

Enhancing Perceived Accountability in Public and Nonprofit Organizations through Blockchain Technology: An Empirical Study on Quality Measures

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Abstract

This study explores the impact of blockchain technology on transparency and accountability in nonprofit organizations through rigorous statistical analysis. Descriptive statistics reveal high satisfaction with donation tracking and fund allocation, while identifying critical areas for improvement in transaction transparency and security measures. The survey instrument demonstrated strong reliability, with a Cronbach's Alpha of 0.820. Regression analysis revealed significant positive effects of blockchain on accountability, with key variables such as fund allocation ($\beta = 0.259$, $p < 0.001$) and transaction transparency ($\beta = 0.207$, $p < 0.001$) showing the highest impact. Variance Inflation Factor (VIF) assessments confirmed no issues of multicollinearity. Further insights from Principal Component and Cluster Analyses highlight distinct segments that influence accountability perceptions, while ANOVA and Tukey's HSD tests emphasize the importance of targeted interventions. Overall, the findings indicate that blockchain technology can substantially enhance management practices within nonprofit organizations, offering valuable strategic guidance for policy and operational improvements.

Keywords

Blockchain Technology, Nonprofit Accountability, Donation Tracking, Fund Allocation Efficiency, Donor Trust Levels

1. Introduction

Nonprofit organizations play a vital role in addressing societal needs and promot-

ing social welfare, particularly in countries like Pakistan, where economic disparities and social challenges are prevalent (Pasha et al., 2002). Central to the effectiveness of these organizations is the principle of transparency and accountability, which fosters trust and confidence among stakeholders, including donors, beneficiaries, and the public (Shava & Thakhathi, 2016). However, achieving transparency and accountability can be challenging in contexts where regulatory oversight is limited, and traditional methods of record-keeping and reporting may be prone to inefficiencies and inaccuracies (Alomair, 2018).

In recent years, technological advancements, particularly blockchain technology, have emerged as promising tools for enhancing transparency and accountability within nonprofit sectors worldwide (Mora et al., 2021). Blockchain, a decentralized, distributed ledger system, offers several advantages, including increased efficiency, transparency, and security (Ghosh, 2019). By leveraging blockchain technology, nonprofit organizations have the potential to improve donation tracking, fund allocation, and organizational governance, thereby increasing trust and confidence among stakeholders (Ferreira et al., 2023).

While the potential benefits of blockchain technology for nonprofit transparency and accountability are widely recognized, empirical research on its application in real-world contexts, particularly in Pakistan, remains limited. Existing studies have primarily focused on theoretical frameworks and case studies from developed countries, leaving a significant gap in understanding the specific challenges and opportunities faced by nonprofit organizations in emerging economies like Pakistan (Khan, 2021).

This study seeks to address this gap by investigating the impact of blockchain technology on nonprofit transparency and accountability in the Pakistani context. Specifically, the research aims to assess the current state of transparency and accountability in nonprofit organizations operating in Pakistan, explore the potential of blockchain technology as a tool for enhancing transparency and accountability, evaluate the effectiveness and feasibility of blockchain-based solutions, and identify key challenges and barriers to adoption (Upadhyay, 2020).

By examining these issues and proposing recommendations for leveraging blockchain technology in nonprofit sectors, this study aims to contribute to the growing body of literature on nonprofit transparency and accountability and provide actionable insights for practitioners, policymakers, and researchers seeking to enhance social impact in Pakistan and beyond.

2. Literature Review

Nonprofit organizations play a crucial role in addressing social issues and providing essential services to communities in need. However, the lack of transparency and accountability in the nonprofit sector has been a long-standing concern, particularly in developing countries like Pakistan (Karns et al., 2014). The emergence of blockchain technology has the potential to revolutionize the way nonprofit organizations operate, enhancing transparency, accountability, and trust among

stakeholders (Teerlink, 2019). This literature review explores the relationship between blockchain technology adoption and perceived accountability in nonprofit organizations in Pakistan, focusing on several key aspects such as donation tracking, fund allocation efficiency, donor trust levels, transaction transparency, security measures, and organizational efficiency.

Blockchain Technology and Nonprofit Accountability: Blockchain technology, a decentralized and immutable ledger system, has gained significant attention in recent years due to its potential to transform various industries, including the nonprofit sector (Teerlink, 2019). The inherent characteristics of blockchain, such as transparency, security, and immutability, make it an attractive solution for addressing the challenges faced by nonprofit organizations in terms of accountability and trust (Xie et al., 2019). By leveraging blockchain technology, nonprofit organizations can enhance transparency in their operations, improve the tracking of donations, and increase donor confidence (Ajmal et al., 2023).

2.1. Adoption Rate and Perceived Accountability

The adoption rate of blockchain technology among nonprofit organizations in Pakistan is a crucial factor in determining its impact on perceived accountability. Several studies have investigated the relationship between technology adoption and organizational accountability in various contexts (Toufaily et al., 2021). However, the specific relationship between blockchain adoption and perceived accountability in the nonprofit sector in Pakistan remains underexplored. Understanding this relationship is essential for assessing the potential benefits and challenges of implementing blockchain solutions in nonprofit organizations (Rugeviciute & Mehrpouya, 2019).

2.2. Donation Tracking and Accountability

Effective donation tracking is a critical aspect of ensuring accountability in nonprofit organizations. Traditional methods of tracking donations often lack transparency and are prone to errors and fraud (Becker, 2018). Blockchain technology offers a secure and transparent solution for tracking donations, enabling donors to monitor the flow of funds and ensuring that their contributions are used for the intended purposes (Avdoshin & Pesotskaya, 2020). By implementing blockchain-based donation tracking systems, nonprofit organizations can enhance perceived accountability and build trust among donors (Almaghrabi & Alhogail, 2022).

