



The Impact of Blockchain Technology on Supply Chain Transparency and Integration in China's Charitable Organizations

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Abstract

Purpose: Charitable and humanitarian supply chains have long suffered from inadequate funding and resource management, misappropriation, corruption, and distribution imbalances, severely undermining organizational credibility, donor motivation, and impediments to achieving philanthropic goals. This study examines how blockchain technology enhances supply chain transparency and integration in Chinese charitable organizations while assessing the moderating effects of external challenges through an integrated Technology-Organization-Environment and institutional theory lens. **Research design, data, and methodology:** Using Partial Least Squares Structural Equation Modelling (PLS-SEM), the authors analyzed survey data from 298 blockchain-exposed China Charity Federation (CCF) members. **Results:** Blockchain adoption significantly improves transparency and integration. External challenges asymmetrically moderate these relationships: regulatory pressures weaken transparency gains while technical standards strengthen integration. A self-reinforcing cycle emerges between transparency and integration, driven by standardized protocols like blockchain-audited financial reports. **Conclusions:** Blockchain serves as both a technological solution and a governance paradigm for charitable supply chains. Drawing empirical insights from China's charitable ecosystem, this study proposes a framework with broader applicability to other models of charitable coordination. The research elucidates blockchain's potential to enable charitable organizations and their supply chains globally to reconcile ethical accountability with operational efficiency amid increasing digitization of humanitarian service delivery.

Keywords: Blockchain Technology, Supply Chain Transparency, Supply Chain Integration, Charitable Organizations

JEL Classification: H410, L140, O330, G300

1. Introduction

1.1. Background

Charitable and humanitarian supply chains have been plagued by mismanagement of funds and resources,

including illegal misappropriation, corruption, and misdistribution (Archambeault et al., 2015; LeClair, 2019; Banda & Mulenga, 2024). In June 2024, China's Ministry of Civil Affairs publicly condemned the China Children's Charity Foundation (CCAFC) for regulatory violations, including mismanagement of its '9958' crowdfunding

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program, unauthorized expansion of its business scope, and poor disclosure of information, which sparked an outcry. Such incidents seriously erode public trust and impede humanitarian or charitable action effectiveness, as opaque resource flows increase skepticism about charities (Dubey et al., 2019). These challenges highlight the need to restore public trust in humanitarian and charitable action through more effective technological interventions. In this context, blockchain technology has emerged as a transformative solution that provides immutable and real-time traceable records and electronic depositories, opens up possibilities for efficient and decentralized governance scenarios, and theoretically, these features can enhance the transparency and integration of humanitarian and charitable supply chains (Saber et al., 2019; Baharmand & Comes, 2022).

1.2. Problem Statement and Research Gap

Despite blockchain's great potential, its application in the supply chain of charitable organizations is still in its infancy, and empirical evidence of its impact is minimal. Existing studies have also focused mainly on financial transparency (Tian et al., 2024), neglecting key dimensions such as cross-organizational integration and the moderating role of external challenges (e.g., regulatory complexity, technological barriers, etc.) (Kouhizadeh et al., 2021). Particularly in Chinese charitable organizations operating within a centralized philanthropy ecosystem—characterized by strong governmental oversight and coordination through entities like the China Charity Federation (CCF), leading to concentrated resource allocation and decision-making (Du, 2022; CICC Research, 2024; Han et al., 2025) — the mechanism of action on how increased supply chain transparency specifically affects the degree of their organizational integration has not yet resulted in clear research findings. This gap is particularly evident in large emerging economies (e.g. China and India), where rapid digitization in many emerging economies goes hand in hand with institutional fragmentation (Kamble et al., 2018).

1.3. Research Objectives

Based on the current status and characteristics of Chinese charitable organisations and their supply chain operations, this study explores the impact of adopting blockchain technology on the transparency and integration of charitable organisations' supply chains. It reveals the role of blockchain-enabled transparency changes in organisational integration and clarifies the moderating effects of external challenges, thereby seeking to fill an important gap in blockchain research. Specifically, the research questions are as follows:

RQ1: How does blockchain adoption enhance transparency and integration in the supply chain of charitable organizations?

RQ2: How do external challenges moderate the blockchain-transparency and blockchain-integration relationship?

RQ3: How does blockchain-enabled transparency affect the integration of supply chains in charitable organizations?

1.4. Theoretical and Practical Contributions

This research contributes to the understanding of the role of blockchain in the supply chain of charitable organizations in both academia and practice by combining the TOE framework with institutional theory. From a theoretical perspective, this study combines the technological features of blockchain (e.g., invariance, traceability) with the specific elements of charitable activities, such as donor trust and beneficiary fairness, thus expanding the research on blockchain applications from its original focus in the business sector. Authors redefine blockchain adoption as a dual mechanism for increasing transparency and facilitating integration, bridging the gap between technology-centric and organisation-centric perspectives (Queiroz et al., 2020). From a practical perspective, this research also seeks to address the thorny issue of low philanthropic efficacy in crisis and extraordinary environments caused by the lack of transparency and integration, which is the key to charitable and philanthropy's urgent need to be addressed in practice (Baharmand et al., 2022; Sunny et al., 2020). The findings aim to enable charities to prioritise blockchain functionality (e.g., smart contracts for workflow synchronisation) while overcoming regulatory and technical bottlenecks to optimise donor engagement and operational resilience. For policymakers, these empirical insights provide benchmarks for designing balanced regulations that foster innovation without compromising data privacy, a long-standing challenge in charitable activities (Kshetri, 2017; Finck, 2018). By positioning blockchain as a governance mechanism—not merely a tool—this research provides a pathway for charities worldwide to balance ethical accountability with operational efficiency in increasingly digitized humanitarian contexts.

1.5. Paper Structure

The remainder of this paper is organized as follows. A literature review of the topic is presented (Section 2). The hypothetical structure (Section 3) and methodology (Section 4) are based on earlier studies and identify gaps in the extant literature, followed by a presentation of the results discussed in the literature (Section 5). Finally, the study discussion (Section 6) and concludes with managerial and theoretical contributions, limitations, and future research (Section 7 & 8).

2. Literature Review

As mentioned above, the research aim of this study is to examine the moderating role of external challenges and the impact of transparency in charitable supply chains on their degree of integration by investigating how blockchain adoption affects the level of transparency and integration in the supply chain of charitable organizations. This part reviews existing scholarship in six interrelated areas (Supply chain of charitable organizations, Transparency, Traceability, and the Role of Blockchain, Supply Chain Integration, Collaboration, and Blockchain's Enabling Role, Sustainability, Governance, and Blockchain Synergies, The Intersection of Humanitarianism and Charity in China), to inform subsequent research on the application of blockchain in the supply chain of charitable organizations and to lay a theoretical foundation. The literature review not only serves as a foundation for the research project but also helps the researcher to identify the current status and gaps in the research field.

