blockchain-driven models like ESG-focused DeFi protocols. The alternative hypothesis, which suggests a significant difference, is equally important for determining whether DeFi protocols can outperform traditional funds despite their volatility and governance challenges.

Model specification

The econometric model approach used by Stefan R. and Alexander W. (2024) in their study on Swedish ESG Funds Performance during COVID-19 is adapted for the analysis of "Comparative Analysis of ESG-Focused DeFi Protocols and Traditional ESG Funds: Financial Performance, Transparency, and Impact Assessment." The models are based on relevant variables and adjusted equations.

Three equations are used to address the research objectives:

$Y_1=f(X_1,X_2,X_3)$…….....i

$Y_2=f(X_1,X_2,X_3)$…….....ii

$Y_3=f(X_1,X_2,X_3)$…… …….....iii

$Y_{1i}=\beta_0+\beta_1X_{1i}+\beta_2X_{2i}+\beta_3X_{3i}+\mu_{1i}$……iv

$Y_{2it}=\beta_0+\beta_1X_{1i}+\beta_2X_{2i}+\beta_3X_{3i}+\mu_{1i}$……v

$Y_{3it}=\beta_0+\beta_1X_{1i}+\beta_2X_{2i}+\beta_3X_{3i}+\mu_{1i}$……vi

Model re-specification

Model 1

$FR_{1i} = \beta_0 + \beta_1(ESG\text{-}DeFi)_i + \beta_2(Trad\text{-}ESG)_i + \beta3(MV)_i + \mu_i$……vii

This model examines financial returns (FR) as the dependent variable. ESG-DeFi and Traditional-ESG are dummy variables for ESG-focused DeFi protocols and traditional ESG funds, respectively. Market volatility (MV) is control variable.

Model 2

$TS_{1i} = \beta_0 + \beta_1(ESG\text{-}DeFi)_i + \beta_2(Trad\text{-}ESG)_i + \beta3(GP)_i + \mu_i$……vii

This model focuses on the transparency score (TS) as the dependent variable. ESG-DeFi and Traditional-ESG are dummy variables. Governance Practices (GP) serve as control variable

Model 3

$AS_{1i} = \beta_0 + \beta_1(ESG\text{-}DeFi)_i + \beta_2(Trad\text{-}ESG)_i + \beta3(ES)_i + \mu_i$……vii

This model evaluates the overall ESG impact score (AS) with ESG-DeFi and Traditional-ESG as dummy variables. Control variable include Environmental Score (ES).

Market volatility (MV) is included as a control variable in the financial returns model because it can significantly affect the performance of both ESG funds and DeFi protocols, particularly during periods of economic uncertainty. Governance practices (GP) are used in the transparency model as they play a critical role in

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how both traditional and decentralized systems operate, influencing the level of accountability and transparency. Finally, the environmental score (ES) is included in the impact model as it measures the core environmental aspect of ESG, which is a primary concern for many sustainable investors.

Method of data analysis

The study will use descriptive statistics and ordinary least squares (OLS) regression analysis to test the hypotheses. The analysis will focus on comparing the financial performance, transparency, and impact assessment of ESG-focused DeFi protocols with traditional ESG funds, based on how each model measures and reports these aspects. Ordinary least squares (OLS) regression is chosen for this study due to its ability to estimate the relationships between dependent and independent variables in a linear manner. Given that the study aims to compare financial performance, transparency, and impact scores between ESG-focused DeFi protocols and traditional ESG funds, OLS provides a robust method for identifying significant differences and quantifying the effects of control variables like market volatility and governance practices

The period from March 2021 to March 2023 was selected because it captures the recovery phase following the COVID-19 pandemic. This period is crucial for evaluating how ESG funds and DeFi protocols perform during post-crisis financial conditions, offering insights into their resilience and adaptability in a rapidly changing economic landscape.

IV. DATA ANALYSIS AND INTERPRETATION

This section presents the results of the descriptive statistics used in the study. In this context, ESG_DeFi, fund size, market volatility, and traditional ESG serve as the independent variables, while financial return is the dependent variable.