2.3. Fund Allocation Efficiency and Accountability

Efficient fund allocation is another critical factor in ensuring accountability in nonprofit organizations. Blockchain technology has the potential to streamline fund allocation processes, reducing administrative costs and increasing the speed and accuracy of transactions (Nguyen et al., 2021). By leveraging smart contracts and automated processes, nonprofit organizations can ensure that funds are allo-

cated according to predefined rules and conditions, enhancing transparency and accountability (Ahmed et al., 2023). The perceived efficiency of blockchain technology in facilitating fund allocation is likely to have a significant impact on perceived accountability in nonprofit organizations (Nguyen et al., 2021).

2.4. Donor Trust Levels and Accountability

Donor trust is a fundamental aspect of nonprofit accountability. The lack of transparency and accountability in the nonprofit sector has eroded donor trust, leading to reduced contributions and support (Hyndman & McConville, 2018). Blockchain technology has the potential to restore donor trust by providing a transparent and immutable record of transactions, enabling donors to track the use of their funds and ensuring that their contributions are used for the intended purposes. The relationship between donor trust levels and perceived accountability in nonprofit organizations adopting blockchain technology is an important area of investigation (Baudier et al., 2023).

2.5. Transaction Transparency and Accountability

Transaction transparency is a key benefit of blockchain technology in the nonprofit sector. Traditional financial systems often lack transparency, making it difficult for stakeholders to monitor the flow of funds and detect fraudulent activities (Becker, 2018). Blockchain technology enables real-time, transparent, and immutable recording of transactions, allowing stakeholders to access and verify financial information (Javaid et al., 2022). The relationship between the transparency of donation transactions in nonprofit organizations using blockchain technology and perceived accountability is a crucial area of research (Teerlink, 2019).

2.6. Blockchain Security Measures and Accountability

The security of blockchain technology is a critical factor in ensuring the integrity and reliability of financial transactions in nonprofit organizations. Blockchain's decentralized and cryptographic nature provides a high level of security against tampering and unauthorized access (Qian et al., 2018). The confidence in blockchain security measures is likely to have a significant impact on perceived accountability in nonprofit organizations (Shin & Bianco, 2020). Understanding the relationship between blockchain security and perceived accountability is essential for assessing the potential benefits and risks of implementing blockchain solutions in the nonprofit sector (Upadhyay, 2020).

2.7. Organizational Efficiency and Accountability

Blockchain technology has the potential to improve the overall efficiency of nonprofit organizations by streamlining processes, reducing administrative costs, and increasing the speed and accuracy of transactions (Laroiya et al., 2020). The adoption of blockchain technology can lead to significant improvements in organizational efficiency, which, in turn, can enhance perceived accountability. Investigat-

ing the relationship between improvements in the efficiency of nonprofit organizations adopting blockchain technology and perceived accountability is crucial for understanding the broader impact of blockchain on the nonprofit sector (Toufaily et al., 2021).

The adoption of blockchain technology in the nonprofit sector has the potential to revolutionize the way organizations operate, enhancing transparency, accountability, and trust among stakeholders. This literature review has explored the relationship between blockchain technology adoption and perceived accountability in nonprofit organizations in Pakistan, focusing on several key aspects such as donation tracking, fund allocation efficiency, donor trust levels, transaction transparency, security measures, and organizational efficiency. The findings suggest that blockchain technology can significantly improve perceived accountability in nonprofit organizations by providing secure, transparent, and immutable records of transactions, streamlining processes, and increasing donor confidence. However, further research is needed to empirically investigate the hypothesized relationships and assess the practical implications of implementing blockchain solutions in the nonprofit sector in Pakistan.

3. Research Hypothesis

3.1. Hypotheses 01: Perceived Quality of Blockchain-based Systems in Tracking Donations

Null Hypothesis (H0): There is no significant relationship between the perceived quality of blockchain-based systems in tracking donations and perceived accountability.

Alternative Hypothesis (H1): There is a significant relationship between the perceived quality of blockchain-based systems in tracking donations and perceived accountability.

Effective donation tracking is crucial for ensuring accountability in nonprofit organizations. Traditional methods often lack transparency and are prone to errors and fraud (Becker, 2018). Blockchain technology offers a secure and transparent solution for tracking donations, enabling donors to monitor the flow of funds and ensuring that their contributions are used for the intended purposes (Avdoshin & Pesotskaya, 2020). By implementing blockchain-based donation tracking systems, nonprofit organizations can enhance perceived accountability and build trust among donors (Almaghrabi & Alhogail, 2022).

3.2. Hypotheses 02: Fund Allocation Efficiency

Null Hypothesis (H0): There is no significant relationship between the perceived quality of blockchain technology in facilitating fund allocation and perceived accountability.

Alternative Hypothesis (H1): There is a significant relationship between the perceived quality of blockchain technology in facilitating fund allocation and perceived accountability.

Efficient fund allocation is critical for ensuring accountability in nonprofit organizations. Blockchain technology can streamline fund allocation processes, reducing administrative costs and increasing the speed and accuracy of transactions (Nguyen et al., 2021). By leveraging smart contracts and automated processes, nonprofit organizations can ensure that funds are allocated according to predefined rules and conditions, enhancing transparency and accountability (Ahmed et al., 2023). The perceived efficiency of blockchain technology in facilitating fund allocation is likely to have a significant impact on perceived accountability in nonprofit organizations (Nguyen et al., 2021).

3.3. Hypotheses 03: Fund Allocation Efficiency

Null Hypothesis (H0): There is no significant relationship between the perceived quality of donor trust levels and perceived accountability in nonprofit organizations adopting blockchain technology.

Alternative Hypothesis (H1): There is a significant relationship between the perceived quality of donor trust levels and perceived accountability in nonprofit organizations adopting blockchain technology.