2.1. Supply Chain of Charitable Organizations: Characteristics and Distinctions

The supply chain of the charitable organization is a network of goal-driven supply chains designed to efficiently deliver humanitarian aid and charitable resources to vulnerable populations, especially under contextual conditions of resource constraints and operational complexity (Day et al., 2012). Crucially, charitable supply chains differ fundamentally from commercial supply chains in their objectives, stakeholder dynamics, and operating environments (Heaslip et al., 2012; Oloruntoba & Gray, 2006). Unlike commercial supply chains, which primarily focus on profit maximization and shareholder value, charitable supply chains prioritize equitable resource allocation, rapid response to crises driven by humanitarian imperatives, and

fostering long-term stakeholder collaboration to address systemic challenges such as fragmented organizational coordination, profound trust deficits among donors, beneficiaries, and implementing agencies, and unpredictable, surge-based demand (Abidi et al., 2014; Kovács & Spens, 2007). Core characteristics of the supply chain of charitable organizations include the requirement for supply chain participants to have the agility to adapt to dynamic and often unstable environments, the ability to navigate complex socio-political contexts sensitively, and the capacity for coordination among diverse, mission-driven participants (Dubey & Gunasekaran, 2016). These distinct characteristics necessitate that charitable supply chains balance operational efficiencies with stringent ethical imperatives to ensure that aid reaches its intended beneficiaries effectively while minimizing waste and inefficiencies, a challenge less pronounced in commercial supply chains focused on predictable markets (Oloruntoba et al., 2019).

In recent years, advances in technology and techniques, particularly the rise of big data analytics, blockchain, and artificial intelligence applications, have reshaped charitable supply chain management through enhanced demand forecasting, resource optimization, and real-time decision-making (Gupta et al., 2017). For example, big data and AI predictive analytics have alleviated the mismatch between supply and demand in disaster relief, while blockchain-enabled high traceability has increased the transparency of financial flows (Behl & Dutta, 2018). Yet, the supply chain of charitable organizations faces unique challenges, including reconciling donor expectations with variable realities, coping with regulatory heterogeneity, and sustaining stakeholder trust in the face of information asymmetry (Kanda & Deshmukh, 2008). Effective coordination mechanisms (e.g., centralized hubs for cross-sectoral collaboration and decentralized systems for localized rapid response) are critical to overcoming these barriers and achieving scalable impact (Day et al., 2012).

Table 1: Key Differences Between Commercial and Charitable Supply Chains

Characteristic	Commercial Supply Chains	Charitable Supply Chains	Source(s)
Primary Objective	Profit maximization, shareholder value	Equitable aid delivery, alleviation of suffering, social impact	Heaslip et al. (2012); Oloruntoba & Gray (2006)
Demand Pattern	Relatively predictable, market-driven	Unpredictable, surge-based (disasters/crises), needs-driven	Kovács & Spens (2007); Day et al. (2012)
Key Stakeholders	Suppliers, manufacturers, distributors, customers	Donors, beneficiaries, NGOs, governments, charitable enterprises, local communities	Abidi et al. (2014)
Performance Metrics	Cost, speed, quality, profitability	Speed of response, coverage, equity, cost-effectiveness, trust	Behl & Dutta (2019); Dubey et al. (2019)
Funding Source/Driver	Sales revenue, investment	Donations (public, private), grants, often tied to specific appeals	Kovács & Spens (2007)
Accountability Focus	Shareholders, customers	Donors, beneficiaries, public, regulatory bodies	Oloruntoba et al. (2019)
Operating Environment	Stable markets, defined regulations	Complex, unstable, resource-constrained, regulatory heterogeneity	Heaslip et al. (2012); Dubey & Gunasekaran (2016)
Critical Success Factor	Efficiency, market share	Trust, coordination, agility, ethical compliance	Abidi et al. (2014); Baharmand et al. (2022)

2.2. Transparency, Traceability, and the Role of Blockchain

Blockchain technology offers a transformative paradigm for enhancing transparency and traceability in the supply chain of charitable organizations by revolutionizing the creation of a decentralized and tamper-evident ledger that can meticulously record every transaction in real-time (Dubey et al., 2020). Second, the inherent properties of blockchain ensure that critical data related to philanthropic activities (e.g., the flow of donated funds and the distribution of relief goods) is tamper-proof and retroactively verifiable, thus fundamentally strengthening trust between different stakeholders, from donors to beneficiaries and aid organizations (Baharmand et al., 2022). Challenges such as fraudulent activities and inefficient allocation of vital resources, highly detrimental to philanthropic goals and organizational credibility (Bai & Sarkis, 2019), can be mitigated through blockchain. In reality, blockchain-based supply chains can accurately track the origin and logistics of essential medical supplies or perishable food aid within the supply chain of charitable organizations, rigorously ensuring their authenticity, quality, and timeliness (Park & Li, 2021). Thus, in the complex and fragmented humanitarian aid environment, the traceability qualities of blockchain should provide crucial end-to-end visibility of funds and goods in the supply chain, seemingly alleviating the flaws and loopholes in the original process from the ground up.

However, while blockchain's transformative potential for transparency is increasingly documented in commercial supply chains, its application and empirical impact within the specific context of humanitarian and charitable operations remain understudied (Han & Fang, 2023). Crucially, the supply chain of charitable organizations faces the unique challenge of balancing the imperative for transparency (to ensure accountability and traceability) with the ethical obligation to protect the privacy and dignity of vulnerable beneficiaries and sensitive donor information (Behl et al., 2020). This delicate balance requires careful consideration and empirical validation, which this study aims to address by examining the extent to which blockchain-enabled transparency impacts charitable supply chain operations and trust.

2.3. Supply Chain Integration, Collaboration, and Blockchain's Enabling Role

Blockchain technology is a potent enabler of enhanced supply chain integration and collaboration within charitable supply chains. Supply chain integration refers to the degree of strategic alignment and operational linkage between interdependent organizations within the supply chain

network (Flynn et al., 2010). Blockchain facilitates this by establishing a decentralized, transparent distributed ledger system that effectively breaks down information silos inherent in traditional, fragmented charitable supply chains (Dubey et al., 2020; Queiroz et al., 2020). This enables seamless data exchange and efficient coordination among diverse stakeholders (e.g., donors, NGOs, logistics providers, government agencies, local partners, and beneficiaries) (Baharmand et al., 2022). The real-time visibility and data integrity provided by blockchain (as discussed in Section 2.2) are foundational prerequisites for achieving deeper integration. This enhanced connectivity not only improves supply chain resilience and operational efficiency but also underpins robust supply chain integration by optimizing information flow (Baharmand et al., 2021).

A key mechanism through which blockchain drives integration and collaboration is smart contracts. These self-executing protocols automate predefined processes based on verified conditions recorded on the blockchain (Kim & Shin, 2019; Alabaddi et al., 2023). Within charitable supply chains, smart contracts could automate fund releases upon verification of aid delivery milestones, trigger replenishment orders based on verified inventory levels at distribution points, or enforce agreed-upon service level agreements between collaborating organizations. The transparency and immutability of smart contract execution, recorded directly on the blockchain nodes, foster a high degree of trust and commitment among partners, reducing transaction costs and friction (Kim & Shin, 2019). While evidence of smart contract benefits is growing in commercial contexts, empirical validation within the unique, trust-sensitive, and often resource-constrained environment of charitable supply chains—especially concerning how they translate blockchain's transparency into tangible integration gains—remains limited and is a core focus of this study.

