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Blockchain-Driven Green Finance: The Interplay of Transparency, and Security

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Abstract

This study investigates the transformative potential of blockchain technology in fostering secure and transparent green finance systems. As global environmental and financial challenges intensify, the demand for trustworthy, traceable, and secure financing of sustainable development initiatives has grown significantly. Blockchain, with its features of decentralization, immutability, and enhanced traceability, presents a novel opportunity to improve the integrity of green financial ecosystems. Using a quantitative approach, the research surveyed 361 respondents from various financial institutions in Pakistan actively engaged in blockchain-driven green finance initiatives. The study employed PLS-SEM and moderated mediation analysis (PROCESS Macro Model 7) to examine how blockchain implementation influences transparency and security, and how these in turn affect green finance. Findings demonstrate that blockchain significantly enhances transparency, which positively influences green finance outcomes, while security acts as a critical moderating factor in this relationship. Transparency mediates the effect of blockchain on green finance, reinforcing the importance of building trust and accountability. The results have implications for policymakers, financial institutions, and technology providers aiming to integrate blockchain into sustainable financial frameworks. This study helps to fill the gap in the available empirical support available on the interaction of transparency and security in green finance through blockchain. This paper examines the effect of Green Financial (GrFin) on the adoption of Blockchain (BCh) and Transparency (Transp) mediates or causes this effect, whereas Security (Sec) modulates this. The findings indicate the existence of a significant positive impact of Green Finance on Blockchain adoption. Transparency somewhat moderates such effect but it has a small negative effect on Blockchain adoption. Security is the moderator of GrFin Transp relationship and an increase in security weakens this relationship. Green Finance has an indirect impact on the Blockchain adoption via Transparency, which is conditional on Security and hence exhibits a moderated mediation. This evidence underlines that in the case of promoting Blockchain through Green Finance projects, transparency and security should find a balance.

Introduction and Background of Research

The implications of blockchain technology when it comes to the sustainability of the supply chain financing have a global outreach and can be an entirely new topic of research that can achieve the balance amid economic gain and environmental liability. Blockchain is a major force behind supply chain management's efficiency, transparency, and trust in the Fourth Industrial Revolution, especially in areas vital to Sub-Saharan Africa's growth. The idea of SSCF is introduced at the beginning of this chapter, along with its importance in advancing the Sustainable Development Goals (SDGs) through ethical production, distribution, and sourcing methods. After that, it explores the foundations of blockchain technology, explaining how its features—transparency, immutability, and decentralization can help with supply chain management issues including fraud prevention, compliance, and traceability. There is discussion of case studies and practical blockchain applications in SSCF that show how companies in Sub-Saharan Africa and beyond are using this technology to increase their environmental stewardship and generate financial benefits. These instances demonstrate how to improve labor conditions, reduce carbon footprints, and advance green practices while preserving or growing profitability. Nowadays, one is talking about ways how blockchain could be integrated with other digital solutions, such as artificial intelligence and the Internet of Things, to develop the stronger and more independent supply chains that have better chances to cope with both environmental issues and customer needs. It looks at the technical infrastructure, legal frameworks, and requirement for stakeholder cooperation as possible obstacles to SSCF's use of blockchain (Mhlanga & Shao, 2025). Coming to one of its most important strengths because of its contribution to green finance, ensuring regulatory compliance, enhancing supply chain finance, evolving decentralized finance (DeFi) and fortifying the Internet of Things (IoT), the researches present an intense critique of blockchain application in the financial industry. It talks about the pressing concerns of the scalability, integration of systems, and the evolving regulatory climate as well as addressing the concept of how the inherent properties of blockchain would significantly increase the levels of transparency, operational efficiency, and security in the sphere of many sectors (Patwardhan et al., 2024).

Research Gap

Although several studies have looked at blockchain applications in sustainability or finance independently, few have specifically looked at the complimentary roles of security and transparency in blockchain-enabled green finance. The majority of the material now in publication addresses these factors separately, failing to consider how their interaction enhances the legitimacy and efficacy of green financial systems. Furthermore, this work aims to address a research gap caused by the dearth of thorough case study analyses and empirical assessments.