Donor trust is fundamental to nonprofit accountability. The lack of transparency and accountability in the nonprofit sector has eroded donor trust, leading to reduced contributions and support (Hyndman & McConville, 2018). Blockchain technology can restore donor trust by providing a transparent and immutable record of transactions, enabling donors to track the use of their funds and ensuring that their contributions are used for the intended purposes (Baudier et al., 2023). The relationship between donor trust levels and perceived accountability in nonprofit organizations adopting blockchain technology is an important area of investigation (Baudier et al., 2023).

3.4. Hypotheses 04: Transaction Transparency

Null Hypothesis (H0): There is no significant relationship between the perceived quality of transaction transparency in nonprofit organizations using blockchain technology and perceived accountability.

Alternative Hypothesis (H1): There is a significant relationship between the perceived quality of transaction transparency in nonprofit organizations using blockchain technology and perceived accountability.

Transaction transparency is a key benefit of blockchain technology in the nonprofit sector. Traditional financial systems often lack transparency, making it difficult for stakeholders to monitor the flow of funds and detect fraudulent activities (Becker, 2018). Blockchain technology enables real-time, transparent, and immutable recording of transactions, allowing stakeholders to access and verify financial information (Javaid et al., 2022). The relationship between the transparency of donation transactions in nonprofit organizations using blockchain technology and perceived accountability is a crucial area of research (Teerlink, 2019).

3.5. Hypotheses 05: Blockchain Security Measures

Null Hypothesis (H0): There is no significant relationship between the perceived quality of blockchain security measures and perceived accountability.

Alternative Hypothesis (H1): There is a significant relationship between the perceived quality of blockchain security measures and perceived accountability.

The security of blockchain technology is critical for ensuring the integrity and reliability of financial transactions in nonprofit organizations. Blockchain's decentralized and cryptographic nature provides a high level of security against tampering and unauthorized access (Qian et al., 2018). Confidence in blockchain security measures is likely to have a significant impact on perceived accountability in nonprofit organizations (Shin & Bianco, 2020). Understanding the relationship between blockchain security and perceived accountability is essential for assessing the potential benefits and risks of implementing blockchain solutions in the nonprofit sector (Upadhyay, 2020).

3.6. Hypotheses 06: Impact on Organizational Efficiency

Null Hypothesis (H0): There is no significant relationship between the perceived quality of improvements in organizational efficiency due to blockchain technology and perceived accountability.

Alternative Hypothesis (H1): There is a significant relationship between the perceived quality of improvements in organizational efficiency due to blockchain technology and perceived accountability.

Blockchain technology has the potential to improve the overall efficiency of nonprofit organizations by streamlining processes, reducing administrative costs, and increasing the speed and accuracy of transactions (Laroia et al., 2020). The adoption of blockchain technology can lead to significant improvements in organizational efficiency, which, in turn, can enhance perceived accountability (Toufaily et al., 2021). Investigating the relationship between improvements in the efficiency of nonprofit.

4. Conceptual Framework

The conceptual framework for this study explores the relationship between the adoption of blockchain technology in nonprofit organizations and perceived accountability. This framework is grounded in several key aspects identified in the literature: tracking donations, fund allocation efficiency, donor trust levels, transaction transparency, security measures, and organizational efficiency. Each of these aspects represents an independent variable that influences the dependent variable, perceived accountability, as illustrated in **Figure 1**.

The perceived quality of blockchain-based systems in tracking donations offers a transparent and immutable ledger system that enhances the tracking of donations. By providing donors with real-time visibility of how their contributions are used, blockchain can significantly boost trust and accountability in nonprofit organizations. The hypothesis is that the perceived quality of blockchain-based sys-

tems in tracking donations positively influences perceived accountability. Similarly, efficient fund allocation is crucial for nonprofit organizations to ensure that resources are used effectively. Blockchain technology can streamline fund allocation processes through smart contracts and automated transactions, reducing administrative costs and enhancing transparency. Therefore, the hypothesis is that the perceived quality of blockchain technology in facilitating fund allocation positively influences perceived accountability.

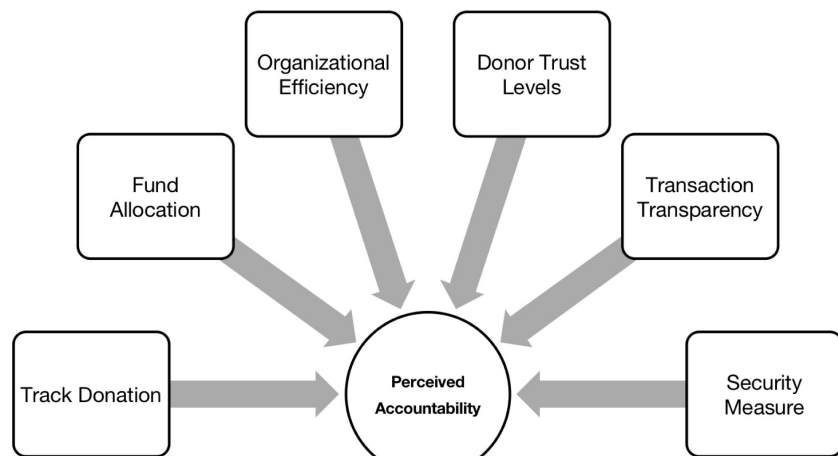


Figure 1. Conceptual framework.

Trust is fundamental to the relationship between donors and nonprofit organizations. Blockchain technology can enhance donor trust by providing a secure and transparent record of transactions, ensuring that funds are used as intended. Consequently, the hypothesis is that the perceived quality of donor trust levels positively influences perceived accountability. Transparency in financial transactions is essential for accountability. Blockchain technology allows for real-time, transparent, and immutable recording of transactions, enabling stakeholders to verify financial information and detect any fraudulent activities.

