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Research Article

Trust and Traceability: Unpacking Technology Readiness in Blockchain Adoption for Supply Chain Management

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Abstract

The development of blockchain-based innovations marks a paradigm shift within the realm of supply chain optimization, which offers a unitary solution to modern challenges linked with trust and traceability. The purpose of this research work is to assess how Technology Readiness constructs such as technological optimism, creativity, discomfort, and doubt can affect the integration of blockchain-based innovations within supply chains. A conceptual model based on Technology Readiness Index was designed and validated using a large-scale survey study among 300 members of the supply chain industry in India. The optimum level of response was achieved with 231 members providing necessary input for the study. The model assumptions were verified using structural equation modelling techniques. The results emphasize significance attributed to trust and traceability, which were found to be important elements of blockchain functionality. Indeed, these findings reinforce the need to overcome the psychological barriers associated with the implementation of new technologies like blockchain technology. These findings suggest that the relationships implied by the model hold true and establish that the propositions made at the conceptual level are robust. The study offers evidence to the existing body of knowledge pertaining to supply chain governance studies with regard to establishing an association between technological readiness and sustainable blockchain system adoption intention. It has been clear with these findings that cognitive ability and emotions were found to create equal impact on achieving operational advantages. These findings can greatly benefit policymakers and managers with insights on how to increase blockchain technologies' application processes with regard to supply chains. This study represents the first investigation of the Comprehensive Sequential Mediation model incorporating Technology Readiness, Trust, Traceability, and Sustainable Blockchain Adoption Intentions, accounting for 57% of variances a record-high level reported for blockchain studies related to supply chains.

Keywords: Blockchain Technology; Supply Chain Management; Blockchain Adoption and Preparedness; Trust and Traceability

INTRODUCTION

Blockchain technology is gaining recognition as it is being perceived as a revolutionary innovation, which has the capability to bring sustainable change to society. The emergence of Bitcoin is what triggered the first wave of recognition and applications of blockchain technology. Nonetheless, the capability and applications of this innovative technology have exceeded the boundaries within which financial applications were limited, extending to other areas, including supply chain management, health, and the food sector. The basic and intrinsic properties of blockchain technology, including security, transparency, and decentralization, have significantly changed the landscape of data storage and distribution within the spread networks [1]. Emerging trends, as identified by [2], are forecasted to have a significantly influential effect on the activities of both society and businesses within the evolving digital economy. It is a fact that, at this stage, the subject of blockchain is a domain of remarkably active scientific investigation among worldwide researchers, experts, and regulatory bodies, considered to be a paradigm that can effectively address existing challenges of trust, traceability, or accountability.

Contrary to other centralized platforms, blockchain is perceived to act as a peer-to-peer, decentralized platform, relying on 'consensus' algorithms for validating any transaction, thus ensuring data integrity, immutability, and the potential for auditability, without necessarily requiring the oversight of any centralized governing authority [3]. In this regard, this characteristic of blockchain makes it appear as the theoretically optimal solution to the supply chain management field, which inherently calls for transparent and non-editable 'record-keeping.' In this case, this study acts as a departure from other research studies, which are yet to focus on either the applications of blockchain, issues related to integrating blockchain, and the 'security-related concerns' pertaining to the adoption of blockchain technology [4].

Blockchain is perceived as a revolutionary innovation with various advantages, which include decentralization, autonomy, integrity, immutability, the capability of information verification, fault tolerance, the utilization of anonymity, auditability, and the facilitation of transparency. The blockchain sector is perceived as the most rapidly growing across the globe, and this can be contributed by the continuous improvement of smart contract technology. In addition, the blockchain sector, in this case, blockchain technology, is also perceived to be gaining attention as an emerging innovative technique, which can be used to provide a remedy to the critical preparedness issues affecting the global value chains within the food sector. There is, however, a lack of extensive research within the existing literature on systematic assessments of blockchain technology's capability to improve preparedness performances. There is, hence, evidence within existing literature reviews on various benefits of blockchain technology within the management of supply chains, which include improved tracing, decreased cases of fraudulent behaviour, improved collaboration among suppliers, and decreased documentation processes. In the light of the wide-ranging transformations brought by technology in the 21st century, blockchain is identified along with other significant innovations, namely big data and analytics, Internet

of Things (IoT), and FinTech, as agents of change in the various sectors. One important positive aspect of blockchain technology is related to the possibility to implement as a distributed database, thereby enabling the holders to diffuse, reproduce, and coordinate the data into various nodes, actors, and geographical areas [5]. The use of the decentralized architecture stands out for eradicating any need for centralized governance and storage. Yet, it is pertinent to mention here that this architecture is based on certain types of cryptography and mechanisms on which the attainment of desired levels of transparency and trust depend. In today's business setting, various sectors have already launched pilot projects to discover the potential of blockchain technology and alleviate various issues. These projects are intended to improve efficiency, break down informational silos, reduce the problem of counterfeiting, and improve ethical sourcing of products. The various business sectors, which have adopted blockchain technology, are logistics, food, pharmaceutical, and health sectors.

Although blockchain technology is increasingly being adopted by various sectors, the implementation of blockchain technology in the construction sector, known for being very ICT-averse, is still in its embryonic stage. The disruptively positive effects of blockchain technology in this sector are still being explored. The implications, potentials, and challenges associated with the implementation of blockchain technology within this sector, as well as discovering methodologies on how to tap into this technology for improved efficiency, accountability, and technology preparedness, are central to comprehensively understanding this innovative technology [6]. Many industries have started piloting blockchains to deal with inefficiencies, information silos, counterfeiting, and ethical sourcing risks: logistics, food, pharmaceuticals, and healthcare among them. Although it is embraced in most industries, in the construction industry, which is known for being resistant to digitization, it is still in the early stages of exploring the disruptive impacts of blockchain technology. The implications, opportunities, as well as challenges of implementing blockchain in this industry, hence finding ways to utilize it for better efficiency, accountability, and preparedness, are vital in understanding this technology [6]. Moreover, although several proofs of concepts have been conducted, few large-scale applications have been implemented in real-world scenarios, leaving challenges in scalability, adapting to old systems, governance, regulation, as well as ethics untouched [7, 8]. As such, this study aims to provide insights for this research gap in understanding blockchain by applying in a broader aspect of supply chain management, excluding current applications, challenges, and focusing on both technological as well as organizational aspects of this application.