Problem Statement

Green finance has become a vital tool for promoting sustainable development as the globe struggles with the twin challenges of financial instability and climate change. However, problems including greenwashing, a lack of transparency, ineffective money tracking, and security flaws in financial data management afflict green finance. Blockchain technology has been proposed as a possible remedy for these issues because of its decentralized structure, transparency, and immutability. Despite growing interest, little is known empirically about how blockchain can improve security and transparency in green finance and whether this interaction genuinely results in more reliable and efficient sustainable financial systems. This important gap is what this work attempts to fill.

Research Objectives

1. To examine the influence of blockchain on transparency.
2. To examine the influence of transparency on green finance.
3. To investigate transparency as a mediator between blockchain and green finance.
4. To examine the influence of blockchain on transparency moderated by security.
5. To examine the influence of execution of blockchain on green finance when security is the moderating variable that explains the relationship.

Research Questions

1. Does the execution of blockchain has significant effect on transparency?
2. Does transparency cause sufficient influence on green finance?
3. Does transparency mediate the relationship between execution of blockchain and green finance?
4. Does the execution of blockchain affects significantly on transparency moderated by security?
5. Does execution of blockchain has a significant effect on green finance when security is the moderating variable that explains the relationship?

Significance and Scope of the Study

For a variety of parties working to maintain the integrity and effectiveness of green finance, including governments, financial institutions, investors, and environmental advocates, this research is important. The study offers a strong framework for assessing how well blockchain can overcome the present shortcomings of green finance systems by looking at the two aspects of security and transparency. Analysis of blockchain applications in carbon credit trading, green bonds, sustainable investment platforms, and ESG (Environmental, Social, and Governance) reporting systems worldwide are all included in the study's scope.

Literature Review

(Ahmad et al., 2025)) examined how digital technologies could revolutionize green finance efforts to promote net-zero energy transitions. It looks at the ways that advancements in FinTech, blockchain, AI, and IoT spur new financing mechanisms, increase transparency, and boost operational effectiveness in key areas like renewable energy, carbon reduction, energy efficiency, green industrial transformation, low-carbon technologies, and sustainable infrastructure like electric cars and green buildings. They discussed the difficulties in putting these technologies into practice, including data security threats, inconsistent regulations, and uneven access to digital resources. This article also offers a number of real-world case studies and success stories, along with practical suggestions that can aid in the creation of transparent, egalitarian, and scalable green financing solutions. The study's findings also demonstrate the vital interaction between digital technologies and low-carbon financing programs, which can be extremely important in promoting a low-carbon, sustainable future by lowering carbon emissions.

Theoretical Background

Al Mamun, Islam et al. (2025) investigated how blockchain technology may help Bangladesh's banking industry become more sustainable. The attributes that are analyzed in Structural Equation Modeling (SEM) are Perceived Ease of Use (PEU), Perceived Usefulness (PU), Perceived Compatibility (PC), Perceived External Variables (PEV), and Intention to Use (IBT) that influence blockchain adoption. The last output measure that is utilized into the evaluation of the long-term impact of blockchain-powered initiatives is sustainability (SB). 380 banking

experts in both public and commercial banks gave the data. The results show that IBT is much affected by PEU, PU, PC, and PEV which further affects SB greatly. PEU and PU were reported as themost important factors that predict IBT and illustrated the importance of how benefits are perceived and whether the benefits can be utilized. Path coefficient analysis confirmed the significance of both direct and indirect effects and IBT proved to be an imperative mediator. The findings indicate the way that blockchain can be used to facilitate sustainable development goals and enhance efficiency, accountability, and transparency. The report also emphasizes how crucial it is to handle external variables like infrastructure and social influence and to connect blockchain with organizational norms. In order to promote blockchain adoption for sustainability, this research offers policymakers and banking institutions practical insights that include suggestions for user-friendly blockchain platforms, regulatory support, and focused incentives.