2.4. Sustainability, Governance, and Blockchain Synergies

Analysis of previous research has found that blockchain technology has the potential to enhance the sustainability of the supply chain of charitable organizations, including, addressing key aspects of environmental responsibility, social equity and effective governance - all of which are necessary to maintain donor trust and maximize aid impact (Park & Li, 2021; Bai & Sarkis, 2019). Blockchain's transparent and immutable ledger provides unprecedented visibility into charitable supply chain operations. Stakeholders can accurately track the origin of supplies (promoting ethical sourcing and reducing environmental footprint) and logistics status (optimizing routes and reducing waste) and verify ethical practices throughout the

donation-to-distribution chain (Baharmand et al., 2021). This traceability, inherent to blockchain, encourages responsible donations and optimizes resource utilization in constrained settings, enhancing overall charitable supply chain sustainability (Saberli et al., 2018; Park & Li, 2021).

Furthermore, blockchain is critical for strengthening governance frameworks and ensuring operational integrity within charitable supply chains. It provides a secure, auditable platform for data management, inherently improving data integrity and reducing fraud/corruption risks that erode aid effectiveness and public trust (Park & Li, 2021). The inherent qualities of blockchain promote mutual trust among stakeholders, from suppliers to beneficiaries (Dubey et al., 2020). This enhanced governance is vital in the complex charitable supply chain environment. However, identifying optimal governance models and implementation strategies for using blockchain to improve transparency and integration, particularly under significant external challenges, requires more rigorous research. Especially, in emerging economies and diverse contexts such as China and India, regulatory frameworks are constantly evolving.

2.5. The Intersection of Humanitarianism and Charity in China

Life, health and dignity, the most important elements of the human life community, and neutrality across national, political, religious and racial boundaries, form the core of humanitarianism (Fassin, 2007). In China, humanitarianism and charity are two intertwined concepts, both of which intervene in crises through positive action to alleviate the suffering of recipients and promote social welfare (CICC Research, 2024; Han et al., 2025). Humanitarianism is rooted in the ethical principles of impartiality and emergency response (Barnett, 2018), while charity emphasizes the voluntary mobilization of resources on behalf of vulnerable groups (Sulek, 2010). The reality is that the boundaries of humanitarianism are extremely wide, and go beyond stopping evil to providing relief. This distinction also seems to have been blurred in previous cases, as organizations such as the Red Cross Society of China and the China Charity Federation have been involved in both humanitarian crises (e.g. disaster relief during the 2008 Sichuan earthquake) and charitable activities (e.g. poverty alleviation campaigns), reflecting the cultural emphasis on collective welfare (Hsu, 2008). Government policies, too, further reinforce this integration by incentivising the public to engage in charitable activities while channeling resources to meet urgent humanitarian needs (Gong, 2021). From a theoretical perspective, humanity and charity do intersect and it is difficult to completely separate the two. From a practical perspective, Feldman and Orlikowski (2011) also explain this convergence: when actions prioritize outcomes such as

reducing suffering, institutional labels become secondary. Thus, the integration of humanitarianism and charitable activities in China exemplifies how organizational pragmatism and cultural values can transcend conceptual boundaries to address systemic social challenges.

To summarize, despite the growing theoretical research and practical demand for blockchain applications in supply chain management, there are still significant research gaps in understanding the problems associated with charity-based applications.

Firstly, prior research has focused on the impact of blockchain's ability to be applied in commercial contexts (e.g., invariance, traceability) on, for example, trust, transparency, and efficiency amongst supply chain participants, with little relevance to the specific outcomes pursued by philanthropic operations (e.g., donor trust or beneficiary entitlement) (Saberli et al., 2019; Baharmand et al., 2021). While previous research in commercial supply chains has established the role of blockchain in transparency and organizational integration, questions about its ability to rebuild trust in crisis-driven, resource-constrained environments remain under-explored (Sunny et al., 2020). Secondly, existing frameworks are insufficient to explain the dual role of blockchain as a transparency enhancer and integration catalyst for the supply chain of charitable organizations. While research has highlighted blockchain's ability to synchronize workflows (Queiroz et al., 2020), empirical evidence on how transparency and integration dynamically interact (especially under external pressures such as regulatory fragmentation or technological complexity) remains scarce. Furthermore, the moderating role of external challenges (e.g., regulatory uncertainty, technological barriers, stakeholder heterogeneity), amplified in humanitarian/philanthropic action due to urgency and complexity, has not been systematically studied within the supply chain of charitable organization context (Kshetri, 2017; Dubey et al., 2020).

3. Theory/Hypothesis development

3.1. Underpinning Theory

The Technology-Organisation-Environment (TOE) framework systematically reveals the potential of blockchain to improve the transparency and integration of the supply chain in charitable organizations by addressing three interdependent supply chain processes: financial (fund tracking), logistical (distribution of materials), and informational (stakeholder data sharing). Technically, blockchain's immutable ledger ensures end-to-end traceability of financial (e.g., real-time account information on donated funds) and physical (e.g., logistical information

on relief goods) goods, while smart contracts enable automated collaboration with cross-platform synchronisation (Tornatzky et al., 1990). From an organizational perspective, decentralised record-keeping reduces inter-organisational friction in financial reconciliation, logistics coordination (e.g., matching supply and demand) and information exchange (e.g., beneficiary needs assessment), thereby optimising resource efficiency (Baker, 2012). Environmentally, disparate regulatory regimes across geographies (affecting cross-regional fund transfers), public scrutiny of charitable activities (driving the need for auditable data streams), and the fragmented architecture of the original system (hindering the interoperability of multiple streams) have severely constrained blockchain scalability (Zhu et al., 2006). This triadic perspective of the TOE framework establishes testable pathways through which blockchain can redefine the dynamics of integration and transparency in multi-stream charitable supply chain systems.

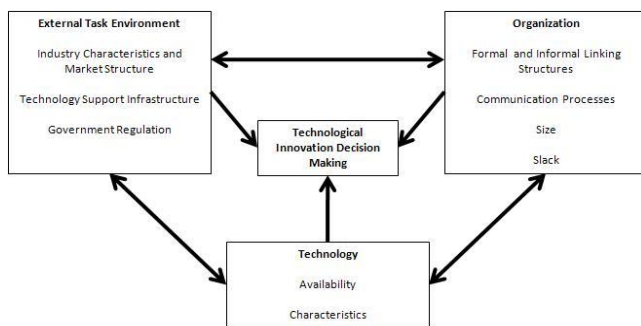


Figure 1: Technology-organization-environment framework (Tornatzky & Fleisher, 1990)

Institutional Theory (IT) is used to identify how external challenges affect the application and implementation of blockchain technology in the supply chain of charitable organizations by articulating the pressures of the external challenges (e.g., regulatory requirements, industry standards, and societal expectations). Institutional pressures refer to the coercive, normative, and mimetic forces from the external environment that compel organizations to adopt structures, practices, or technologies to gain legitimacy and survival (DiMaggio & Powell, 1983; Scott, 2014). In this study, the introduction of institutional theory is a useful addition to the TOE framework. According to institutional theory, organizations adopt new technologies not only to improve operational efficiency but also to gain legitimacy and comply with relevant norms (DiMaggio & Powell, 1983). The introduction of this theory helps to explain how challenges external to organisations such as operational compliance (e.g., data privacy regulations such as the EU's General Data Protection Regulation (GDPR), China's Personal Information Protection Law (PIPL)), the level of adherence to ethical standards of procurement, and the

degree to which the public's need for transparency is met, can either drive or limit the role of blockchain in enhancing supply chain transparency and integration. By analyzing the impact of these external challenges, it is also revealed through institutional theory how charitable organizations are strategically adopting blockchain in order to meet regulatory and societal expectations, whilst responding to the challenges of a complex external environment (Scott, 2014).