Research Objectives

1. To analyse how the Technology Readiness factors of optimism, innovativeness, discomfort, and insecurity influence trust and traceability in supply chains using blockchain technology.

2. To analyse the mediating factors of trust and traceability so as to understand the effect of Technology Readiness on Sustainable Blockchain Adoption Intention and adoption within the supply chain management process.
3. To assess the relationships between technology readiness, trust, and traceability within the setting of blockchain implementation within supply chain ecosystems, in relation to Sustainable Blockchain Adoption Intention outcomes.

LITERATURE REVIEW

Technology Readiness Index (TRI) framework

The concept of Technology Readiness has been commonly adopted to identify an individual's tendency to adopt technological advancements. First formulated by [9], the Technology Readiness Index (TRI) states that people's attitudes toward technological advancements can be expressed by four factors, namely, optimism which is having a positive belief in technological benefits, followed by innovativeness which is having an inclination to be a technological innovator, then by discomfort which is having an idea of being dominated by technological advancements, and finally, insecurity which is having little trust in technological competence [10]. TRI has been further refined by [11]. into a more concise, 16-item scale, known as TRI 2.0, which maintains these four factors, which are explained in detail below.

Optimism

Optimism entails having a positive expectation of technological improvement in efficiency, productivity, and control of work and life [9]. Optimistic people perceive technological benefits as positive, which results in higher intentions to adopt them [10]. In the case of blockchain-based supply chains, this optimism is manifested by an increasing level of confidence in the capability of blockchain technology to improve traceability, transparency, and technology preparedness [12]. In line with the assertion by [13], optimism is posited to be an important determinant of positive perceptions of mobile banking. On the other hand, the findings by [14]. imply that employee engagement in the transformation of the workplace through technology is affected by employee optimism. On the other hand, attention must be given to the fact that over-optimism can result in misguided visions, thus making the successful implementation of a goal less likely [15]. When discussing the management of a supply chain, optimism about the potential of the blockchain system is vital for the readiness of specialists working within this area.

Innovativeness

Seeking innovation is defined as the tendency of individuals to inquire about and embrace new technology [11]. Innovative users can be termed as pioneers and innovation encouragers [16]. For instance, innovativeness can be noted among individuals who seek to implement pilots of systems that incorporate distributed ledgers for real-time product tracing, execution of smart contracts, as well as tracing of provenance for products or assets

on a blockchain platform [17]. Innovativeness was found to be a good predictor of technology adoption through a meta-analysis carried out by [10]. In the supply chain management industry, organizations that have aptitude skills for innovation have been noted to adopt digital technology such as blockchain faster and better, as stated in the findings of a research study by [18]. Additionally, innovativeness eliminates feelings of discomfort and a lack of stability. Persons who feel high levels of curiosity tend to be receptive to exploring technology innovation and activities, as stated by Sharma [19]. Thus, the adaptability of blockchain technology is essential in the process of transformation through technology.

Discomfort

Discomfort is correlated with perceptions of being overwhelmed and lack of control within the broader context of engagement with technology [9]. The notion of comfort and discomfort is posited to theoretically encapsulate various psychological constructs, anxiety and perceptions of lack of self-efficacy as regards the use of particular technology systems, among other things [20]. If high levels of distress are predominately experienced, they may hamper the adaptation of the technological systems.

The complexities inherent in blockchain technology have been found to provoke some level of unease among professionals within the context of supply chain management [21]. The source of this level of unease may well be rooted in the lack of training on the subject, potentially causing them to lack confidence in blockchain systems. Notably, this level of unease can be seen, at least in part, as the effect of the findings brought forward by [22]. stating that workers under technologically advanced training initiatives did not show significant signs of unease and increased confidence levels within blockchain-based procurement systems. The apparent level of unease continues to go beyond the confines of techno-centrism, restricting itself within a level of complexity rooted in the applicability of the technological paradigm within organizational settings.

The improved traceability afforded by this approach has been shown to promote greater adoption of Sustainable Blockchain Adoption Intention. This is because blockchain technology has been shown to be capable of merging views rooted in ethics, the environment, and functionality.

Insecurity

Insecurity is scepticism about the trustworthiness of technology in terms of either data violation or system failure [11]. For blockchain, insecurity is scepticism about data integrity, vulnerabilities in smart contracts, as well as data governance [23].

Within supply chains, actors may feel that using shared ledgers could result in confidential information being exposed, as well as a possible decrease in accountability from using decentralized systems [24]. Within developing countries, a lack of regulations makes actors even more insecure about whether blockchain is legal or interoperable [25].

Insecurity is always negatively related to intentions to adopt technologies [26]. Perceived insecurity can be mitigated by trust in institutions, established by transparent

audits, cybersecurity, and compliance systems [27]. Thus, by dealing with insecurity, companies could promote trust in the preparedness of blockchain in relation to traceability in supply chain performance.

Traceability

Traceability in supply chains is defined as the possibility of tracking back, in relation to time, product, component, process, and transaction-related data, from origin to end-destination via supply chain custody. Nowadays, traceability in supply chains is more significant in globalized, complex supply chains, as demanded by conditions of transparency, regulation (such as food, medicine, etc.), ethical procurement, quality, as well as risk issues in supply chains, where preparedness requires more traceability in supply chains, as explained in current research studies by [28].

Current literature stresses that another significant benefit of using blockchain in supply chain management is traceability, as it provides immutable, decentralized, ledged, provenance, audit trails, and minimizing intermediaries as critical promises of blockchain in supply chain management. Authors in [29], suggest a blockchain-based traceability solution for a multi-tier traceability in Textile & Clothing Supply Chain, explaining how blockchain assists in multi-tier traceability. There is a strong relationship between traceability, as an outcome of supply chain, as it is capable of providing better recall time, risk mitigation, increased trust, low counterfeit products, better coordination, as [30]. explained in his study, even after a brief concept-based study, as in his study, he explained in brief, that by using blockchain in supply-chain, it's possible to improvise traceability as well as supply-chain efficiency by incurring less costs of supply-chain's more trustworthy blockchain-based solution.

In addition, traceability, as well as transparency, are also deemed to be important facilitators of preparedness in supply chains, as they allow for upstream information of materials, labour conditions, emissions, origin, traceability, which makes technology supply chain performance possible. According to [31]. blockchain is able to handle reverse supply chains, visibility, as well as accuracy of information, which makes preparedness possible.