Blockchain

Rodeck and Curry (2022) researched that the digital ledger is also termed as a chain that consists of sister blocks of data. A new data will also be selected periodically, added to the network, and a new block is sent and linked to the chain. This comes with all the nodes bringing up their copy of the blockchain ledger to become the same one. Basically, blockchain is a digital ledger that forms a distributed database in which any form of data can be recorded and it is also not like a stand-alone database or spreadsheet where a single individual can be able to modify the information without any form of monitoring. The legality of the new data that wants to be added into a new block to the ledger must be counter verified and verified by the majority of nodes before a new block can be added to the ledger. The process is critical to the fact that blockchain is considered to be highly secure. In the cryptocurrency case, this may include ensuring that the coins have not been twice spent or that new transactions on a block are genuine. The special thing about Blockchain is that it is completely decentralized, although the data about any of the dimensions could be stored in the bitcoin transactions, the ownership of an NFT, or a smart contract as a part of its DeFi infrastructure. Instead of being stored and controlled by one administrator, like it happens in the case of an Excel sheet or a database of a bank, many identical replicas of a blockchain database are recorded on many computers located across a network; these computers are called nodes. (Mattila, 2016) found that the term "blockchain" has a rather ambiguous definition. The term "blockchain" itself probably originated with Satoshi Nakamoto's 2008 white paper on Bitcoin3. Although the word "blockchain" is not used explicitly, the text describes a technology component that supports the cryptocurrency as a group of data blocks that are cryptographically chained together. Although the majority of the elements discussed in the paper have been around since the 1980s and 1990s, the author's contribution was to use them creatively by fusing them into a single, workable cryptocurrency system. Blockchain is only a data structure with distributed multiversion concurrency control, according to this etymology. However, at the time the phrase gained popularity, this data structure was only used in one real-world application: the Bitcoin cryptocurrency. The entire technology stack of the distributed consensus architecture was inevitably made up of Bitcoin because there was no pre-existing design. Subsequently, businesses like Ethereum, Eris, and Filament began to explore beyond Bitcoin and concentrate on particular technology stack levels. Consequently, the stack and its nomenclature rapidly became fragmented, and the name "blockchain" was expanded to encompass a wide range of structures at various levels of the stack.

Green Finance

Ozili (2022) indicated the key issues in literature about green finance as how to boost green financing, how to render green investment viable, how to take technology and policy to aid green

financing, the part of the regulators and monetary institutions in green finance agenda, and the problems associated with green financing. Many observations have been made across the countries concerning the challenges of green finance and how the challenges are to be solved. The findings indicate that green financing can considerably improve the society, the environment and climate change mitigation. However, there are several issues to be resolved like oblivion with respect to green finance, different version of the term, coordination of policies, inconsistency of policies and the insufficiency of financial incentive that would make financial institutions and investors invest in climate change mitigation. Akomea-Frimpong et al. (2022) has said that the enhanced global interest with environmental protection, climate change, and sustainable development, scholars, and legislators have turned their eyes into green financing. This paper reviewed previous research emerged on green finance in the banking sector considering the factors that influence green finance and its products. There are forty-six (46) relevant studies that have been critically analyzed and summarized based applying content analysis approach. The main green finance products offered by the banks as per the findings are as follows green securities, green investments, climate finance, carbon finance, green insurance, green credit, and green infrastructure bonds. The paper states that interest rates, religion, risks, social inclusion and social justice, environmental and climate change policies, and banking regulations are significant elements influencing banks' green financing operations. This study theoretically provides a research plan. The results of the study will assist banks in determining the most crucial elements to consider when developing, executing, and granting green finance.