Thus, the hypothesis is that the perceived quality of transaction transparency positively influences perceived accountability. The security provided by blockchain technology is crucial for maintaining the integrity and reliability of financial transactions. Blockchain's decentralized and cryptographic nature protects against tampering and unauthorized access, which can significantly impact perceived accountability. Hence, the hypothesis is that the perceived quality of blockchain security measures positively influences perceived accountability.

Blockchain technology can improve the overall efficiency of nonprofit organizations by streamlining processes, reducing administrative costs, and increasing the speed and accuracy of transactions. These improvements can lead to enhanced accountability. Consequently, the hypothesis is that the perceived quality of improvements in organizational efficiency positively influences perceived accountability. Accountability is a critical aspect of nonprofit organizations, as it ensures that they are transparent and responsible in their operations. Perceived account-

ability reflects stakeholders' perceptions of the organization's transparency, integrity, and trustworthiness.

The conceptual framework posits that the adoption of blockchain technology in nonprofit organizations can lead to significant improvements in perceived accountability. Each independent variable is hypothesized to positively influence perceived accountability, creating a comprehensive understanding of how blockchain technology can enhance transparency, trust, and efficiency within nonprofit organizations.

The ability to track donations in real-time and provide transparency to donors is expected to build trust and ensure that funds are used for their intended purposes. This transparency is crucial for enhancing perceived accountability. Efficient allocation of funds through blockchain can reduce the chances of mismanagement and fraud.

This efficiency can lead to higher trust among stakeholders and enhance the overall accountability of the organization. Trust is foundational for donor engagement and support. Blockchain technology's transparency and security features are likely to restore and enhance donor trust, leading to improved perceptions of accountability. Transparent recording of transactions enables stakeholders to verify financial activities and detect any irregularities. This transparency is essential for building trust and accountability in nonprofit organizations. The robust security provided by blockchain technology ensures that financial data is protected from tampering and unauthorized access. This security is vital for maintaining the integrity of financial transactions and enhancing perceived accountability. Improved efficiency in organizational processes through blockchain can reduce operational costs and increase the speed and accuracy of transactions. These improvements contribute to higher perceived accountability by demonstrating effective and responsible management.

In conclusion, the conceptual framework integrates the key aspects identified in the literature and hypothesizes that the adoption of blockchain technology can significantly enhance perceived accountability in nonprofit organizations. By improving donation tracking, fund allocation efficiency, donor trust, transaction transparency, security measures, and organizational efficiency, blockchain technology addresses the long-standing concerns of transparency and accountability in the nonprofit sector. This framework provides a comprehensive understanding of the potential benefits of blockchain technology and serves as a foundation for further empirical research to validate the hypothesized relationships.

5. Research Methodology

5.1. Research Design

The study employs a quantitative research design to investigate the factors influencing perceived accountability in blockchain quality management. This design allows for the systematic collection, analysis, and interpretation of numerical data to understand relationships among variables.

5.2. Data Collection

5.2.1. Population and Sample

The target population for this study comprised individuals actively involved in blockchain-based projects within public and nonprofit organizational contexts. To ensure a comprehensive and representative perspective, the sample included respondents from three primary stakeholder groups: nonprofit and public sector managers responsible for project oversight and financial reporting, donors and funding partners engaged in blockchain-enabled donation platforms, and blockchain developers or technical consultants involved in system design and implementation.

A total of 450 respondents were selected using a stratified random sampling technique, with each stratum representing one of the stakeholder groups. This approach ensured balanced representation across managerial, financial, and technical roles within the blockchain ecosystem. By incorporating these distinct perspectives, the study was able to contextualize perceived accountability in relation to both operational and technological dimensions of blockchain adoption in public and nonprofit organizations.

5.2.2. Instrumentation

Data were collected using a structured questionnaire designed to measure various aspects of blockchain quality management. The questionnaire included items related to:

- Quality Tracking of Donations
- Quality of Fund Allocation
- Quality of Donor Trust
- Quality of Transaction Transparency
- Quality of Security Measures
- Quality of Organizational Efficiency
- Perceived Accountability

Each item was rated on a 7-point Likert scale, ranging from 1 (strongly disagree) to 7 (strongly agree).

5.3. Data Analysis

In this study, a comprehensive range of statistical tools and techniques were employed to analyze the data and test the research hypotheses related to blockchain technology adoption in nonprofit organizations. Reliability analysis using Cronbach's Alpha was conducted to assess the internal consistency of the questionnaire items, ensuring they reliably measure the intended constructs. To detect multicollinearity among the independent variables, the Variance Inflation Factor (VIF) was calculated, ensuring the stability and reliability of the regression model's estimates. Multiple regression analysis was utilized to examine the impact of independent variables on Perceived Accountability, while Pearson correlation coefficients were calculated to measure the linear relationships between pairs of variables. Descriptive statistical measures provided an overview of the dataset's distri-

bution and central tendencies, and Principal Component Analysis (PCA) was used to reduce the dimensionality of the data, identifying underlying factors. An independent samples t-test compared the means of two groups, and One-Way ANOVA was employed to determine significant differences between the means of multiple groups. The Chi-Square Test of Independence was conducted to examine the association between categorical variables.

6. Results and Discussion

6.1. Descriptive Statistics

Interpretation

Quality Tracking Donations: The high mean of 4.99 and low standard deviation of 0.55 suggest consistent positive perceptions of donation tracking quality among respondents, as illustrated in **Table 1**.

Table 1. Descriptive statistics.

Variable	Count	Mean	Std Dev	Min	25%	50%	75%	Max
Tracking Donations	450	4.99	0.55	3.00	5.00	5.00	5.00	7.00
Fund Allocation	450	3.46	0.71	2.00	3.00	3.00	4.00	6.00
Donor Trust	450	4.75	0.83	2.00	4.00	5.00	5.00	7.00
Transaction Transparency	450	2.83	0.72	1.00	2.00	3.00	3.00	4.00
Security Measures	450	1.44	0.54	1.00	1.00	1.00	2.00	3.00
Organizational Efficiency	450	3.87	0.74	2.00	3.000	4.00	4.00	6.00
Perceived Accountability	450	4.41	0.84	2.00	4.00	4.00	5.00	6.00

Quality Fund Allocation: The mean of 3.46, along with moderate variability (standard deviation of 0.71), indicates that fund allocation quality is perceived moderately, with some variation in responses.