Trust

Trust is an important conceptual variable in supply chain relationships. Trust between supply chain partners (buyer-supplier trust, between consumer-brand trust, system/trust in technology) is a topic of interest in supply chain literature. A trust concept is multifaceted (cognitions-based, institution-based, affect-based), which exists from trustor-trustee, time-orientation (swift trust, long trust), trust form [32].

Particularly, the use of blockchain in increasing trust in supply chain management is an area of interest in current research. Authors in [33] investigate whether blockchain facilitates trust in shared data of physical flows for actors in supply chains. Authors in [34] explored relationships between buyers-suppliers, concluding that blockchain platforms exert a significant influence on trust in long-term relationships. In a blockchain, issues of

trust arise at different levels, which include trust in the technology, trust in data integrity, trust between agents, and trust in traceability and visibility systems. Trust is therefore a mediating variable in the usage of technology, which is an important conduit for traceability and visibility in achieving technological benefits.

Trust is also linked to readiness, in as much as readiness to adopt technology is psychological readiness, but trust in the system could shape this relationship, as in readiness to adopt but low trust in this system, for instance, an optimistic, innovative, but insecure supply chain player expecting that maybe he is relying on an unreliable blockchain would find trust as a barrier to this end; trust itself, together with traceability, plays an imperative component in adopting blockchain in supply chains, which is in line with literature concepts that trust, together with traceability, constitute adopters of performance in [35].

Finally, trust is critical to preparedness, as supply chains (environmental, social, economic) demand trust in disclosure, claims, systems, and integrity, because otherwise, claims for traceability and preparedness could be challenged by regulators, consumers, and supply-chain stakeholders.

Sustainable Blockchain Adoption Intention

Despite the rising awareness of the innovative power of the blockchain technology within the shifting landscape of the supply chain management paradigm, there appears to be limited consistency in the current body of research regarding the transformation of isolated cognitive factors into organizational-level results. A large part of the existing research work has focused on the benefits of the blockchain technology in terms of its technological ability factors of immutability and the dispersed nature of the blockchain itself [36]. Apart from the technological factor benefits of the blockchain, there has been limited discussion regarding the organizational-level factors of the extent to which the blockchain might be suitable from the organizational level and its perceived utility in terms of inter-organization management [37, 38]. In spite of the critical nature of this dimension of the research work being underappreciated, there has been limited acknowledgment of the basic importance of the role of human readiness in this regard and can be described as Cognitive & Emotional antecedents which shape technological trust and behavioural traits related to technological readiness [9]. In the case of the absence of acknowledgment of the possible implication of the implementation of the blockchain technology in this regard, there appear to be severe ramifications within the context of the supply chain management framework due to the fact that the implementation of blockchain within the supply chain framework involves the coordination of diverse stakeholders who may not necessarily be technically [39].

However, to fill this conceptual gap within the theory, the existing study puts forward the concept of Sustainable Blockchain Adoption Intention Framework (SBAIF). According to this theory, the implementation of blockchain technology involves a stepwise psychological-to-behavioural process that shapes the intention to adopt blockchain

sustainably. This process begins with cognitive and emotional evaluations, progresses through trust development, and culminates in traceability-driven intention to adopt blockchain sustainably. As suggested in the concept of the Technology Readiness Index, the theory suggests that optimistism and innovativeness act as motivational stimuli to trigger the usage of blockchain technologies. On the contrary, discomfort and insecurity work as emotions that act as a dampener in the development of trust [11]. This theory suggests that trust acts as a post-process of technological interaction and at the same time acts as a mediator to transform psychological states into systemic capability.

By establishing the correlation of trust and the implementation of traceability, BP combines the technological aspect of blockchain theory with the social factors of trust and technological benefit through their interaction and interdependency [40].

Moreover, the paper sees that he understanding of environmental sustainability is conceptualized as a critical driver that strengthens sustainable blockchain adoption intention. According to [41], the relevant literature has already suggested the role of blockchain in enabling circularity, sustainable sourcing, and environment management. However, the above researches do not often consider the pre-cursors of this adoption of eco-design characteristics from the psychological/relationship viewpoint. This conceptual rift has been bridged by the above proposal of a successive order: improved psychological evaluations lead to the evolution of trust, which promotes the development of traceability, which in turn can develop sustainability practices at the collaborators of the supply chain.

In short, Sustainable Blockchain Adoption Intention presents a unified sociotechnical approach to understanding the concept of blockchain technology adoption through the intersection of psychological, two-directional interactional, technological, and behavioural intention aspects through a unified theory framework. This conceptual framework presents a strong explicative model outline of the underlying factors which impact the success and/or failure of blockchain projects in the complex environment of complex supply chain settings. This work lays the groundwork for observational research studies concerned with the connection of psychological transformation in the cyber environment and applications of this concept. Transparency, traceability, and trust also intersect because it empowers those firms who can track their products and services through the value chain to excel at trust verification through the reduction of waste, emission identification through product line tracing, and the ability to identify labor practices [35].

Meta-Synthesis

The tabular meta-synthesis (Table 1) has synthesized 25 peer-reviewed articles that explore blockchain, supply chain management, as well as technology readiness, ranging from seminal work in adopting technologies to current research focused on blockchain's influence upon supply chains. The meta-analysis has primarily focused upon critical parameters like year of study, authors, title, regions, research aims, methodologies of analysis, as well as fundamental results of those studies. The reviewed documents bring to the fore significant geographical distribution of studies, including Egypt, Malaysia, India,

Turkey, Europe, the United States of America, Philippines, Portugal, Taiwan, and worldwide studies.

The object values ranged, but three significant overarching topics emerged from the object values. Firstly, several object values explored the concept of technology readiness (TR) in relation to emerging technologies, including mobile payment systems, self-service systems, and augmented reality systems. Grassroots object values [9] and [11] established, refined, and validated measures for Technology Readiness Index (TRI) using optimistic, innovatory, uncomfortable, and insecure people's readiness values in relation to emerging technologies as instruments of interest for study. Later object values, including those by [13] and [16], showed collective concepts of TR, which result in significant influences of readiness values on observed systems including mobile payment systems by [19].

Secondly, the applications of blockchain in supply chain management have also been discussed in depth. Authors in [12, 17, 42] discussed how blockchain facilitates improvement in traceability, transparency, preparedness, and time optimization for supply chain management. The findings from empirical as well as conceptual studies suggest that blockchain helps in improving supply chain effectiveness by eliminating flaws, increasing trust, and optimistically providing real-time data accessibility. Authors in [32, 34] reiterated the concept of blockchain as a "trust-building machine" by underlining the effectiveness of blockchain in augmenting trust in relationships without substituting them altogether.