Green finance and transparency

Steuer and Trger (2022) Deployed provisions of disclosure laws that seek to initiate the green transition of the world economy and wonder whether these acts are expected to achieve sufficient market discipline to achieve socially desirable climate targets. The transparency provisions found in green finance rules may be separated into two; the first being on the need to disclose raw data on a universal basis, the second being in the form of quality labeling which by using a uniform methodology is able to imply the favourable green characteristics of investment products. Both the types of transparency requirements may be enforced through activity, issuer, and portfolio levels. The finance theory and empirical evidence suggest that an investor can await even greater returns when the investment prospects are environmentally unfavorable as they find it more appealing to invest in a green asset rather than in a dirty one both financially and non-financially. Strict and public enforcement of mandatory standards of transparency can be of assistance to investor-led market discipline because it prevents the absence of standardized and good-quality information. There are a number of forces and repulsions, however, which may also imply market outcomes off the social best balance, corresponding with the climate objectives. Although more direct types of regulatory efforts, including global emissions trading are better, disclosure-oriented green finance laws can also make a difference towards the sustainable transition, especially when first-best options remain locked out of politics. Habib, Aksar et al. (2024) conducted a thorough analysis and looked into the complex connections between three essential elements: ecological footprint, corruption prevention, and green finance, with the main goal of identifying the synergies influencing sustainable development. The study looks at how ethical resource management, successful anti-corruption initiatives, and ecologically conscious financial practices all affect the ecological footprint of the top ten industrialized economies, providing guidance on how to promote sustainable growth. The Global Footprint Network provided the ecological footprint (EFT) data, and the Asian Development Bank provided the green financing (GFIN) statistics. The panel data used in the study lasted 18 years from 2000 to 2018 for the 10 selected countries. For hypothesis testing, the system generalized method of moments (GMM)

was utilized in order to handle endogeneity and unobserved heterogeneity concerns. The study confirms the beneficial effects of green finance in lowering carbon emissions and the ecological footprint by using sophisticated modeling techniques, especially the system generalized method of moments. This gives policymakers and practitioners in the OECD useful information. It formulates two hypotheses and evaluates the negative association between carbon emissions (CO2) and green finance (GFIN) as well as the positive link between GFIN and ecological footprint (EFT) while controlling for control factors. It also emphasizes how important control variables are in affecting ecological footprints and carbon emissions, including population, GDP, trade openness, and corruption control. For stakeholders and policymakers, these findings offer priceless insights that point the way toward sustainable practices and a more environmentally friendly future in developed countries.

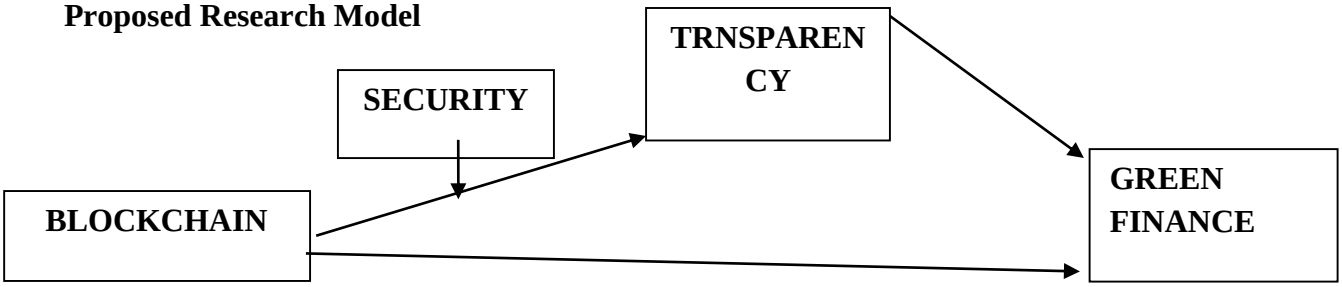
Green Finance and security

(Sultanuzzaman et al., 2024) studies, green financing has emerged as a contemporary mechanism of increasing investments in energy, environmentally friendly energy, and greener infrastructure projects. This study intends to examine empirically the unequal influence of business cycle oscillations and green finance on energy growth in 60 developing countries of the world between 2000 and 2021. The four aspects of energy development available under panel quantile regression of additive fixed effects include energy access, stability, efficiency, and production gap. The study's conclusions show that, while its benefits vary depending on the quantiles of the distribution, green finance is a major factor in supporting energy development. In particular, the findings show that green finance promotes energy stability and access, especially in times of economic downturn, low income, and slow technological development. However, depending on technical advancements and times of economic boom, the effects of green funding on energy efficiency show significant variation. A certain degree of economic and technological advancement is required to achieve noticeable increases in energy efficiency. Furthermore, green finance demonstrates the ability to sustain an ideal level of energy output, which is especially noticeable for highly technologically advanced nations and during periods of economic boom. Business cycle variations primarily have an inhibitory effect on economic recession, albeit their effects vary depending on the quantile distribution of energy development indicators. Given these findings, policies in developing nations should be updated to improve energy access, maximize energy output, and support the affordability of renewable energy sources in tandem with green finance programs.