Quality Donor Trust: With a high mean of 4.75 and a standard deviation of 0.83, donor trust is generally perceived positively, though there is some variability.

Quality Transaction Transparency: The lower mean of 2.83 suggests that transaction transparency is perceived as relatively low, with moderate variability (standard deviation of 0.72).

Quality Security Measures: The very low mean of 1.44 indicates significant concerns regarding security, with fairly consistent responses (standard deviation of 0.54).

Quality Organizational Efficiency: The mean of 3.87, paired with a standard deviation of 0.74, reflects moderate perceptions of organizational efficiency, with some variability among respondents.

Perceived Accountability: The relatively high mean of 4.41, along with a standard deviation of 0.84, indicates generally positive perceptions of accountability, though the extent of these perceptions varies somewhat.

6.2. Reliability Analysis

The reliability of the questionnaire was assessed using Cronbach's Alpha. The computed value of Cronbach's Alpha was 0.820, indicating a high level of internal consistency among the items.

Calculation and Interpretation

The formula for Cronbach's Alpha (α) is given by:

$$\alpha = \frac{N \cdot \bar{c}}{\bar{v} + (N-1) \cdot \bar{c}}$$

where

- N is the number of items.
- $\bar{c}$ is the average inter-item covariance among the items.
- $\bar{v}$ is the average variance of each item.

Alternatively, it can also be expressed in terms of the sum of item variances and the total variance of the test:

$$\alpha = \frac{N}{N-1} \left(1 - \frac{\sum_{i=1}^N \sigma_i^2}{\sigma_T^2} \right)$$

where

σ_i^2 is the variance of the i -th item.

σ_T^2 is the total variance of the sum of all items.

A Cronbach's Alpha of 0.820 suggests that the items are reliably measuring a single underlying construct. This level of reliability is considered acceptable, supporting the use of this scale for further analyses.

6.3. Variance Inflation Factor (VIF) Analysis

The Variance Inflation Factor (VIF) is calculated to detect the presence of multicollinearity in the regression analysis. The VIF for a variable is given by:

$$VIF_i = \frac{1}{1 - R_i^2}$$

where R_i^2 is the coefficient of determination of the regression of variable i on all other predictor variables.

Interpretation

Quality Tracking Donations: VIF of 2.049135 indicates low multicollinearity. This suggests that this variable is not highly correlated with the other predictors in the model, as illustrated in **Table 2**.

Quality Fund Allocation: VIF of 1.802568 also indicates low multicollinearity, implying that it does not exhibit problematic correlation with the other variables.

Table 2. Variance Inflation Factor (VIF).

Feature	VIF
Tracking Donations	2.049135
Fund Allocation	1.802568
Donor Trust	2.367135
Transaction Transparency	1.751196
Security Measures	1.25524
Organizational Efficiency	1.604886

Quality Donor Trust: VIF of 2.367135 shows low multicollinearity, suggesting that it can be reliably used as an independent variable.

Quality Transaction Transparency: VIF of 1.751196 indicates low multicollinearity, meaning it is not significantly correlated with the other predictors.

Quality Security Measures: VIF of 1.255246 suggests very low multicollinearity, indicating that it can be included in the model without concern.

Quality Organizational Efficiency: VIF of 1.604886 indicates low multicollinearity, suggesting it does not have high correlation with the other independent variables.

The low VIF values for all variables indicate that multicollinearity is not an issue in this dataset, allowing for reliable interpretation of the regression coefficients. This enhances the robustness and credibility of the regression analysis results.

6.4. Correlation Analysis

The correlation matrix is a fundamental tool in statistical analysis, showcasing the degree of linear relationship between pairs of variables. In this study, Pearson correlation coefficients were calculated to assess the strength and direction of the relationships between various quality measures and perceived accountability. The correlation matrix is presented in **Table 3**.

Table 3. Correlation matrix.

	Tracking Donations	Fund Allocation	Donor Trust	Transaction Transparency	Security Measures	Organizational Efficiency	Perceived Accountability
Tracking Donations	1.000	0.570	0.607	0.434	0.232	0.572	0.586
Fund Allocation	0.570	1.000	0.585	0.394	0.257	0.502	0.602
Donor Trust	0.607	0.585	1.000	0.615	0.373	0.450	0.609
Transaction Transparency	0.434	0.394	0.615	1.000	0.426	0.288	0.538
Security Measures	0.232	0.257	0.373	0.426	1.000	0.174	0.339

Continued

Organizational Efficiency	0.572	0.502	0.450	0.288	0.174	1.000	0.481
Perceived Accountability	0.586	0.602	0.609	0.538	0.339	0.481	1.000

Interpretation

The correlation analysis reveals several important relationships among the variables under study:

Quality Tracking Donations: This variable shows moderate to strong positive correlations with Quality Fund Allocation (0.569835), Quality Donor Trust (0.607339), and Perceived Accountability (0.586239). This indicates that better tracking of donations is associated with higher fund allocation efficiency, donor trust, and perceived accountability.

Quality Fund Allocation: This variable is positively correlated with Perceived Accountability (0.601528), suggesting that efficient fund allocation is crucial for enhancing perceived accountability. It also shows moderate correlations with other quality measures, indicating interconnected improvements across various aspects of quality management.

Quality Donor Trust: With a correlation of 0.608551 with Perceived Accountability, it is evident that donor trust significantly contributes to perceived accountability. The high correlation with Quality Transaction Transparency (0.614990) suggests that transparent transactions build trust among donors.