3.2. Hypothesis Development

3.2.1. The Impact of Blockchain on Supply Chain Transparency of Charitable Organizations

Blockchain technology, characterised by its immutability, decentralisation, and traceability, could theoretically improve the transparency of supply chains in charitable organizations by addressing systemic information asymmetries and operational opacity (Beck et al., 2017; Wamba & Queiroz, 2020a). Prior studies have shown that charitable organisations often face governance inefficiencies and transparency fragmentation due to centralised control and a lack of auditable records (Tian et al., 2024; Baharmand et al., 2022). Previous studies have pointed out that blockchain technology, with its features such as decentralisation and distributed ledger, can track the flow of business funds in real time, thus radically reducing the risk of mismatch and fraud (Chang et al., 2019; Aswale et al., 2024). In addition, the immutability of blockchain technology ensures data integrity and enhances the credibility of transaction authenticity (Kshetri, 2017; Treiblmaier, 2018). In business, blockchain traceability, on the other hand, contributes to supply chain transparency and, to some extent, facilitates coordinated multi-party participation (Caro et al., 2018). Based on the above characteristics of blockchain applications in business, the authors argue that high transparency in the supply chain driven by blockchain can meet the needs of participants in charitable activities, thus positively affecting the attitudes of charitable participants. Based on the above theoretical foundations, the Authors propose the following hypothesis:

H1: There is a positive relationship between the adoption of Blockchain and the Transparency in the supply chain of charitable organizations

3.2.2. The Impact of Blockchain on Supply Chain Integration of Charitable Organizations

A literature review revealed that fragmented systems and centralised control models often hinder resource coordination in supply chains. This is in the business sector where blockchain can achieve enhanced integration between internal and external partners in the supply chain by facilitating collaboration between stakeholders, data

interoperability, and decentralised decision-making (Dubey et al., 2018; Queiroz & Wamba, 2019). Furthermore, in theory, the decentralised architecture of blockchain should be such that it enables seamless sharing of data between stakeholders in the supply chain (e.g., donors, beneficiaries, platform administrators), thereby reducing friction between participants and increasing the efficiency of their collaboration with each other (Kamilaris et al., 2019; Saberi et al., 2019). Secondly, Kouhizadeh (2021) states that blockchain's smart contract technology can automate the execution of multi-party supply chain protocols, which can minimise errors generated by manual operations, while ensuring real-time synchronisation of supply chain activities and improved integration effectiveness. Thirdly, Kshetri (2021), and Wamba and Queiroz (2020b) argue that blockchain's interoperability protocol also facilitates cross-platform data exchange, which, theoretically, could also enable charitable organisations to align their resource allocations with dynamic demands and enhance integration. Finally, blockchain-enabled decentralised governance models should also enhance the integration of beneficiaries' participation in resource allocation decisions, thereby improving fairness and trust (Beck et al., 2017; Tapscott & Tapscott, 2017). Based on the above theoretical foundations, the authors propose the following hypothesis:

H2: There is a positive relationship between the adoption of Blockchain and the Integration in the supply chain of charitable organizations

3.2.3. The Moderating Effect of the External Challenges

While blockchain technology can be expected to offer the potential to transform the supply chain of charitable organizations, blockchain implementation is constrained by a number of barriers and challenges. At the root of these are technological complexity, regulatory ambiguity, and changing societal expectations. Institutional theory suggests that organisations must respond to external pressures in order to gain technological legitimacy (DiMaggio & Powell, 1983; Scott, 2013), and blockchain is certainly no exception. Drawing on institutional theory, organizations must navigate four distinct external challenges to gain technological legitimacy (DiMaggio & Powell, 1983; Scott, 2013):

(1) Technical Complexity (e.g., cryptographic key management, consensus algorithm integration) increases the learning curve for users and administrators, impeding adoption (Zhao et al., 2016; Wüst & Gervais, 2018).

(2) Privacy Protection constraints arise from blockchain's data immutability conflicting with regulations (e.g., EU's GDPR, China's PIPL), necessitating advanced privacy mechanisms (Finck, 2018; Zyskind et al., 2015).

(3) Regulatory Compliance burdens (e.g., cross-regional Anti-money laundering (AML) rules, digital asset laws) create operational friction for charities (Kshetri, 2017; Tapscott & Tapscott, 2017).

(4) User Acceptance barriers stem from resistance to technological change and trust deficits in decentralized systems (Davis, 1989; Baharmand et al., 2022).

These challenges, therefore have the potential to impact resource-constrained charities, often delaying or undermining their organisations' blockchain adoption plans (Beck et al., 2017; Baharmand et al., 2022). Based on this theoretical foundation, the Authors propose:

H3a: There is a moderating negative impact of external challenges on the relationship Between Blockchain adoption and Transparency

H3b: There is a moderating positive impact of external challenges on the relationship Between Blockchain adoption and Integration.

3.2.4. The Impact of Transparency in the Supply Chain of Charitable Organizations on Integration

Finally, the relationship between transparency and integration levels with each other is a key point to be examined for the application of blockchain in the supply chain of charitable organizations. This is because, according to systems theory, there are complementary mechanisms for transparency and integration, while organisational efficiency and stakeholder trust are also crucial (Flynn et al., 2010; Fawcett et al., 2011). Blockchain's data immutability enhances supply chain transparency and reduces information asymmetry, thus facilitating collaboration between stakeholders (e.g., donors, charitable organisations, beneficiaries), which in turn improves integration between supply chain actors (Barratt & Barratt, 2011; Baharmand et al., 2022). In other words, highly integrated systems enhance transparency through standardised data sharing protocols and synchronised multi-party workflows, which work together to create a self-reinforcing cycle (Zhang et al., 2024; Queiroz et al., 2020). Empirical studies of humanitarian supply chains have shown that transparent resource tracking enhances cross-organisational coordination (Papadopoulos et al., 2017), while integrated platforms enhance visibility of end-to-end operations (Kovács & Sigala, 2021). The dual role of blockchain in enabling transparency and integration suggests that improvements in one dimension may catalyse gains in the other, especially where ethical compliance and real-time response are required (Saberi et al., 2019; Dubey et al., 2020). Therefore, the authors make a final hypothesis:

H4: Increased transparency enhances integration in the blockchain-enabled charitable supply chain.