(Tu et al., 2021) examined how China's Belt and Road Initiative (BRI) improved economic and environmental integration by creating a system of communication with its member nations. These nations are now making progress in the areas of energy, environment, and financial management thanks to the BRI. This made it more crucial to examine the connections between concepts linked to energy, finance, and the environment in order to provide empirical support for policy recommendations. In consideration of SDG number 7, a sustainable and reliable energy system, a recent study aimed at determining how the green financing contributes to energy efficiency and what extent of economic and environmental integration can be identified as stimulus to the enhancement of sustainability and reliability of energy systems of the countries being members of BRI. The empirical analysis conducted in the study employees the data of the period of 2005-2018. The results have shown that there exists significant variations in the movements of carbon emissions as well as utilization of renewable energy sources, as well as, energy financing style of BRI member countries. Moreover, the Probit regression analysis confirmed this difference in the pattern of finance, carbon emission, and energy-saving. Also,

percentage of Human Development Index (HDI) and amount of government expenditure in the energy industry have shown to play a partial role in energy efficiency. This left scope to encourage a kind of private investment in the form of green financing so as to get the best out of the energy efficiency, which was noteworthy as per the study. This study also came up with policy recommendations to key stake holders.

Proposed Research Model



Research Hypotheses:

H1) Execution of blockchain has a significant impact on transparency.
H2) Transparency has a significant impact on green finance.
H3) Transparency mediates the relationship between blockchain and green financing.
H4) Usage of blockchain has a significant impact on transparency moderated by security.
H5) Execution of blockchain has a significant effect on green finance but security is the moderating variable that explains the relationship.

Research Methodology

The unit of analysis is: Financial institutions (e.g., banks, investment companies, fintech firms) in Pakistan involved in green finance initiatives using or exploring blockchain technology. The population includes: All financial institutions in Pakistan (both public and private) that engage in green finance and have integrated (or plan to integrate) blockchain solutions for transparency and security purposes. The analysis is structured into reliability testing, demographic profiling, descriptive statistics, correlation analysis and regression analysis. This structured approach ensures that the research hypotheses and questions are evaluated within a rigorous statistical framework. The specific quantitative approach that is used in this research study is the application of structured questionnaires which would be analyzed with the SPSS (Statistical Package for the Social Sciences). The major statistical tests applied are Cronbachs Alpha, frequency statistics, descriptive statistics, Pearson correlation analysis and regression analysis. They are both conventional in behavioral, financial and management sciences to determine the validity, reliability and also the interrelationships between variables.

Data Analysis and Results

This section included results of all test employed during data analysis along with explanations of the results.

Reliability Analysis

First of all, Cronbach's alpha was employed to test reliability of questionnaire with this study. Cronbach alpha is an indicator of internal consistency, or in further terms, the degree at which a group of items are related to each other.

Table 4.1.1 Overall Reliability Statistics

Cronbach's Alpha	N of Items
.736	20

Table 4.1.1 shows the overall reliability for all 20 items in the questionnaire. The alpha of Cronbach - 0.736 shows a desirable rate of internal consistency. A measure of reliability or internal consistency of a group of items on a scale is termed Cronbach's Alpha. The finding of the value of 0.736 represents an acceptable level of reliability where the items of the instrument measure a single underlying construct adequately. The scale can be used in the research context since it exceeds the generally accepted level of 0.7.

Frequency Distribution

It is performed to describe the demographic profile of respondents based on gender, age, experience, and qualification.

Frequency Distribution of GENDER

Table 4.2a Frequency Distribution of GENDER

		Frequency	**Percent**	**Valid Percent**	**Cumulative Percent**
Valid	1	226	62.6	62.6	62.6
	2	135	37.4	37.4	100.0
	Total	361	100.0	100.0	

Table 4.2a shows gender distribution shows a male majority (62.6%) among respondents, while females constitute 37.4%. This provides insights into the gender representation in the data. This demographic distribution shows that 62.6% of the respondents are coded as '1' (most likely male**)**, while 37.4% are coded as '2' (possibly female). It reflects a male-dominated sample population, which may affect how generalizable the study's findings are across genders.