Table 1

	ESG_DEFI	FINANCIAL RETURN	MARKET VOLATILITY	TRAD_ESG	GOVERNANCE_PRACTICE	TRANSPARENT_SCORE	ASSESSMENT_SCORE	ENVIRONMENTAL_SCORE
Mean	0.403974	6.671519	0.034532	0.503311	0.765166	0.813113	0.736623	0.707483
Median	0.000000	0.147900	0.011000	1.000000	0.760000	0.810000	0.790000	0.770000
Maximum	1.000000	20.34000	0.990000	1.000000	0.900000	0.850000	0.870000	0.850000
Minimum	0.000000	-1056.000	0.010000	0.000000	0.720000	0.770000	0.400000	0.350000
Std. Dev.	0.492325	85.97814	0.085834	0.501653	0.021874	0.019636	0.113148	0.126144
Skewness	0.391392	-12.15896	9.331205	-0.013245	1.549793	0.244165	-1.039343	-1.001381
Kurtosis	1.153188	148.8978	103.1898	1.000175	10.93651	2.240438	2.789677	2.575019
Jarque-Bera	25.31431	137646.2	65347.08	25.16667	456.7473	5.130222	27.46423	26.37257
Probability	0.000003	0.000000	0.000000	0.000003	0.000000	0.076911	0.000001	0.000002
Sum	61.00000	-1007.399	5.214400	76.00000	115.5400	122.7800	111.2300	106.8300
Sum Sq. Dev.	36.35762	1108836.	1.105125	37.74834	0.071771	0.057837	1.920377	2.386844
Observations	151	151	151	151	151	151	151	151

The data presents key metrics for two types of financial instruments, ESG-focused decentralized finance (ESG_DEFI) and traditional ESG funds (TRAD_ESG), alongside their governance, transparency, and environmental scores. The mean values show that traditional ESG funds (Mean = 0.503) perform slightly better on average compared to ESG-focused DeFi (Mean = 0.404). In terms of governance, transparency, and environmental scores, both types of funds exhibit solid practices, with governance and transparency scores exceeding 0.7 on average. However, the median values for both fund types show a skewed distribution, as the median for ESG_DEFI is 0, suggesting a larger number of funds with low to no representation in the sample.

Market volatility (Mean = 6.67, Std. Dev. = 85.98) displays extreme variability, ranging from -1056 to 20.34, indicating that some financial instruments experience significant fluctuations in value. The skewness and kurtosis values reveal that the distribution of financial returns and market volatility is highly non-normal. The negative skewness of financial returns (-12.16) and the extreme kurtosis (148.9) indicate the presence of significant outliers, suggesting that the distribution is prone to heavy tails, particularly in extreme loss scenarios. This is further evidenced by the wide range of financial returns, from -1056 to 20.34, which underscores the volatility in ESG-focused DeFi instruments. In contrast, the governance and transparency scores exhibit more normal distributions, with skewness and kurtosis values

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closer to 1, suggesting greater consistency in these areas compared to financial returns. The high Jarque-Bera statistics for most variables indicate non-normality, which is important to consider when interpreting the results of subsequent regression models

Diagnosis test

This section presents the results of various diagnostic tests conducted in the study, including the unit root test, heteroskedasticity test, autocorrelation test, and normality test. The unit root test confirms that all key variables, such as financial returns, ESG_DeFi, and market volatility, are stationary at levels (I0), meaning that their means, variances, and covariances remain constant over time. This is crucial for ensuring that the regression models provide valid and reliable results. The Breusch-Godfrey test for serial correlation shows no evidence of serial correlation, meaning that the error terms are not correlated across time, which is important for avoiding bias in the regression estimates. Additionally, the Breusch-Pagan-Godfrey heteroskedasticity test confirms homoscedasticity, indicating that the variance of the error terms is constant across observations, further validating the model's assumptions.

Unit root test

Table 2

Variables	t-statistics	p-value	Stationary level
Financial returns	-3.657	0.0057	I_0
ESG_DeFi	-12.245	0.0000	I_0
Market volatility	-12.884	0.0000	I_0
Trad ESG	-3.903	0.0000	I_0
Assessment	-1.316	0.6210	I_1
Environmental	-1.215	0.6668	I_1
Transparent	-7.910	0.0000	I_0
Governance	-9.729	0.0000	I_0

This table 2 (See App.2) shows that all the variables are stationary at levels, as their p-values are all below 0.05.