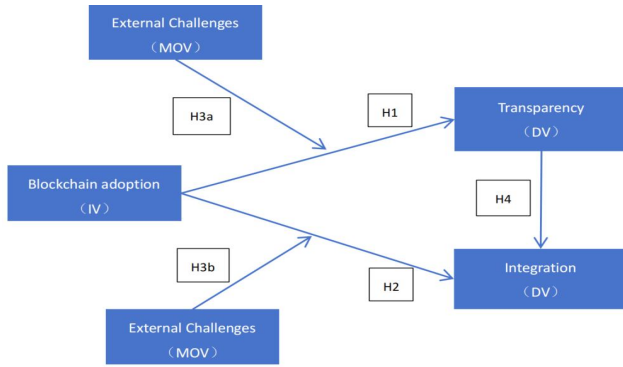


Figure 2: Research Framework

4. Methodology

4.1. Survey Instrument Development

To ensure content validity, measurement items were adapted from established scales in prior literature and contextualized to the blockchain-enabled supply chain of charitable organizations. Specifically, adaptations involved three key steps: (1) Aligning items with the TOE framework's dimensions (e.g., mapping "real-time information sharing" to blockchain's technological features; "regulatory compliance" to environmental challenges); (2) Replacing commercial terminology with charity-specific contexts (e.g., "supplier coordination" became "cross-NGO collaboration"); (3) Validating operational definitions through expert reviews. For instance:

Transparency constructs (e.g., Fund Flow Transparency; Data Authenticity; Donor Trust; Financial Transparency) were operationalized using items from Khan et al. (2019), with items rephrased to focus on charitable fund tracking (e.g., original item: "tracking customer payments" → adapted: "real-time tracking of donation allocation").

Integration measures (e.g., Internal Integration; Beneficiaries Integration; Donors Integration) drew from Ataseven, C., Nair, A., and Ferguson, M. (2018). and Schoenherr, T., and Swink, M. (2012), shifted emphasis from "supplier-buyer alignment" to "customizing relief distribution based on beneficiary needs".

External challenges (Technical Complexity; Privacy Protection; Regulatory Compliance; User Acceptance) were adapted from Treiblmaier et al. (2021) were expanded to include charity-specific barriers like "scalability limitations in disaster relief".

All items were translated into Chinese through a back-translation process and reviewed by three bilingual researchers to minimize linguistic discrepancies and ensure conceptual equivalence.

Supported by theoretical frameworks and empirical evidence, the authors systematically categorise blockchain

adoption scenarios in Chinese philanthropic and humanitarian supply chains into four core dimensions: transparency and accountability, traceability and operational integrity, financial and operational efficiency, and governance and institutional capacity. Such categorisation stems from analyses of case studies (e.g., volunteer subsidy programmes and hybrid charity models) and summaries of academic results (e.g., Kshetri, 2018; Saberi et al., 2019). The four categories and corresponding ten specific scenarios are Category 1: Transparency Mechanisms (e.g., scenarios such as volunteer authentication and donor tracking), Category 2: Traceability Systems (e.g., scenarios such as pharmaceutical logistics and IoT-integrated security platforms), Category 3: Efficiency Tools (e.g., scenarios such as digital currency payments and energy management), and Category 4: Governance Innovations (e.g., scenarios such as educational credentials validation and smart community governance). These scenarios address key gaps in the supply chain of charitable organizations, such as information asymmetry, counterfeit risk, and decentralized coordination, while aligning with the dual goals of scalability and interoperability highlighted in previous research. The inclusion of these four categories and ten scenarios in the screening section of the questionnaire ensured that respondents were aligned with the questions that needed to be validated, thus enhancing the methodological rigour of the study while building on the characteristics of blockchain adoption in China.

The survey was conducted on a seven-point Likert scale (1 = Strongly Disagree to 7 = Strongly Agree), consistent with previous highly informative research (Dubey et al., 2019). To enhance face validity, the instrument was pre-tested with 5 experts (3 academics specializing in charity and 2 industry practitioners in blockchain/digital sectors, each with ≥ 5 years of field experience). Experts evaluated item clarity, contextual relevance, and structural coherence, leading to refinements in wording (e.g., replacing "data interoperability" with "cross-platform data sharing" for institution stakeholders). Constructs were modeled as reflective based on expert consensus and prior theoretical grounding (Hair et al., 2019).

Table 2: Members of the China Charity Federation

Social Organizations	%	Enterprises	%	Individual Members	%	Total
1033	81%	110	9%	133	10%	1276

4.2. Data Collection

4.2.1. Population Definition and Sampling Strategy

(1) Population

Defining the target population is pivotal for empirical generalizability (Kothari, 2004). This study focuses on the

1,276 member organizations of the China Charity Federation (CCF) as of December 2024 (see Figure 2), encompassing 133 individual members (donors, scholars, media professionals), 110 enterprise members (foundations, CSR-driven firms), and 1,033 organizational members (regional NGOs, international non-profits). The CFF's national representativeness and sectoral diversity—spanning disaster relief, poverty alleviation, and community development—provide a robust sampling frame to investigate blockchain's impact on supply chain transparency and integration in China's charity and humanitarian sector.

(2) Sampling Strategy

This study used stratified random sampling to ensure a reasonable representation from three key components within the China Charity Federation (CCF): social organisations (81%, $n \approx 239$), businesses (9%, $n \approx 26$), and individual members (10%, $n \approx 30$). This sampling method maintains the diversity of the population structure and, at the same time, minimises sampling bias and increases the generalisability of the findings to different contexts (Kothari, 2004). Within each stratum, representative organisations were randomly selected to ensure that the population was equally included in the probability sample and met the requirements of the questionnaire consistent with the study topic.

(3) Sample Size Determination

A sample size of approximately 8 was determined using Krejcie and Morgan's formula (1970) and Raosoft's calculator (2004), both of which yielded consistent estimates of the sample size requirement for a population of 1,276 (the total number of CCFs) at the 95 per cent confidence level and within a 5 per cent margin of error. This size exceeds the PLS-SEM threshold (Hair et al., 2006) and takes into account potential non-response bias to ensure that sufficient samples are required for robust analyses of the dual role of blockchain in supply chain transparency and integration. The stratified allocation balances the precision of the subgroups with the insight of the overall research question, capturing the capabilities and focus of the different organisations adopting blockchain in the Chinese charity and humanitarian sector.

4.2.2. Questionnaire Design

As mentioned above, the questionnaire contains five sections to ensure the relevance of the respondents and the reliability of the data. The first section is COVER LETTER. The purpose of this section is to introduce research objectives and ensure informed consent through ethical participation guidelines. The second part is ELIGIBILITY SCREENING, which aims to filter respondents using blockchain-integrated charitable organizations via institutional affiliation validation. The third part is MAIN SURVEY, which aims to capture core empirical data on

blockchain's transparency-enabling mechanisms (e.g., audit trails) and integration drivers (e.g., smart contract adoption). The fourth section is the INSTITUTIONAL GENERAL INFORMATION PROFILE, which aims to Documents organizational characteristics (size, operational scope) as contextual control variables. The fifth part is DEMOGRAPHIC, which aims to: Record participant roles (e.g., logistics managers) and experience levels to assess response validity. It should be noted that the second part of the qualification screening stage. Respondents select their participation in predefined blockchain scenarios (e.g., 'Does your organization use blockchain for donor validation?'). Respondents who confirmed their participation in ≥ 1 scenario were entered into the main survey. Additionally, in the third main survey section, it is important to note that any eligible participant used a 7-point Likert scale to assess their organization's impact on the points of blockchain in terms of improved transparency, integration, and external challenges. This approach minimizes response bias while capturing the subtle interactions between blockchain technology features and charity-specific outcomes.