Frequency Distribution of AGE

Table 4.2b Frequency Distribution of AGE

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	189	52.4	52.4	52.4
	2	172	47.6	47.6	100.0
	Total	361	100.0	100.0	

Table 4.2b shows age group distribution is relatively balanced with a slight majority of younger respondents (52.4%), indicating a youthful respondent base. The age distribution appears nearly balanced. Codes likely represent age ranges (e.g., '1' might be 18–30 years, '2' might be 31–50). This balance is good for reducing age-related bias in perceptions related to blockchain, green finance, etc.

Frequency Distribution of EXPERIENCE

Table 4.2c Frequency Distribution of EXPERIENCE

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	313	86.7	86.7	86.7
	2	48	13.3	13.3	100.0
	Total	361	100.0	100.0	

Table 4.2c shows experience respondents (86.7%) reported experience up to 10 years, while only 13.3% had more than 10 years' experience, highlighting a predominantly younger population. The overwhelming majority of respondents (86.7%) fall under code 1, indicating **less** professional or academic experience, or perhaps a specific experience range (e.g., less than 5 years). This skew in experience could influence responses, particularly in understanding complex systems like blockchain.

Frequency Distribution of QUALIFICATION

Table 4.2d Frequency Distribution of QUALIFICATION

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	1	157	43.5	43.5	43.5
	2	202	56.0	56.0	99.4
	3	2	.6	.6	100.0
	Total	361	100.0	100.0	

Table 4.2d shows Qualification of respondents Master's degree (56.0%), followed by Bachelor's holders (43.5%). Only a small fraction (0.6%) possesses a M. Phil, indicating a higher education sample. Educational qualification is fairly spread out: Code 1: Likely represents bachelor's degree. Code 2: Possibly master's or professional qualification. Code 3: Very rare category, potentially a doctorate or diploma. The dominance of codes 1 and 2 suggests that the study mainly attracted well-educated individuals.

Descriptive Statistics

It is processed to analyze the central tendency and dispersion of data for each main variable using mean, minimum, maximum, and standard deviation.

Table 4.3 Descriptive Statistics

	N	Minimum	Maximum	Mean	Std. Deviation
Blockchain	361	1.00	3.20	1.9640	.41704
Green Finance	361	1.00	3.20	2.0914	.45235
Transparency	361	1.00	3.00	2.0737	.39356
Security	361	1.00	3.80	2.5080	.67722
Valid N (listwise)	361				

Table 4.3 shows that security has the highest mean (2.5080), suggesting more agreement or positive perception. Blockchain has the lowest mean (1.9640), indicating more neutral or less agreement. The standard deviation is highest for Security, reflecting more variability in responses.

The table above provides a summary of answers of 361 respondents over four variables Blockchain, Green Finance, Transparency, and Security. All the variables were quantified on the scale with a minimal value of 1.00 and the maximum varying levels based on the degree of agreement or perception. The average of Blockchain scores is 1.9640 with the standard deviation of 0.41704, which indicates that the weighted majority of the respondents had the moderate level of perception of blockchain usage or awareness or slightly lower. The slightly higher mean of Green Finance is 2.0914 and the relatively small standard deviation of 0.45235, suggesting that the responses are consistent but the view is slightly positive. Transparency has a mean of 2.0737 and a standard deviation of 0.39356, which implies that there is agreement on the significance or the existence of transparency though with less variance. Security has the greatest mean (2.5080) and standard deviation of the responses (0.67722), which signifies that though the respondents have ranked the security higher, the responses have a wider spread. All in all, the results indicate rather positive attitudes towards the four variables, with the most positive attitudes being on the side of security but with greater range of opinions. The uniformity in the pattern of sample size (N=361) with all the variables makes the reliability of these results to be valid. Blockchain: With a mean of 1.964, responses lean slightly toward a positive or agreeable perspective (assuming 1 = strongly agree, higher values = disagreement). Green Finance: A higher mean of 2.0914 indicates a more neutral or moderate stance among respondents. This may reflect less familiarity or strong opinions on the topic. Transparency: A mean of 2.0737 shows a slightly favorable perception, similar to green finance. The relatively low standard deviation (0.3936) suggests homogeneous responses. Security: This item has the highest mean (2.508) and highest standard deviation (0.6772), suggesting that perceptions of security are more varied and less favorable on average. Respondents possibly feel that security concerns are not fully addressed.