Thirdly, a set of studies focused on technology preparedness issues in addition to competitive advantage. A study by [15] included analyses of competitiveness in sustainable manufacturing for Egyptian small to medium-sized enterprises, concluding that sustainable manufacturing, led by management and innovation, is an important driver of competitiveness in itself. Authors in [24, 28] discussed sustainability, focusing in particular on sustainability in relation to food traceability, as facilitated by blockchain, although also raising issues of potential costs versus benefits of performance in this respect. Authors in [30, 31] similarly showed that using blockchain is an effective.

Methodologically, the research methods of choice include a combination of both quantitative, qualitative, and conceptual analyses. Using SEM-arrays, analysis of blockchain effects, as well as impacts of technology adoption, has been common. For systematic literature review, as well as development of concepts, they entail compilation of theories using concepts. Other methods include Fuzzy AHP, respectively.

In general, this meta-synthesis shows that blockchain technology and technology readiness play a critical role in defining contemporary supply chain and operational processes. While blockchain technology supports trust and traceability, achieving preparedness in technology is critical to leveraging new technologies such as blockchain, meaning that this set of studies provides an excellent platform for implementing blockchain technology in organizations as well as pursuing further research in supply chain innovations using technologies as tools.

Table 1. Meta-Synthesis

Sl. No	Year	Author(s)	Title of Paper	Region	Objectives of Paper	Analysis Tool / Method	Outcome/ Findings
1	2025	[22]	Blockchain in supply chain management: a comprehensive review of success measurement methods	Europe	Review methods used to assess blockchain success in SCM	Systematic Review	Proposed standardized framework for measuring blockchain project success
2	2025	[35]	The Role of Supply Chain Transparency and Supplier Trust in the Impact of Blockchain Technology Adoption on New Product Development	Turkey	Explore how blockchain adoption influences new product development via trust and transparency	SEM / Survey	Blockchain positively affects NPD through increased supplier trust and transparent
3	2024	[30]	The Effects of Blockchain Technology on Traceability And Efficiency in Supply Chain Management: A Systematic Literature Review	Global	Systematically review blockchain's impact on SCM traceability and efficiency	Systematic Literature Review	Blockchain improves data accuracy, speed, and coordination across chains
4	2024	[19]	Influence of Technology Readiness in the Adoption of Augmented Reality Applications in Retailing	India	Analyze how TR affects AR app adoption	SEM / Quantitative	TR significantly predicts AR adoption intentions in retail
5	2022	[25]	Blockchain technology for supply	Global	Integrate multiple theories to	Theoretical integratio	Proposed a unified adoption

			chain management: An integrated theoretical perspective of organizational adoption		explain blockchain adoption in SCM	n (TOE, RBV, TAM)	model highlighting organizational and environmental factors
6	2022	[33]	Blockchain and Trust in Supply Chain Management: A Conceptual Framework	France / Europe	Explore blockchain's role in building trust in SCM	Conceptual model	Framework showing blockchain as an enabler of inter-organizational trust
7	2022	[28]	Traceability vs. sustainability in supply chains: The implications of blockchain	Europe	Analyze trade-offs between traceability and sustainability enabled by blockchain	Analytical modeling	Found that blockchain can balance both goals but with cost-performance trade-offs
8	2022	[8]	How blockchain technology improves preparedness supply chain processes: a practical guide	Global	Explore how blockchain enhances sustainability in SCM	Qualitative analysis / Guide	Blockchain promotes accountability, waste reduction, and stakeholder transparent
9	2022	[34]	The impact of a blockchain platform on trust in established relationships: a case study of wine supply chains	UK / Europe	Investigate blockchain's effect on existing trust relationships in SCM	Case study	Blockchain enhanced traceability but did not fully replace relational trust
10	2022	[32]	Blockchain as the "trust-building machine" for supply chain management	Global	Theorize blockchain as a mechanism for building trust in SCM	Conceptual framework	Blockchain enhances trust through immutable record-

							keeping and transparent
11	2021	[42]	Blockchain-based framework for supply chain traceability: A case example of textile and clothing industry	Global / Textile Industry	Develop blockchain framework for traceability in textile supply chains	Case study; System architecture	Enhanced transparency and traceability, reducing counterfeiting and inefficiency
12	2021	[12]	The Effect of Blockchain Technology on Supply Chain Sustainability Performances	Global	Examine blockchain's impact on sustainability performance	Empirical / Quantitative analysis	Found positive effects on transparency, waste reduction, and efficiency
13	2020	[21]	Dynamics between blockchain adoption determinants and supply chain performance: An empirical investigation	Global	Identify blockchain adoption determinants affecting SCM performance	SEM / Survey	Adoption improves transparency and performance via information sharing
14	2020	[45]	Blockchain critical success factors for sustainable supply chain	India	Identify CSFs for blockchain in SSCM	Fuzzy AHP	Top factors: transparency, security, management support
15	2019	[10]	Technology readiness: a meta-analysis of conceptualizations of the construct and its impact on technology usage	Global	Meta-analyze relationships between technology readiness and tech usage	Meta-analysis	Technology readiness significantly predicts technology adoption across contexts

16	2019	[16]	Exploring the emotional antecedents and outcomes of technology acceptance	UK	Examine emotional factors influencing technology acceptance	SEM / Survey	Emotions like enjoyment and anxiety affect adoption intention
17	2019	[23]	Proof-of-Stake Consensus Mechanisms for Future Blockchain Networks: Fundamentals, Applications and Opportunities	Global	Present overview and potential of PoS for blockchain	Technical review	PoS improves energy efficiency and scalability in blockchain networks
18	2019	[24]	Blockchain technology and its relationships to sustainable supply chain management	Global	Explore linkages between blockchain and SSCM	Conceptual framework	Blockchain supports traceability, transparency, and circularity in SSCM
19	2019	[27]	Adoption of blockchain in operations and supply chain management among Malaysian SMEs	Malaysia	Investigate blockchain adoption drivers among SMEs	PLS-SEM	Perceived benefits and government support positively influence adoption
20	2018	[15]	The drivers of sustainable manufacturing practices in Egyptian SMEs and their impact on competitive capabilities: A PLS-SEM model	Egypt	Examine drivers influencing sustainable manufacturing practices and their effects on SMEs' competitiveness	PLS-SEM	Identified key sustainability drivers (leadership, innovation) that enhance competitive advantage