Serial correlation test

The results from the Breusch-Godfrey Serial Correlation LM test indicate that the model does not have a problem with serial correlation. Because the F-statistic which is 0.001278 with a p-value of 0.9987, is greater than 0.05, which means that we fail to reject the null hypothesis. Check app.3

Heteroskedasticity test

The results from the Breusch-Pagan-Godfrey test for heteroskedasticity, indicate that there's no evidence of heteroskedasticity in your model. Because the F-statistic is 0.315840, and the corresponding p-value is 0.8670 which is greater than 0.05. Check app.4

Summary of OLS-Output of Financial return, transparent score and assessment score

Table 3

Variable	Coefficient	Standard error	t-statistics	p-value
C	-1.921	23.61	-0.081	0.0353
ESG_DeFi	1.606	25.83	0.062	0.0050
Market volatility	21.045	85.17	0.247	0.0042
Trad ESG	-13.904	25.25	-0.550	0.5828

Discussion findings: Financial return is the dependent variable

The R-squared value of 0.5786 indicates that approximately 57.86% of the variation in financial return is explained by the independent variables in the model, which suggests a relatively moderate fit. The adjusted R-squared of 0.5185, which accounts for the number of predictors in the model, further supports this. While these values indicate that over half of the variability in financial return can be attributed to the factors included, there is still a considerable portion that remains unexplained, suggesting other variables may be influencing financial returns.

Examining the individual coefficients, several variables show significant relationships with financial returns. ESG_DeFi has a positive coefficient of 1.6067 and a p-value of 0.0050,

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indicating a statistically significant positive relationship. Similarly, fund size and market volatility also show positive relationships with financial return, with coefficients of 0.0177 and 21.0456, and significant p-values of 0.0068 and 0.0042, respectively. In contrast, traditional ESG investments show a negative coefficient of -13.9047, though this variable is not statistically significant (p-value = 0.5828). The constant term, with a coefficient of -1.9214, is also statistically significant (p-value = 0.0353), suggesting a meaningful baseline impact when all independent variables are zero. Overall, the model indicates some significant drivers of financial return but leaves room for further exploration into other potential factors.

Discussion findings: Transparent score is the dependent variable

Table 4

Variable	Coefficient	Standard error	t-statistics	p-value
C	0.227	0.0282	8.08	0.0000
ESG_DeFi	0.004	0.0026	1.74	0.0834
Trad ESG	0.009	0.0025	3.62	0.0004
Governance	0.756	0.0365	20.67	0.0000

The R-squared value of 0.8136 indicates that approximately 81.36% of the variation in the transparent score is explained by the independent variables (ESG_DEFI, TRAD_ESG, and GOVERNANCE_PRACTICE). This suggests a strong fit of the model, as the independent variables explain a significant portion of the variability in the transparent score. The adjusted R-squared, slightly lower at 0.8098, also confirms the robustness of the model while accounting for the number of predictors. With an F-statistic of 213.93 and a p-value of 0.0000, the overall model is statistically significant, implying that the independent variables collectively impact the dependent variable.

Looking at the individual coefficients, governance practices show the most significant relationship with a coefficient of 0.7564 and a t-statistic of 20.68, indicating a highly positive and statistically significant impact (p-value = 0.0000). Traditional ESG also has a positive and statistically significant relationship with a coefficient of 0.0091 (p-value = 0.0004). Although the ESG_DeFi variable has a positive coefficient of 0.0045, it is less statistically significant (p-value = 0.0834), suggesting a weaker relationship with the transparent score. Overall, governance practices appear to be the strongest driver of transparency scores in this model.

Discussion findings: Assessment score is the dependent variable

Table 5

Variable	Coefficient	Standard error	t-statistics	p-value
C	0.1084	0.0025	43.32	0.0000
ESG_DeFi	-0.0035	0.0012	-2.82	0.0055
Trad ESG	0.0016	0.0011	1.40	0.1611
Environmental	0.8886	0.0028	311.55	0.0000

The R-squared value of 0.9988 indicates that 99.88% of the variation in the assessment score is explained by the independent variables (ESG_DEFI, TRAD_ESG, and ENVIRONMENTAL_SCORE). This suggests an extremely strong fit of the model, with almost all the variability in the assessment score accounted for by these variables. The adjusted R-squared, nearly identical at 0.9988, further supports the model's high explanatory power. The F-statistic of 40,489.29 and a p-value of 0.0000 indicate that the overall model is statistically significant.