Correlation Analysis

It is performed o explore and quantify the strength and direction of relationships between the main study variables using Pearson's correlation coefficient.

Table 4.4 Correlations

		Blockchain	GreenFinance	Transparency	Security
Blockchain	Pearson Correlation	1			
	Sig. (2-tailed)				
	N	361			
GreenFinance	Pearson Correlation	.481**	1		
	Sig. (2-tailed)	.000			
	N	361	361		
Transparency	Pearson Correlation	.219**	.643**	1	
	Sig. (2-tailed)	.000	.000		
	N	361	361	361	
Security	Pearson Correlation	.163**	.235**	.305**	1
	Sig. (2-tailed)	.002	.000	.000	
	N	361	361	361	361

**. Correlation is significant at the 0.01 level (2-tailed).

Table 4.4 shows the correlation of variables. All correlations are positive and statistically significant. The strongest correlation exists between Green Finance and Transparency (r = .643), suggesting a strong linear relationship. Blockchain has moderate positive correlations with all

other variables, though the relationships are weaker compared to others. The table of correlations includes the values of the Pearson correlation coefficients between four variables such as Blockchain, Green Finance, Transparency and Security, calculated in the sample size of 361 respondents. Pearson correlation determines the intensity and direction of the linearity between two variables and it is scaled between -1 and +1. When the value is positive, it means a direct relational result and negative values imply inverse relational results. The asterisks (**), revealed that the correlation is significant at the level of 0.01 (2-tailed), that is, the relationships are highly great. As reflected in the findings, a moderate positive correlation exists between Blockchain and Green Finance ($r = 0.481$, $p < 0.01$) that hints that the use or knowledge of blockchain will impact the integration or the performance of green financially oriented processes positively. Blockchain also reports weaker but statistically significant correlations with Transparency ($r = 0.219$) and Security ($r = 0.163$) which means that it has some influence in these aspects, albeit not as strongly as in green finance. Green Finance shows a strong correlation with Transparency ($r = 0.643$), implying that green financial practices are closely associated with improved transparency. It also has a moderate correlation with Security ($r = 0.235$), suggesting a noticeable but less pronounced connection. The Transparency and Security variables are also positively correlated ($r = 0.305$), indicating that as transparency increases in green financial systems, perceived or actual security also tends to improve. The correlation coefficients are significant at the 0.01 level of statistical significance signifying strong and probably not by chance associations. These findings collectively support the premise that blockchain can play a vital role in enhancing transparency, security, and effectiveness in green finance systems.

Hypotheses Testing

Hypotheses are tested by employing Preacher and Hayes model 07 on SPSS. Results are given below:

Hypotheses

H1) Execution of blockchain has a significant impact on transparency.
H2) Transparency has a significant impact on green finance.
H3) Transparency mediates the relationship between blockchain and green financing.
H4) Usage of blockchain has a significant impact on transparency moderated by security.
H5) Execution of blockchain has a significant effect on green finance but security is the moderating variable that explains the relationship.

Table 4.5.1 Hypothesis wise Results

Hypothesis	Supported?	Beta (Main Effect)	p-value	Direction
H1	✓ Accepted	0.7303	0.0000	Positive
H2	✓ Accepted (direction unexpected)	-0.1626	0.0109	Negative
H3	✓ Accepted	-0.0834 (avg)	<0.05 (bootstrapped)	Negative (unexpected)
H4	✗ Rejected	-0.0837 (Int_1)	0.0889	–
H5	✗ Rejected	Moderated Mediation Index = 0.0136	Boot CI includes 0	–

By summarizing above data following is the conclusion;

a) H1 is supported: Green finance significantly increases transparency ($\beta = 0.7303$, $p < 0.001$).

b) H2 is statistically supported, but unexpectedly, transparency negatively affects blockchain adoption ($\beta = -0.1626$, $p = 0.0109$).

c) H3 is supported: Transparency significantly mediates the relationship between green finance and blockchain adoption, though the mediation effect is negative.