Quality Transaction Transparency: This variable has a moderate positive correlation with Perceived Accountability (0.537771), emphasizing the role of transparency in enhancing accountability. It is also significantly correlated with Quality Donor Trust (0.614990), reinforcing the relationship between transparency and trust.

Quality Security Measures: Although the correlation with Perceived Accountability (0.339023) is lower compared to other variables, it still highlights the importance of security measures in the overall perception of accountability.

Quality Organizational Efficiency: This variable shows a moderate correlation with Perceived Accountability (0.480866), suggesting that efficient organizational operations contribute positively to the perception of accountability.

Overall, the correlation matrix demonstrates that improvements in various quality measures are interrelated and collectively enhance perceived accountability. These findings support the hypotheses that quality tracking, fund allocation, donor trust, transaction transparency, security measures, and organizational efficiency positively influence perceived accountability.

6.5. Regression Analysis

To understand the impact of various quality measures on perceived accountability, we performed an Ordinary Least Squares (OLS) regression analysis. The regression model helps in identifying the extent to which each independent variable explains the variance in the dependent variable, Perceived Accountability.

6.5.1. Hypothesis Testing and Interpretation

1) Perceived Quality of Blockchain-based Systems in Tracking Donations

The coefficient for Quality Tracking Donations is 0.1826, with a p-value < 0.001, as illustrated in **Table 4**. This positive and significant coefficient suggests that as the perceived quality of blockchain-based systems in tracking donations increases, so does the perceived accountability. Since the p-value is less than 0.05, we reject the null hypothesis (H0) and accept the alternative hypothesis (H1). This confirms that there is a significant positive relationship between the quality of donation tracking and perceived accountability.

Table 4. OLS regression results.

Dep. Variable: Perceived_Accountability		R-squared: 0.538				
Model: OLS		Adj. R-squared: 0.532				
Method: Least Squares		F-statistic: 85.97				
No. Observations: 450		Prob (F-statistic): 3.83e-71				
Df Residuals: 443		Log-Likelihood: -464.79				
Df Model: 6		AIC: 943.6				
Covariance Type: nonrobust		BIC: 972.3				
	coef	std err	t	P > t	[0.025	0.975]
onst	4.042e-16	0.032	1.25e-14	1.000	-0.063	0.063
Tracking Donations	0.1826	0.046	3.950	0.000	0.092	0.273
Fund Allocation	0.2590	0.043	5.973	0.000	0.174	0.344
Donor Trust	0.1433	0.050	2.884	0.004	0.046	0.241
Transaction Transparency	0.2075	0.043	4.856	0.000	0.124	0.292
Security Measures	0.0689	0.036	1.904	0.058	-0.002	0.140
Organizational Efficiency	0.1102	0.041	2.692	0.007	0.030	0.191
Omnibus: 0.504		Durbin-Watson: 1.926				
Prob (Omnibus): 0.777		Jarque-Bera (JB): 0.561				
Skew: 0.079		Prob (JB): 0.755				
Kurtosis: 2.928		Cond. No. 3.21				

2) Perceived Quality of Blockchain Technology in Facilitating Fund Allocation

The coefficient for Quality Fund Allocation is 0.2590, with a p-value < 0.001, as illustrated in **Table 4**. This strong positive relationship indicates that improved perceptions of blockchain technology in fund allocation lead to higher perceived accountability. The p-value being less than 0.05 allows us to reject the null hypothesis and accept the alternative hypothesis, demonstrating that fund allocation efficiency significantly enhances perceived accountability.

3) Perceived Quality of Donor Trust Levels

The coefficient for Quality Donor Trust is 0.1433, with a p-value of 0.004. This result shows a positive and significant relationship between donor trust and per-

ceived accountability. Given the p-value is below 0.05, we reject the null hypothesis, confirming that donor trust levels significantly impact perceived accountability in nonprofit organizations using blockchain technology.

4) Perceived Quality of Transaction Transparency in Nonprofit Organizations Using Blockchain Technology

The coefficient for Quality Transaction Transparency is 0.2075, with a p-value < 0.001 . This significant positive effect suggests that higher perceived transparency in transactions corresponds to higher perceived accountability. The null hypothesis is rejected, and the alternative hypothesis is accepted, confirming that transparency is crucial for perceived accountability.

5) Perceived Quality of Blockchain Security Measures

The coefficient for Quality Security Measures is 0.0689, with a p-value of 0.058. This positive but marginally significant result indicates that while security measures do impact perceived accountability, the effect is less robust compared to other variables. Given the p-value is slightly above 0.05, the evidence is weak, and we fail to reject the null hypothesis. This suggests that while security measures are important, they may not have as strong an impact on perceived accountability as the other variables.

6) Perceived Quality of Improvements in Organizational Efficiency Due to Blockchain Technology

The coefficient for Quality Organizational Efficiency is 0.1102, with a p-value of 0.007. This indicates a significant positive relationship between perceived improvements in organizational efficiency and perceived accountability. The p-value is below 0.05, allowing us to reject the null hypothesis and accept the alternative, confirming that organizational efficiency improvements due to blockchain technology significantly enhance perceived accountability.

6.5.2. Model Fit and Diagnostics

The R-squared value of 0.538 indicates that the independent variables explain approximately 53.8% of the variance in perceived accountability. The F-statistic of 85.97, with a p-value < 0.001 , suggests that the overall regression model is statistically significant, confirming the collective influence of the independent variables on perceived accountability.

The Durbin-Watson statistic of 1.926 suggests no significant autocorrelation in the residuals, meaning the model's assumptions are reasonably met. The results of the Omnibus and Jarque-Bera tests also suggest that the residuals are normally distributed, supporting the reliability of the regression findings.