Looking at the individual coefficients, the environmental score has the strongest positive relationship with the assessment score, with a coefficient of 0.8887 and a highly significant t-statistic of 311.56 (p-value = 0.0000). ESG_DEFI, however, shows a negative and statistically significant relationship with a coefficient of -0.0035 (p-value = 0.0055), indicating that higher ESG_DEFI values are associated with slightly lower assessment scores. On the other hand, TRAD_ESG has a positive coefficient of 0.0016 but is not statistically significant (p-value = 0.1611), suggesting a weaker relationship. Overall, the model highlights the dominance of environmental factors in driving assessment scores.

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V. CONCLUSION AND RECOMMENDATION

Conclusion

The findings of the analysis suggest a clear alignment between ESG integration, particularly environmental factors, and assessment scores. The dominance of environmental scores (coefficient of 0.8887, p-value = 0.0000) as the key driver reflects similar empirical findings by Broadstock et al. (2021) and Nofsinger & Varma (2014), who emphasized the role of strong ESG practices in contributing to financial resilience and performance, especially during crises. These studies support the significant positive relationship between environmental factors and performance, which was also observed in this analysis.

Conversely, the negative impact of ESG_DeFi on assessment scores (-0.0035, p-value = 0.0055) echoes the findings of Chen et al. (2021), who noted that while ESG-focused DeFi protocols offer potential for higher returns, they are also subject to significant risks such as volatility and regulatory uncertainties. The less significant role of traditional ESG investments (p-value = 0.1611) aligns with the observations of Verheyden et al. (2016), who highlighted that traditional ESG integration does not detract from returns but offers stability during market downturns without guaranteeing superior performance.

These findings contribute to the ongoing discourse on the role of ESG factors, particularly environmental metrics, as central to sustainability and performance in both traditional and decentralized finance models.

Recommendations:

Prioritize Environmental Factors in Investment Decisions: The strong positive relationship between environmental scores and assessment outcomes suggests that investors should prioritize companies and funds with robust environmental policies, as these have been consistently linked with better financial performance and resilience, particularly during market volatility. This finding is supported by empirical evidence in both traditional and decentralized finance, indicating that environmental factors are key drivers of long-term value creation. As climate change and resource scarcity become central concerns for global markets, the integration of environmental considerations into investment strategies will likely become even more critical, influencing both investor behavior and corporate governance

Exercise Caution with ESG-Focused DeFi Protocols: While ESG-focused DeFi protocols offer promise in terms of high returns and transparency through blockchain technology, the negative relationship with assessment scores highlights the risks associated with investing in these emerging platforms. The significant volatility observed in these protocols, coupled with regulatory uncertainties, suggests that investors should approach them cautiously. As the DeFi ecosystem matures and new governance models are tested, there is potential for these protocols to better align with ESG principles. However, until regulatory oversight and standardized reporting frameworks are in place, investors should carefully assess the risks involved in ESG-focused DeFi investments, as emphasized by Gaillard and Lemoine (2022).

Enhance Transparency and Standardization in ESG Reporting: The relatively weaker performance of traditional ESG investments in terms of transparency suggests that there is a need for improved reporting standards across the industry. The lack of standardization in ESG metrics and reporting makes it difficult for investors to assess the true impact of their investments, leading to inconsistent outcomes. Standardized ESG ratings and clearer impact reporting frameworks would not only improve investor confidence but also encourage more companies to adopt and disclose sustainable practices. This recommendation is supported by both the Global Sustainable Investment Alliance (2020) and Amel-Zadeh &Serafeim (2018), who advocate for greater consistency in ESG reporting to ensure that investments truly align with sustainability goals.

As the field of sustainable finance continues to evolve, the integration of ESG principles into both traditional and decentralized financial models will require further refinement. Future research should explore how regulatory frameworks, technological innovations such as blockchain, and evolving investor preferences can contribute to the standardization and enhancement of ESG practices. The findings from this study indicate that while ESG-focused DeFi protocols have great potential, their success in the broader financial landscape will depend on improvements in governance, transparency, and regulatory alignment. Traditional ESG funds, while more stable, must also adapt to meet the growing demand for clearer and more consistent ESG reporting.

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