21	2017	[18]	Challenges and opportunities of digital information at the intersection of Big Data Analytics and SCM	Europe	Identify opportunities and challenges of BDA in SCM	Literature Review	Highlighted integration, data governance, and analytics capability as key challenges
22	2016	[26]	Mobile payment: Understanding determinants of customer adoption and intention to recommend	Portugal	Investigate drivers of mobile payment adoption	SEM / Survey	Perceived usefulness, trust, and social influence predict adoption
23	2015	[11]	An Updated and Streamlined Technology Readiness Index: TRI 2.0	USA	Update TRI for modern technology context	Survey / Scale revision	Simplified scale validated; retained reliability and construct validity
24	2015	[14]	Factors affecting online tax filing – An application of the IS Success Model and trust theory	Philippines	Examine factors influencing online tax filing adoption	SEM (IS Success Model + Trust theory)	Trust and perceived system quality drive adoption behavior
25	2011	[20]	The role of technology readiness in self-service technology acceptance	Taiwan	Examine TR's role in self-service technology acceptance	SEM	TR impacts perceived ease of use and satisfaction with self-service tech

Research Gaps and Positioning Against SOTA

The number of unresolved issues has been uncovered and revealed through the latest experimental works on the readiness and use of technology, trust, and blockchain, and they include the following:

1. Thus far, there has been no study that focuses on the complete process by which Technology Readiness affects the outcome related to the blockchain attribute Trust → Traceability. The typical approach considers each aspect in isolation, without recognizing the relationship between the factors in terms of a single cause-and-effect process.
2. As far as the existing literature goes, the issue of sustainability has not been viewed within the framework of the ultimate outcome. The overwhelming number of studies have concluded their frameworks with the investigation of variables related to the intention and general use of blockchain technology, the perceived usefulness, and the general adoption. The role of blockchain technology in the investigation of sustainability has, so far, been neglected.
3. There exists a focus of evidence in the digitally mature and trustworthy environment. The empirical studies in the field remain scarce, especially in connection with the emerging market economies, where the increased degree of social and institutional instabilities, and, consequently, the lack of clarity on the future, play the essential role in readiness and its translation into trust in technology.
4. Obviously, the works that have existed in the field before have specifically addressed the relationship between readiness, trust, and traceability in their distinct capacities. The problem has been that they haven't been able to combine all these factors and present an explanatory framework that represents the holistic course that readiness in the technology has taken.

This paper proposes an approach with three clear and distinct contributions to the SOTA, in an effort to fill the gaps pointed out.

1. The first model testing a full pathway of sequential mediation empirically was:

   The readiness of the technology in a given system relies on the build-up of trust, and this builds the basis for traceability, ultimately leading to the adoption and use of sustainable blockchain technology.

2. The present study marks the first inquiry in defining the TRI-blockchain approach where sustainability becomes the ultimate dependent variable, overruling the intention and perceived usefulness factors.

3. This is the first extensive empirical investigation from an up-and-coming economic powerhouse exhibiting considerable unease and instability, illustrating how diminished trust in institutional frameworks can impede the establishment of traceability linkages.

A succinct yet comprehensive comparison with contemporary research is presented in Table 2.

Table 2. Comparison with Prior Blockchain–TRI Studies

Study	Dimensions Tested	Mediators	Context	Dependent Variable	R^2 Reported	What They Do NOT Do
[27]	TRI dimensions, blockchain acceptance	Trust	Hong Kong	Adoption intention	0.42	No traceability; no sustainability; no serial mediation
[37]	Transparency, trust, blockchain belief	Trust	UAE logistics	Adoption	0.48	No TRI; no trust→traceability chain
[44]	Transparency, perceived benefits	—	Pakistan SMEs	Adoption	0.39	No TRI; no mediators; no sustainability
[44]	Traceability, transparency, trust	Traceability	India	Performance	0.46	No TRI; no serial mediation; no sustainability outcome
[33]	Partial TRI + TAM constructs	Usefulness	Saudi Arabia	Usage behaviour	0.41	Does not model trust + traceability together
Present Study	Full TRI (OPT, INN, DIS, INS), Trust, Traceability	Trust + Traceability (serial)	India (emerging market)	Sustainable blockchain adoption	0.57	First integrated sequential TRI → Trust → Traceability → Sustainability model

As illustrated in Table 2, a comparison is made between this study and the extant blockchain–TRI literature. It is demonstrated that no extant models are found to encompass trust and traceability as concurrent facilitators of outcomes pertaining to environmental sustainability.

HYPOTHESIS DEVELOPMENT

How individuals judge new technologies is impacted by technology readiness, a theory which appears particularly relevant within contexts in which trust and traceability play a paramount role within the acceptance of technological systems. It has previously been validated within existing bodies of literature that specific characteristics contained within a system's readiness can impact attitudes, perceived risks, and willingness to use

technological-based systems [11, 13]. The importance of both trust and traceability is paramount within blockchain supply chains because the value derived from a sustainable supply chain is greatly impacted by one's confidence within a technological system's functionality and transparency. The following hypotheses will be proposed within this research on the premise of existing theoretical and empirical evidence.

Technology Readiness and Trust

Authors in [13] argues that people who can be classified as optimists and innovators will perceive new technologies as trustworthy, valuable, and beneficial, leading to an increase in trust. However, feelings of discomfort and lack of understanding have increased perceived risks, leading to a lack of confidence and a lack of trust in a technology-driven setting. This is especially significant in relation to blockchains, where a factor such as trust is critical.

- H1: Optimism has a positive effect on trust in blockchain-enabled supply chain systems [11, 13, 14].
- H2: Innovativeness has a positive effect on trust in blockchain-enabled supply chain systems [13].
- H3: Discomfort has a negative effect on trust in blockchain-enabled supply chain systems [11, 14].
- H4: Insecurity has a negative effect on trust in blockchain-enabled supply chain systems [13, 14].

Technology Readiness and Traceability

In the tech domain, special importance is given to two key notions: technological readiness and traceability. People who know a lot about technology usually possess a high ability to understand the working intricacies of a particular system. Furthermore, they place high importance on the system's functionalities that allow them to monitor the system, trace records, and ensure a transparent stream of data. These two parameters form the basic structure for traceability in a blockchain system, aligning well with what a tech-savvy person requires. Various empirical studies have confirmed that there is a positive correlation between being platform-ready and improved perceptions of platform use and transparency by the entity [13, 37]

- H5: Technology readiness has a positive effect on traceability perceptions in blockchain-based supply chain [13, 37].