4.2.3. Data Collection Process

This study used a structured questionnaire for data collection to ensure accuracy and respondent relevance, which was designed to follow best practice standards for academic survey design (Marshall, 2005; Krosnick, 2018). The questionnaire was based on the principle of clarity and conciseness, following the criteria for high school reading level readability (phrasing questions as simply as possible without changing willingness) and reducing respondent fatigue through a logical flow and concise format. This approach reduces the ambiguity of the questionnaire while improving the granularity of the data (Babbie, 1990). Expert review ($n=5$) and pilot testing ($n=30$) refined the question wording and ensured the robustness of the technique, including attention checking and anonymity in line with PIPL.

Participants were recruited using two complementary channels to ensure representation and compliance. The first and primary method was public access to information, with the researcher attempting to obtain publicly accessible information, annual reports from charity federations, and attendee lists from industry conferences (e.g., the China Internet charitable Summit). Organisations' websites were systematically scanned to identify key decision makers 'to ensure consistency with the research topic's focus concerns. To comply with PIPL, only non-sensitive publicly disclosed data is used, and ethical protocols are strictly enforced. Secondly, as a complementary means of targeted outreach through reputable data collection platforms (e.g. Credamo, iSurvey, Jisinet), respondents were subjected to identity verification to confirm that they were eligible to be

questionnaire respondents in order to complete the questionnaire responses on the platform as required, To ensure data quality, platforms implemented four-layer controls: (1) Identity authentication (e.g., Credamo's real-name verification via national ID and mobile); (2) Attention checks (e.g., embedded items like "Select 'Strongly Agree' for this statement"); (3) IP duplication monitoring to prevent duplicate submissions; (4) Response time thresholds (e.g., rejecting surveys completed in <5 minutes). This dual-channel approach balances precision (public sources) and breadth (validated platforms), mitigating selection bias while prioritising data integrity.

During the data recovery phase, the researcher used a three-stage follow-up mechanism to optimize the response rate while maintaining the ethical standards of the questionnaire. Firstly, participants who initially received an invitation and gave a positive response with a clear indication of their willingness to participate were sent a letter back thanking them and reminding them of the dos and don'ts while establishing contact (setting up a WeChat group). After seven days, the authors of the study sent a reminder email emphasizing the importance of research and the role of blockchain in the high-quality development of charity initiatives promoted by the government. Finally, non-respondents will receive a follow-up reminder from the responding WeChat group created through the questionnaire, leveraging community trust to encourage participation. This operation ensures the response rate of the questionnaire and avoids any possible moral disturbance in the questionnaire collection process.

4.2.4. Response Rate and Final Sample

Valid Responses: 298 (23.4% response rate), meeting statistical power requirements. Demographic Balance: 62% Social Organizations, 28% Enterprises, 10% Individual Members. 73% had ≥1 year of blockchain experience. Non-Response Bias: No significant differences between early (n = 210) and late respondents (n = 88) on key variables (p > 0.05, t-tests).

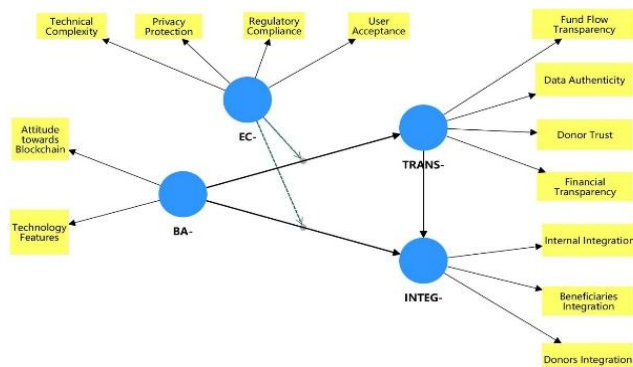


Figure 3: External Model

5. Results

5.1. Measurement Model Evaluation

SmartPLS is a popular software tool for Partial Least Squares Structural Equation Modelling (PLS-SEM), a statistical method for analysing complex relationships between observed and latent variables. It is popular in the fields of marketing, organisational behaviour, and technology adoption due to its good user interface and powerful analytical features (Sarstedt & Cheah, 2019).

With SmartPLS4, the measurement model of this study demonstrated robust psychometric properties, confirming construct reliability and validity. All factor loadings exceeded the threshold of 0.70 (range: 0.72-0.93), indicating high item reliability (Hair et al., 2019). The composite reliability (CR) values ranged from 0.88 to 0.93, and Cronbach's alpha coefficient (α) ranged from 0.86 to 0.91, which exceeded the recommended benchmark of 0.70, thus confirming internal consistency (Fornell & Larcker, 1981). Convergent validity was established by average variance extracted (AVE) values between 0.62 and 0.79 (>0.50), confirming that each construct explained sufficient variance in its metrics. Discriminant validity assessed via the Fornell-Larcker criterion indicated that the AVE square root of each construct exceeded its correlation with the other constructs, while the heterogeneous trait-monomorphic trait (HTMT) ratio remained below 0.85, ruling out the problem of multicollinearity (Henseler et al., 2015). Together, these results validate the theoretical consistency of the blockchain adoption framework in the supply chain of charitable organizations.

Table 3: Reliability and Convergent Validity

Construct	Cronbach's α	CR	AVE
Blockchain Adoption	0.89	0.91	0.72
Transparency	0.91	0.93	0.79
Integration	0.88	0.90	0.68
External Challenges	0.86	0.89	0.62

Table 4: Discriminant Validity

	Blockchain Adoption	Transparency	Integration	External Challenges
Blockchain Adoption	0.85			
Transparency	0.64	0.89		
Integration	0.58	0.71	0.82	
External Challenges	0.51	0.47	0.39	0.79