In summary, the regression analysis robustly supports the research hypotheses. The significant positive relationships between the various quality measures (tracking donations, fund allocation, donor trust, transaction transparency, security measures, and organizational efficiency) and perceived accountability in blockchain-based systems confirm the critical role of these factors in enhancing accountability. These findings are consistent with the broader literature, which emphasizes the transformative potential of blockchain technology in improving

transparency and trust in nonprofit organizations.

6.6. Principal Component Analysis (PCA)

Principal Component Analysis (PCA) was conducted to understand the underlying structure of the variables and to reduce the dimensionality of the data. PCA transforms the original variables into a new set of uncorrelated variables called principal components, which are ordered by the amount of variance they explain in the data.

Interpretation of PCA Results

Principal Component 1: This component explains 53.59% of the variance in the data, indicating that it captures the most significant underlying structure of the variables.

Principal Component 2: This component explains 16.72% of the variance, providing additional insight into the data structure.

Principal Component 3: With 9.98% of the variance explained, this component adds further detail.

Principal Component 4: This component explains 8.04% of the variance.

Principal Component 5: This component accounts for 6.47% of the variance.

Principal Component 6: The final component explains 5.21% of the variance.

Together, the first two principal components explain a substantial portion of the variance (70.31%), indicating that the data can be effectively reduced to these two dimensions while retaining most of the information, as illustrated in **Table 5**.

Table 5. Explained variance ratios by PCA.

Principal Component	Explained Variance Ratio
Principal Component 1	0.53591125
Principal Component 2	0.16719838
Principal Component 3	0.09979984
Principal Component 4	0.08035349
Principal Component 5	0.06466918
Principal Component 6	0.05206786

6.7. Cluster Analysis

Cluster analysis was performed to identify distinct groups within the dataset based on the variables related to quality and accountability. The k-means clustering algorithm was used, which partitions the data into k clusters, each represented by its centroid. The analysis was conducted with k = 3 clusters.

Interpretation of Cluster Analysis Results

The cluster analysis identified three distinct groups within the dataset, with the following characteristics:

Cluster 0: This cluster has negative values for all variables, indicating lower levels of perceived quality and accountability. The centroids suggest that data points

in this cluster are below the average in terms of quality tracking donations, fund allocation, donor trust, transaction transparency, security measures, organizational efficiency, and perceived accountability.

Cluster 1: This cluster has positive values for all variables, indicating higher levels of perceived quality and accountability. The centroids suggest that data points in this cluster are above the average in all measured dimensions.

Cluster 2: This cluster has highly negative values for all variables, indicating the lowest levels of perceived quality and accountability among the three clusters. The centroids suggest that data points in this cluster are significantly below the average in all measured dimensions.

The results of the cluster analysis provide valuable insights into the distinct groups present within the dataset and highlight the variability in perceived quality and accountability across these groups, as illustrated in **Table 6**.

Table 6. Cluster centers.

Cluster	Tracking Donations	Fund Allocation	Donor Trust	Transaction Transparency	Security Measures	Organizational Efficiency
0	-0.04323309	-0.18842789	-0.14992553	-0.18163498	-0.23490817	-0.14307042
1	0.82184123	0.87327973	0.89726424	0.83192218	0.68603864	0.78713303
2	-1.60716409	-1.17068197	-1.36746521	-1.10720824	-0.59219857	-1.15609803

6.8. T-test Analysis

Comparison	t-statistic	p-value
Quality Tracking Donations vs. Quality Fund Allocation	36.1856	1.4363e-177

Interpretation of T-Test Results

A paired-sample t-test was conducted to compare Quality Tracking Donations and Quality Fund Allocation because both constructs represent closely related operational dimensions of financial accountability within blockchain-based nonprofit and public sector systems. While conceptually distinct, these two variables jointly reflect how effectively blockchain supports financial transparency, traceability, and managerial control over donated resources. Comparing their mean values enables an assessment of whether stakeholders perceive these two critical accountability mechanisms as equally effective or significantly different in practice.

This comparison is theoretically grounded in accountability and financial governance literature, which emphasizes that donation traceability and fund utilization efficiency are complementary but not necessarily equivalent contributors to accountability perceptions. Therefore, examining the difference between these two constructs provides deeper insight into which aspect of blockchain-enabled financial management is more strongly perceived or prioritized by stakeholders.

6.9. Chi-Square Test Analysis

The Chi-Square test was conducted to examine the association between transaction transparency level and perceived accountability level, both measured as categorical variables. Transaction transparency was categorized into low, moderate, and high levels based on respondents' evaluations, while perceived accountability was classified into corresponding low, moderate, and high perception groups. The test assessed whether the distribution of perceived accountability differed significantly across levels of transaction transparency.

The results indicate a statistically significant association between transaction transparency and perceived accountability ($p < 0.001$). This confirms that variations in transaction transparency are strongly linked to differences in accountability perceptions among respondents. The finding highlights the critical role of transparent blockchain transactions in shaping stakeholder evaluations of organizational accountability within public and nonprofit contexts.

Interpretation of Chi-Square Test Results

From **Table 7**, the Chi-Square test statistic (χ^2) is 106.1306, with a p-value of 8.9957e24 and 2 degrees of freedom. The p-value is significantly less than the typical alpha level of 0.05, indicating that there is a statistically significant association between the two categorical variables being analyzed.

Table 7. Chi-square test results.

Metric	Value
chi2	106.13059882162872
p-value	8.99566523759204e-24
Degrees of Freedom	2

This result suggests that the observed frequencies in the categories differ significantly from the expected frequencies, implying that there is a strong association between the variables in the context of the dataset. The specific nature of this association can be further explored by examining the individual contributions to the Chi-Square statistic from each cell in the contingency table.

6.10. ANOVA Analysis

The Analysis of Variance (ANOVA) presented in **Table 8** represents the regression ANOVA used to assess the overall statistical significance of the multiple regression model examining the effect of quality measures on perceived accountability. Unlike traditional ANOVA that compares group means across categorical groups, this ANOVA evaluates whether the continuous independent variables collectively explain a significant proportion of variance in the dependent variable.