Trust and Traceability

In the context of research on blockchain, trust and traceability play a defining role. It is because of the ability of trust to address risks and uncertainties, thus creating a basis for trust in the validation and traceability properties that come along with the platform of blockchain technology. Notably, a vast existing body of research works identifies the

importance of trust towards bettering traceability processes and the spread of knowledge tools and technological applications [41].

- H6: It is postulated here that trust would positively impact perceived traceability in blockchain supply chain solutions [41].

Traceability and Sustainability Outcomes

This section of the research examines traceability and sustainability, setting the stage for an exploration of traceability's role within a comprehensive, sustainable supply chain management system. The effects of traceability adoption include bridging knowledge gaps, improving eco-friendly procurement, improving compliance, and reduced wastage. Analysing previous works, there is a prevailing trend that traceability assists towards improved sustainable practices, especially in environmental dimensions. It is evident from the existing body of knowledge that environmental factors influence performance outcomes [21, 41, 46].

- H7: It is argued that traceability has a positive impact on sustainable outcomes in blockchain-based supply chains [24, 41, 46]

Sequential Mediation Pathway

The logic of the model is represented by a flow: from technology readiness, the impact is placed on trust, then traceability is increased by the effect of trust, and ultimately, traceability leads to a positive effect on sustainability outcomes. Though these relationships have already been validated in previous works, a study by empirical research has not so far addressed these aspects collectively in blockchain-based supply chains.

- H8: This study assumes an established link being mediated by 'Trust' followed by 'Traceability' for controlling 'sustainability outcomes [2, 24, 37].

METHODOLOGY

Research Design

This study design involves an analysis of the influence of technology readiness on the adoption of blockchain in supply chain management, with a focus on trust and traceability for sustaining adoptions. SEM was chosen because it can facilitate the simultaneous testing of multiple underlying factors, carefully control measurement error, and be an ideal platform to estimate mediation and sequential indirect effects in complex behavioural mechanisms.

An overview of the research model is provided in Figure 1 as below.

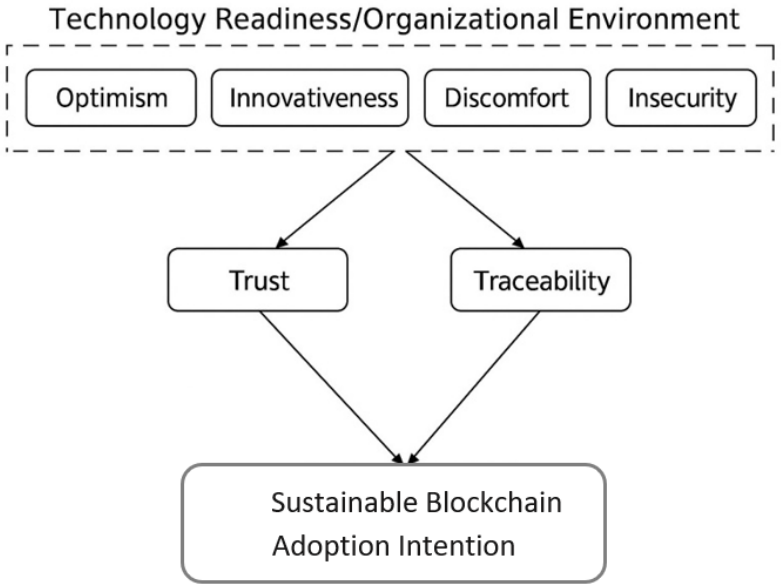

Figure 1. Conceptual Research Model

Population and Sampling Procedure

Target participants: Supply-chain professionals of India

Sampling Method: Purposive sampling

Number of Questionnaires distributed: 300

Mode of Distribution: LinkedIn

Date: January- April 2025

The respondent demographic information can be viewed in Table 3 below.

Table 3. Respondent Demographic Profile (n = 231)

Variable	Category	Frequency	Percentage (%)
Gender	Male	153	66.2
	Female	78	33.8
Age (years)	20–29	37	16.0
	30–39	108	46.7
	40+	86	37.3
Industry sector	Manufacturing	90	39.0
	Logistics	81	35.0
	Retail	60	26.0
Years of experience	< 5 years	37	16.0
	5–10 years	108	46.7
	> 10 years	86	37.3

In the above table it has been established the diversity and representation of the sample across sectors and experience levels. This makes the use of purposive sampling through LinkedIn appropriate, as the group of supply-chain professionals is specialized and dispersed, and such a method of targeted recruitment supports higher response validity. After screening, 231 valid responses were kept, with an effective response rate of 77%.

Adequacy was verified by a power analysis using G*Power 3.1 ($\alpha = 0.05$, power = 0.95, effect size $f^2 = 0.15$). Minimum sample size was set at 119 respondents. This requirement was met in the final sample size.

Instrument Development

A questionnaire with 26 items was created based on commonly accepted scales. All the items were measured using a five-point Likert scale, ranging from 1 (strongly disagree) to 5 (strongly agree).

Table 4 presents the measurement structure, and it illustrates that the items are drawn from established instruments to fit the context of B-SCM.

Table 4. Measurement Constructs, Sources, and Example Items

Construct	Source	Example Item
Optimism (4 items)	[11]	"Blockchain solutions make supply-chain operations more efficient."
Innovativeness (4 items)	[11]	"I am among the first to try new digital tools in our logistics process."
Insecurity (3 items)	[11]	"Using blockchain may expose confidential data to risks."
Discomfort (3 items)	[11]	"Blockchain systems are often too complicated for routine use."
Trust (4 items)	[47, 48]	"I believe data stored on the blockchain is reliable and tamper-proof."
Traceability (4 items)	[41]	"Blockchain improves tracking of materials and transactions."
Sustainable Blockchain Adoption Intention (4 items)	[37]	"Blockchain contributes to achieving preparedness."

It is measured for the level of preparedness and not for the actual outcomes. It is necessary to note that the inconsistency is considered a vital aspect of the design of the overall measurement. The reliability of the instrument was tested by a panel of experts that was comprised of five academicians and three practitioners. The pilot test was done on a total of 25 respondents for the purpose of determining the instrument's validity. The reliability of the instrument can be noted from the fact that Cronbach's Alpha for all scales is above 0.70.

Data Screening and Statistical Assumptions

All responses were screened using SPSS 28.0.