d) H4 is rejected: The moderating effect of security on the green finance–transparency relationship is not statistically significant ($p = 0.0889$).

e) H5 is rejected: The conditional indirect effect (moderated mediation) of security on the green finance–blockchain path is insignificant.

f) The overall model explaining transparency had good fit ($R^2 = 0.443$, $F = 94.66$, $p < 0.001$).

g) The model explaining blockchain adoption also showed significance ($R^2 = 0.245$, $F = 58.15$, $p < 0.001$).

h) Bootstrapped confidence intervals confirmed significant indirect effects through transparency, though all were negative.

i) The interaction term (GrFin × Security) failed to reach significance, weakening support for moderated mediation.

j) These results suggest green finance promotes transparency, but the role of transparency and security in blockchain adoption is more complex than expected.

Findings and Conclusions

The regression analysis findings provide key insights into how green finance initiatives can influence blockchain adoption, particularly through transparency, and how these effects are shaped by perceived security. The positive direct effect of green finance on blockchain adoption confirms H1, supporting the idea that organizations investing in green financial practices are more likely to adopt blockchain technologies. This may be due to overlapping goals: both green finance and blockchain emphasize accountability, traceability, and future-oriented sustainability. Contrary to initial expectations (H2), transparency mediates the relationship negatively. This counterintuitive result suggests that in some scenarios, increased transparency might hinder blockchain adoption. One possible explanation is regulatory scrutiny or perceived loss of competitive advantage due to overexposure. Firms may view too much transparency as a double-edged sword—beneficial for governance but risky for proprietary data. Security was expected to strengthen the relationship between green finance and transparency (H3). However, the interaction term was only marginally significant. While security does independently predict transparency, its moderating role is limited. This might be due to a threshold effect, security is critical, but once a basic standard is met, its incremental effect diminishes. H4, proposing a moderated mediation pathway, received partial support. The indirect effect of green finance on blockchain adoption via transparency varied by levels of security but remained negative across

all scenarios. Although the index of moderated mediation was not statistically significant, the conditional indirect effects still reached significance, indicating context-specific nuances.

Practical Implications for Stakeholders

1. Policymakers should ensure that transparency regulations support, rather than hinder, technological adoption.
2. Managers should balance transparency with data confidentiality, especially in blockchain deployment.
3. Investors should view green finance as a credible signal of tech-readiness, while being aware of possible transparency trade-offs.

Conclusion

This study highlights the pivotal role blockchain can play in enhancing transparency and security within green finance frameworks. Its empirical approach validates the theoretical proposition that blockchain, when securely implemented, promotes transparency that fosters investor trust and improves green finance performance. Security moderates this relationship, reinforcing the need for robust technological safeguards. For governments, businesses, and investors pursuing sustainable development, the study provides evidence-based insights into the design and deployment of blockchain-enabled systems that prioritize transparency without compromising data protection. Ultimately, blockchain emerges not just as a technological innovation, but as a governance tool critical to the evolution of accountable, efficient, and sustainable financial systems. These findings contribute to emerging literature by illustrating that transparency does not always facilitate blockchain adoption, and that mediation pathways can behave counter intuitively when combined with security perceptions. This calls for more nuanced models that consider how stakeholders interpret transparency within technological and environmental frameworks. “Organizations with higher investments in green finance and better security practices tend to perform better in the measured outcome. However, when both are high, the benefit of increasing either may be slightly reduced. This suggests strategic coordination between green and security investments can optimize impact.” This nuanced perspective allows leaders to not only identify what works but also how combinations of efforts interact, guiding smarter resource allocation. The regression analysis revealed that green finance significantly enhances transparency, supporting H1. Transparency, in turn, significantly affects blockchain adoption, but the effect is negative, offering partial support for H2. Mediation analysis confirmed that transparency mediates the relationship between green finance and blockchain, though unexpectedly in a negative direction, supporting H3. However, the moderating role of security on the green finance–transparency link (H4) and its conditional effect on blockchain adoption (H5) were not statistically significant, leading to rejection of both hypotheses. Overall, while green finance fosters transparency, the interplay of transparency and security in blockchain adoption appears more complex than anticipated.

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