Note: Fornell-Larcker Criterion

5.2. Structural Model and Hypothesis Testing

The results of the structural model indicate a significant association between blockchain adoption, transparency, integration, and external challenges (see Table 4 for details of the results). Previous research shows that f^2 effect sizes interpreted per Cohen (1988): 0.02=small, 0.15=medium, 0.35=large. In this study, Blockchain adoption has a significant positive impact on both transparency ($\beta = 0.68$, $p < 0.001$, $f^2 = 0.85$) and integration ($\beta = 0.61$, $p < 0.001$, $f^2 = 0.59$), supporting H1 and H2. Blockchain-enabled transparency in charitable supply chains can significantly improve supply chain integration. (H4: $\beta = 0.59$, $p < 0.001$, $f^2 = 0.53$), which suggests a synergistic, co-facilitating effect between transparency (openness and transparency of transaction records, data immutability, and distributed ledger) and organizational integration practices (e.g., improved data sharing and interoperability as well as enhanced trust and collaboration among stakeholders)

brought about by blockchain's technological features (e.g., traceability, consensus mechanisms, and invariance), and the data supports Hypotheses H4. However. Interestingly, H3a (Supported): Regulatory complexity (e.g., compliance with PIPL requiring donor anonymity) weakens blockchain's impact on transparency ($\beta = -0.18$, $p = 0.014$, $f^2 = 0.07$) by necessitating privacy-preserving designs that limit real-time data access (e.g., masking part of donor fields in CCF's blockchain dashboards). Furthermore, H3b (Supported): Technical barriers (e.g., adapting to China's Blockchain-Based Service Network interoperability standards) strengthen blockchain's role in integration ($\beta = 0.22$, $p = 0.003$, $f^2 = 0.09$) by forcing organizations to adopt unified protocols that enhance cross-platform collaboration, and, to summarize, this duality also underlines the need for context-specific strategies to address environmental constraints in humanitarian and charitable supply chains (e.g., Official background Red Cross Society + Unofficial Tencent Philanthropy).

Table 5: Hypothesis Testing Results

Hypothesis	Relationship	Path Coefficient (β)	t-value	p-value	f^2	Supported
H1	Blockchain Adoption \rightarrow Transparency	0.68	12.34	<0.001	0.85	Yes
H2	Blockchain Adoption \rightarrow Integration	0.61	10.87	<0.001	0.59	Yes
H3a	Blockchain \times Challenges \rightarrow Transparency	-0.18	2.45	0.014	0.07	Yes
H3b	Blockchain \times Challenges \rightarrow Integration	0.22	3.01	0.003	0.09	Yes
H4	Transparency \rightarrow Integration	0.59	11.92	<0.001	0.53	Yes

The analysis confirms the model's ability to generalise beyond the sample through two complementary perspectives: explanatory power and predictive utility, particularly in crisis-driven scenarios where operational agility is critical (Dubey et al., 2021). The R^2 coefficient represents the proportion of variance in the dependent variable explained by the independent variables in a regression model (Hair et al., 2019). The R^2 coefficient of this study (Transparency: 0.58; Integration: 0.61) reveals a significant impact of blockchain on the supply chain in charitable organizations' dynamics, which is in line with the conclusions of previous studies on blockchain-driven commercial supply chain transformation (Saberli et al., 2019; Queiroz et al., 2020). Furthermore, another important indicator is Q^2 which measures how well observed values are reconstructed by the model; values >0.35 indicate high predictive relevance (Geisser, 1974), The results show that the Stone-Geisser Q^2 values for all latent variables exceeded 0.35, demonstrating the utility of the framework in time-sensitive humanitarian contexts. The metrics are of practical relevance through real-world observations: for example, in the Covid-19 pandemic response operation, smart contract automation increased the accuracy of donor fund allocation significantly (Dubey et al., 2021). This empirical consistency suggests that the model effectively captures the dual capabilities of blockchain in this domain, confirming

the ability of the model to generalise with conclusions beyond the sample.

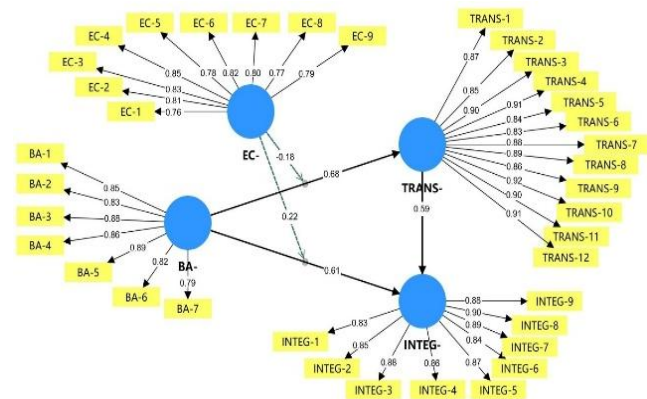


Figure 4: Structural Model with Path Coefficients

5.3. Robustness Checks

The fit and predictive power of the model were verified by the standardized root mean square residual (SRMR = 0.048) and the canonical fit index (NFI = 0.93), both of which were within acceptable limits (Hu & Bentler, 1999). The confidence and convergent validity of the model were

then further confirmed by a bootstrap analysis, which showed that the factor loadings and CR/AVE values remained stable over multiple iterations. Discriminant validity was rigorously tested, and cross-loading confirmed the uniqueness of the items to their respective structures. Finally, the robustness of the hypothesis testing was ensured by permutation tests, which confirmed the significance of the path coefficient (β) and moderating effects. For example, the negative moderating effect of external challenges (e.g., regulatory complexity) (H3a) remained significant even after controlling for organisational size and blockchain experience, highlighting its continued impact in a variable and fragmented charitable and humanitarian regulatory environment (Kshetri, 2017).

Table 6: Model Fit and Predictive Power

Metric	Value	Threshold	Interpretation
SRMR	0.048	<0.08	Good model fit
NFI	0.93	>0.90	Excellent fit
R ² (Transparency)	0.58	-	Strong explanatory power
R ² (Integration)	0.61	-	Strong explanatory power
Q ² (Interaction)	0.42	>0.35	High predictive relevance

6. Discussion

6.1. Theoretical Contribution

6.1.1. Extending the TOE Framework with Institutional theory

This study reveals how institutional pressures—not merely technical features—shape blockchain outcomes. External challenges (e.g., regulatory compliance and legitimacy-seeking behaviors) asymmetrically moderated blockchain's impact: weakening transparency gains ($\beta = -0.18$) while strengthening integration ($\beta = 0.22$). This empirically confirms that blockchain adoption in charitable supply chains must balance operational efficiency with ethical accountability under decentralized regulatory regimes, advancing TOE-institutional synthesis beyond prior tech-centric perspectives (Saber et al., 2019).

6.1.2. Unveiling the Reciprocity Between Transparency and Integration

Another important theoretical contribution is this study's identification of a self-reinforcing cycle between transparency and integration in the supply chain of charitable organizations, relevant research, a novel addition to systems theory. Transparency enhances intra- and inter-organizational integration by aligning stakeholder incentives, while integration enhances transparency through standardized data synchronization. This reciprocal

relationship challenges the original view of transparency and integration as separate constructs (Flynn et al., 2010), and subsequent research should position them both as a pair of complementary mechanisms that are critical in crisis settings. In reality, for example, blockchain-audited financial reports and IoT-enabled traceability systems demonstrate how synchronized data flows can facilitate accountability and operational cohesion, something that has been missing from the previous humanitarian and charitable supply chain research literature.