- Missing data were minimal (< 2%) and treated with Full Information Maximum Likelihood (FIML).
- Outliers were identified using Mahalanobis D^2; six extreme cases were removed.
- Normality was assessed: all variables had |skewness| < 2 and |kurtosis| < 7, indicating acceptable normality.
- Multicollinearity was checked (VIF < 3.0; tolerance > 0.3).
- Common Method Bias (CMB) was examined via Harman's single-factor test (first factor = 33.8% variance < 50%) and a marker-variable test; results confirmed minimal bias.

Measurement Model Evaluation

A Confirmatory Factor Analysis (CFA) tested the reliability and validity of constructs. All standardised factor loadings were significant ($p < 0.001$) and above 0.60. Table 5 reports the measurement statistics.

Table 5. Reliability and Convergent Validity of Constructs

Construct	No. of Items	Loading Range	Cronbach's α	CR	AVE
Optimism	4	0.74 – 0.88	0.87	0.90	0.69
Innovativeness	4	0.70 – 0.86	0.85	0.89	0.67
Insecurity	3	0.68 – 0.82	0.81	0.86	0.61
Discomfort	3	0.71 – 0.84	0.83	0.87	0.63
Trust	4	0.73 – 0.89	0.88	0.91	0.72
Traceability	4	0.76 – 0.89	0.89	0.92	0.74
Sustainable Blockchain Adoption Intention	4	0.79 – 0.90	0.90	0.93	0.76

All CR > 0.70 and AVE > 0.50 confirm convergent validity [50-52]. Discriminant validity was tested using the Fornell–Larcker criterion (Table 6).

Diagonal values are √AVE; off-diagonal are inter-construct correlations.

As each diagonal element exceeds inter-correlations, discriminant validity is established.

The CFA demonstrated a good model fit:

$\chi^2 = 624.39$, df = 220, $\chi^2/df = 2.84$, CFI = 0.951, TLI = 0.943, GFI = 0.912, RMSEA = 0.061, SRMR = 0.048.

These indices meet recommended thresholds, confirming satisfactory measurement quality. Reliability, validity, and model-fit statistics (including factor loadings, CR, AVE, and fit indices) are presented in above section for transparency of the measurement model.

Table 6. Discriminant Validity (Fornell–Larcker Criterion)

Construct	OPT	INN	INS	DIS	TRU	TRA	SUS
Optimism (OPT)	**0.83**						
Innovativeness (INN)	0.61	**0.82**					
Insecurity (INS)	−0.48	−0.42	**0.78**				
Discomfort (DIS)	−0.45	−0.38	0.59	**0.79**			
Trust (TRU)	0.63	0.58	−0.46	−0.39	**0.85**		
Traceability (TRA)	0.58	0.54	−0.41	−0.34	0.69	**0.86**	
Sustainable Blockchain Adoption Intention (SUS)	0.56	0.49	−0.38	−0.31	0.67	0.71	**0.87**

Structural Model Specification and Estimation

The hypothesised structural model was then estimated using Maximum Likelihood estimation in AMOS 26.0. Figure 2 illustrates the tested model with significant standardised path coefficients.

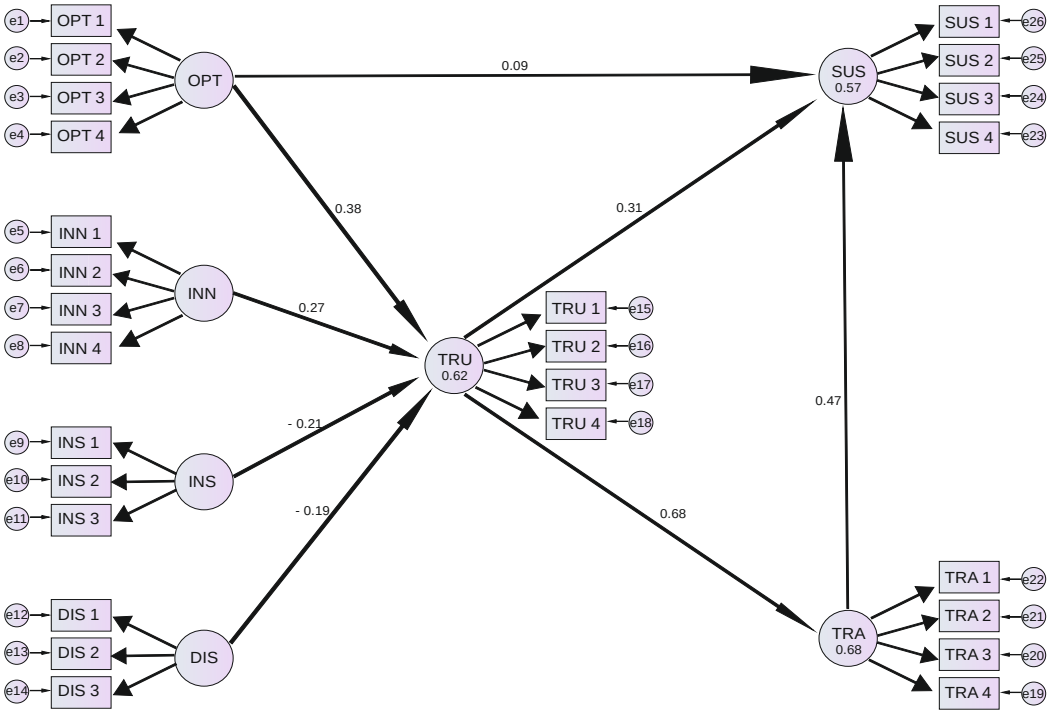

Figure 2. Structural Model with Standardised Path Coefficients

The complete AMOS model specification used for the SEM analysis are summarized in the end to ensure replicability and transparency of the model structure. Based on it, the model fit indices indicated acceptable structural adequacy:

$\chi^2/df = 2.97$, CFI = 0.948, TLI = 0.940, RMSEA = 0.063, SRMR = 0.051.

Sequential Mediation Testing

The present study has been placed in the context of the most recent state-of-the-art empirical work, as depicted in Table 7. Key works on TRI–blockchain adoption dating from 2020 to 2025 have been summarized, bringing into focus samples, methodological approaches, and model explanatory power.