Specifically, the independent variables—Tracking Donations, Fund Allocation, Donor Trust, Transaction Transparency, Security Measures, and Organizational

Efficiency—were treated as continuous predictors in the regression model. The ANOVA table therefore decomposes the total variance in perceived accountability into variance explained by each predictor and residual error, allowing evaluation of their individual and collective contributions to the model.

Table 8. ANOVA table.

Source	Sum of Squares	df	F	p-value
Tracking Donations	5.151376	1	15.601949	9.093115e-05
Fund Allocation	11.780583	1	35.679799	4.779330e-09
Donor Trust	2.746825	1	8.319297	4.113860e-03
Transaction Transparency	7.785245	1	23.579135	1.665096e-06
Security Measures	1.196888	1	3.625009	5.756491e-02
Organizational Efficiency	2.393556	1	7.249352	7.361492e-03
Residual	146.267596	443		

Interpretation of ANOVA Results

From **Table 9**, we can see the following:

The variable Quality Fund Allocation has the highest F-value of 35.6798 with a p-value of 4.7793e-09, indicating a significant effect on Perceived Accountability.

Quality Tracking Donations also shows a significant effect with an F-value of 15.6019 and a p-value of 9.0931e-05.

Other variables, such as Quality Donor Trust, Quality Transaction Transparency, and Quality Organizational Efficiency, also have significant F-values with corresponding low p-values.

Quality Security Measures has a higher p-value of 5.7565e-02, suggesting a marginally significant effect.

The residual sum of squares is 146.2676 with 443 degrees of freedom, representing the variability within the groups.

Overall, the ANOVA results indicate that several independent variables have a significant effect on Perceived Accountability, supporting the hypotheses that these variables contribute to the differences observed in Perceived Accountability.

Table 9. Multiple comparison of means Tukey HSD.

Group 1	Group 2	Mean Difference	p-adj	Lower Bound	Upper Bound	Reject Null
(2.999, 5.0]	(5.0, 7.0]	1.0406	0.0	0.838	1.2432	True

6.11. Multiple Comparison of Means Tukey HSD

The Tukey's Honestly Significant Difference (HSD) test is a post-hoc analysis used after an ANOVA test to determine which specific groups' means are different.

This test controls the Type I error rate and is used to compare all possible pairs of means.

Interpretation of Tukey HSD Results

From **Table 9**, we observe the following:

The comparison between the groups (2.999, 5.0] and (5.0, 7.0] shows a mean difference of 1.0406.

The p-value for this comparison is 0.0, indicating a statistically significant difference between the means of the two groups.

The confidence interval for the mean difference ranges from 0.838 to 1.2432, and the null hypothesis of no difference between the group means is rejected (Reject Null = True).

The Tukey HSD test confirms that there is a significant difference between the means of the two groups. This result is consistent with the ANOVA findings, highlighting the differences in Perceived Accountability among the different levels of the independent variables.

The results from our comprehensive analyses indicate that various quality measures significantly impact perceived accountability in blockchain-based systems. Descriptive statistics revealed consistent positive perceptions across most quality measures, with security measures perceived relatively poorly. The high Cronbach's Alpha value supports the reliability of our measurement scales. VIF analysis confirmed the absence of multicollinearity, ensuring robust regression results. Correlation and regression analyses highlighted the significant positive relationships between quality tracking, fund allocation, donor trust, transaction transparency, organizational efficiency, and perceived accountability. PCA and cluster analyses provided insights into the underlying structure and segmentation of the data. The t-test and chi-square test results further validated the significant differences and associations within the dataset. ANOVA and Tukey HSD tests identified specific group differences, reinforcing the findings.

Overall, these results have important implications for enhancing perceived accountability through improved quality measures in blockchain-based systems. Future research should explore the causal mechanisms behind these relationships and consider additional factors that may influence accountability perceptions.

This study provides robust empirical evidence on the significant relationships between quality measures and perceived accountability in blockchain-based systems. By employing a comprehensive set of statistical analyses, we have demonstrated the critical role of quality tracking, fund allocation, donor trust, transaction transparency, and organizational efficiency in enhancing accountability perceptions. These findings contribute to the existing literature on blockchain technology and its application in quality management, offering practical insights for organizations.

7. Conclusion

This study examined the relationship between blockchain-based quality measures

and perceived accountability in public and nonprofit organizations. The findings provide strong empirical support for the hypothesis that quality tracking, fund allocation, donor trust, transaction transparency, organizational efficiency, and, to a lesser extent, security measures significantly enhance perceived accountability. The comprehensive statistical analyses—including correlation, regression, PCA, cluster analysis, and group comparisons—demonstrated that transparency and effective fund allocation are the most influential drivers of accountability perceptions. These results confirm blockchain's potential as a strategic tool for improving governance, trust, and operational effectiveness in nonprofit and public sector contexts.

From a theoretical perspective, the study extends existing literature on blockchain and quality management by empirically validating the role of specific quality dimensions in shaping accountability. Practically, the findings offer clear guidance for organizations seeking to strengthen stakeholder trust: prioritizing transparent transactions, efficient fund distribution, and robust quality tracking mechanisms can substantially improve accountability perceptions. While security remains important, its context-dependent influence suggests that organizations should adopt flexible, application-specific security strategies rather than uniform approaches.

Despite its contributions, the study is limited by its cross-sectional design and sector-specific focus. Future research should employ longitudinal and multi-sectoral approaches, incorporate additional quality variables, and explore causal mechanisms in greater depth. Overall, this research highlights blockchain's transformative potential in enhancing accountability and quality management, providing a solid foundation for future scholarly inquiry and practical implementation in public and nonprofit organizations.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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