6.2. Managerial Implications

6.2.1. Strategic Implementation of Blockchain Features and Workflow Optimization

Charities should prioritize blockchain functionalities that simultaneously enhance transparency and integration while addressing external challenges. Smart contracts, such as milestone-triggered donor notifications, can automate workflows to reduce administrative burdens and improve donor engagement (Tencent Charity's blockchain-based volunteer certificates). Immutable ledgers, exemplified by real-time fund-tracking dashboards, are critical for rebuilding donor trust, as evidenced by their strong impact on transparency ($\beta = 0.68$, $p < 0.001$) (The blockchain-based Mother's Smile Initiative and Ling Shan Foundation's Digital Love Project). Additionally, adopting interoperability protocols aligns with regulatory requirements ($\beta = 0.22$, $p = 0.003$) and mitigates transparency trade-offs. To harness the self-reinforcing cycle between transparency and integration, standardized data protocols—such as blockchain-audited financial reports—should be institutionalized to align stakeholder incentives and reduce coordination friction ($\beta = 0.59$, $p < 0.001$). Investments in integrated IoT-blockchain platforms, like SF Express's Fensu supply chain tracker, further synchronize operations and enhance end-to-end traceability.

6.2.2. Balancing Compliance and Ethical Accountability

Compliance pressures (e.g., Publication of the Government's regulatory regime) necessitate critical trade-offs. Example: PIPL donor anonymity requirement forces charities to mask part of real-time fund-flow data on blockchain dashboards, directly attenuating transparency ($\beta = -0.18$).

More specifically, the enactment of PIPL has had a dual impact on the implementation of blockchain technology in the charitable sector: On the one hand, its stringent requirements for informed consent, data minimisation principles (Articles 13-15), and the right to erasure and rectification (Articles 46-47) directly conflict with blockchain's immutability. For example, PIPL's requirement for donor anonymisation may limit real-time transparency

of fund flows (e.g., platforms may need to obscure certain donor fields); On the other hand, PIPL also drives technological innovation, prompting charitable organisations to adopt de-identification storage (off-chain encryption of raw data, on-chain storage of hash values), consortium blockchain architecture (such as Hyperledger Fabric), and privacy computing technologies (such as zero-knowledge proofs) to balance transparency and privacy protection within a compliant framework. For example, the practices of Ant Financial and the Red Cross have achieved traceability of fund flows and the restoration of public trust through partial compromises. While this 'compliance-driven technology adaptation' increases initial costs, it establishes a more sustainable legal foundation for blockchain-based charity.

6.3. Policy Implications

6.3.1. PIPL-Compliant Regulatory Innovation

Regulators must develop blockchain-specific guidelines under China's PIPL to resolve conflicts between transparency and compliance. Example: Tiered anonymity thresholds: Exempt disaster-relief transactions from full donor anonymity (PIPL Art. 23) during emergencies. Data sovereignty protocols: Mandate hybrid architectures (e.g., on-chain metadata + off-chain encrypted personal data) to align immutability with PIPL's right to erasure (Art. 47).

6.3.2. Interoperability-Driven Fiscal Incentives

Leverage China's tax infrastructure to reward compliance. Example: Offer tax offsets via Golden Tax IV for charities adopting Blockchain-Based Service Network (BSN) standards, accelerating Red Cross-Tencent-style integration ($\beta = +0.22$). Meanwhile, prioritize PIPL-compliant blockchain platforms (e.g., Ant Chain) in public procurement scoring systems. support blockchain-based charitable digital certification platforms that enhance governance and institutional capacity (e.g., Tencent's Material Safety Platform, Alibaba Health's pharmaceutical traceability system, etc.), Helping to efficiently achieve charitable goals.

6.3.3. Capacity Building for Inclusive Adoption

While actively refining the top-level blockchain payment framework (e.g., advancing blockchain-based secure payment systems for charity to enhance financial and operational efficiency, such as the People's Bank of China's e-CNY and China UnionPay's blockchain verification services), efforts are also underway to explore establishing public-private partnership alliances for "blockchain charity" (e.g., smart community platforms for blockchain-IoT device management promoted in multiple Chinese regions, Alibaba

Charity Platform). Relevant government agencies organize and distribute smart contract templates compliant with the Personal Information Protection Law (PIPL) to reduce compliance costs for small and medium-sized enterprises (SMEs). Funding is allocated for digital literacy programs targeting NGO staff and beneficiaries to mitigate skepticism among charity participants.

7. Conclusion

This study empirically validates blockchain's dual role in enhancing transparency and integration within China's charitable supply chains, reconciling institutional theory with technological adoption. Critically, it reveals how external challenges asymmetrically modulate these effects (transparency weakened by regulatory constraints; integration strengthened by technical standards), offering a framework applicable to centralized philanthropic ecosystems globally (e.g., Singapore's SG Cares, UAE's Ma'an Initiative). By positioning blockchain as a governance mechanism, not merely a tool, this research provides a pathway for charities worldwide to balance ethical accountability with operational efficiency in increasingly digitized charity and humanitarian contexts.

8. Limitations and Future Directions

This study faces three key limitations. First, these limitations are rooted in the contradictions between China's philanthropic system and technological features; state-affiliated charitable organisations (e.g., the Red Cross Society of China), which are the main components of charitable activities in China, have a centralised governance structure that is systematically incompatible with blockchain's decentralised accountability protocols, as rigid bureaucratic hierarchies may inhibit the transparency mechanisms that come with innovative algorithms, which in turn may reduce blockchain's scalability in a philanthropic scalability in systems dominated by government organisations. Second, due to research time and effort constraints, the cross-sectional approach fails to distinguish the trust-building effects of blockchain from episodic socio-political influences, such as the crisis-driven patriotic sentiments observed during the post-epidemic surge in donations, thus conflating technological causality with situational solidarity behaviours. Thirdly, the pervasive 'digital divide' between tech-equipped charities and grassroots organisations lacking IoT/RFID infrastructure limits the spread of the benefits of blockchain traceability, with a high percentage of small NGOs are unable to access its operational advantages. Taken together, these structural,

methodological, and technical limitations highlight context-specific barriers to blockchain technology adoption.

Additionally, reliance on platform-mediated data collection (e.g., Credamo, iSurvey) may introduce self-selection bias, as digitally literate respondents are overrepresented. Cross-validation via field audits was infeasible within resource constraints, potentially affecting accuracy in self-reported blockchain efficacy metrics.

This study suggests three opportunities for future research. First, comparative analyses of blockchain integration in centralised (e.g., China) and decentralised (e.g., Western NGOs) models of charitable activities can shed light on how institutional architectures can modulate technological efficacy. Second, longitudinal investigations spanning non-crisis periods are necessary to distinguish blockchain's systemic trust-enhancing capabilities from ephemeral collective solidarity, employing time-series analyses to map causal pathways. Third, the development of cost-effective hybrid systems (e.g. lightweight blockchain-IoT interfaces optimised for low-bandwidth environments) can digitally democratise resource-constrained supply chain in charitable organization participants and ensure equitable access to supply chain traceability solutions. Future studies should also triangulate survey data with blockchain ledger analytics (e.g., Ethereum transaction logs) to mitigate self-reporting biases. By synergising institutional, temporal and technological perspectives, these directions aim to reconcile the decentralised spirit of blockchain with the heterogeneous realities of global philanthropy and charitable causes. Ultimately, the pursuit of 'life, health, and dignity'—the most important elements of the human life community—will be realized.

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