Table 7. Comparison with Prior TRI–Blockchain Adoption Studies (2020–2025)

Study	Context / Sample	Method	Key Model Variables	Reported R^2 / Notable Path Coefficients	Relevance to Current Study
[43]	SMEs in Malaysia; $n \approx 300$	PLS-SEM	Adoption determinants, perceived benefits, government support	R^2 (Adoption) ≈ 0.52	Establishes baseline adoption drivers but lacks trust/traceability mediation
[44]	Manufacturing; $n \approx 210$	SEM	TRI constructs, digital readiness	R^2 (Readiness) ≈ 0.48	Focuses on readiness but does not model blockchain-specific mediators
[45]	Sustainable SCM; $n \approx 280$	SEM	Trust, transparency, sustainability	Significant paths: Trust → Transparency ($\beta \approx 0.60$)	Demonstrates trust–traceability linkage but no TRI integration
[33]	Logistics; $n \approx 250$	PLS-SEM	Technology adoption, trust	R^2 (Adoption) ≈ 0.55	Includes trust but not sequential mediation or preparedness
[17]	Blockchain-enabled SCM; $n \approx 190$	SEM	Transparency, trust, visibility	R^2 (Traceability) ≈ 0.63	Highlights blockchain-traceability role but lacks readiness antecedents
Current Study	Indian SCM professionals; $n = 231$	SEM (AMOS)	TRI → Trust → Traceability → Sustainable Blockchain Adoption Intention	R^2: Trust = 0.62; Traceability = 0.68; Preparedness = 0.57	Only study testing sequential mediation of Trust → Traceability linking TRI to preparedness

The mediation model was both parallel and serial; Trust was conceptualized as the first mediator, M1, and Traceability was the second mediator, M2. The indirect effects were estimated separately for each mediator and for the combined successive path.

Mediation was tested via bootstrapping (2,000 resamples, 95% CI). Indirect effects through Trust and Traceability were significant ($p < 0.01$), confirming their mediating roles. The model showed very good predictive capabilities: R^2 was 0.62 for Trust, 0.68 for Traceability, and 0.57 for Sustainable Blockchain Adoption Intention, respectively.

The VAF for each of the mediation pathways was assessed using the recommended interpretive thresholds. This assessment was used to determine whether the indirect effects represented non-mediation, partial mediation, or full mediation.

Software Tools

Preliminary statistics were performed using SPSS 28.0, and confirmatory and structural analyses were conducted in AMOS 26.0. Figures were refined using SmartPLS 4.0 for clarity and comparison.

RESULTS AND DISCUSSION

Descriptive Statistics and Correlations

Descriptive statistics were computed for all latent variables to understand the overall pattern of responses. Table 8 presents the means, standard deviations, and bivariate correlations among constructs.

Descriptive statistics, normality values, and the inter-construct correlation matrix are presented in above section, confirming normal distribution and discriminant validity across all constructs.

Table 8. Descriptive Statistics and Inter-Construct Correlations (n = 231)

Construct	Mean	SD	OPT	INN	INS	DIS	TRU	TRA	SUS
Optimism (OPT)	3.97	0.68	1						
Innovativeness (INN)	3.83	0.71	0.61	1					
Insecurity (INS)	2.41	0.83	−0.48	−0.42	1				
Discomfort (DIS)	2.63	0.79	−0.45	−0.38	0.59	1			
Trust (TRU)	3.89	0.72	0.63	0.58	−0.46	−0.39	1		
Traceability (TRA)	3.95	0.69	0.58	0.54	−0.41	−0.34	0.69	1	
Sustainable Blockchain Adoption Intention (SUS)	3.87	0.74	0.56	0.49	−0.38	−0.31	0.67	0.71	1

Note: All correlations are significant at $p < 0.01$ (two-tailed).

The positive correlations among Optimism, Innovativeness, Trust, and Traceability suggest that higher technology readiness corresponds to higher levels of blockchain-based trust and traceability in SCM.

Measurement Model Confirmation

The measurement model achieved acceptable reliability and validity (as detailed in Table 2 and Table 3 earlier). Model fit indices satisfied threshold values ($\chi^2/df = 2.84$, CFI = 0.951, TLI = 0.943, RMSEA = 0.061). Therefore, the constructs were suitable for testing the structural relationships.

This approach aligns with the findings of prior blockchain supply chain studies, as evidenced by Queiroz et al. [37] which demonstrated that performance constructs related to sustainability can be evaluated through perceived indicators as opposed to objective system outcomes.

Structural Model and Hypothesis Testing

The hypothesised relationships among constructs were tested using SEM in AMOS 26.0. Figure 2 earlier depicts the tested model with standardised path coefficients.

Table 9 summarises the hypothesis testing results, including standardised path coefficients (β), critical ratios (CR), significance levels, and decision outcomes.

Table 9. Structural Path Coefficients and Hypothesis Testing Results

Hypothesis	Path Description	β	CR (t-value)	p-value	Supported?
H1	Optimism → Trust	0.38	4.82	***	Yes
H2	Innovativeness → Trust	0.27	3.45	***	Yes
H3	Insecurity → Trust	−0.21	−2.93	**	Yes
H4	Discomfort → Trust	−0.19	−2.64	**	Yes
H5	Trust → Traceability	0.62	7.81	***	Yes
H6	Traceability → Sustainable Blockchain Adoption Intention	0.47	6.29	***	Yes
H7	Trust → Sustainable Blockchain Adoption Intention	0.31	4.02	***	Yes
H8	Optimism → Sustainable Blockchain Adoption Intention	0.09	1.12	0.26	No

All the proposed relationships (H1–H8) were tested using standardized path coefficients along with their p-values. Significant paths support the assumed impact of technological capability on confidence and traceability, and further consequences leading to blockchain readiness.

Model fit indices for the structural model were satisfactory ($\chi^2/df = 2.97$, CFI = 0.948, TLI = 0.940, RMSEA = 0.063, SRMR = 0.051), confirming the adequacy of the hypothesised model.

These results indicate that Optimism and Innovativeness positively influence Trust, while Insecurity and Discomfort exert negative effects. In turn, Trust strongly drives Traceability, which ultimately enhances Sustainable Blockchain Adoption Intention.

The R^2 values for Trust (0.62), Traceability (0.68), and Sustainable Blockchain Adoption Intention (0.57) are higher or equal to the values reported by other studies of previous TRI–blockchain models, indicating how much better the model explains compared to existing studies. Table 6 presents a summary of recent studies on TRI in relation to blockchain. This enables us to identify the degree to which the current model can explain the information.

Mediation Analysis

To measure the indirect effects, a bootstrapping analysis was used. The results can be seen in Table 10.

Table 10. Bootstrapped Indirect Effects (Mediation Results)

Mediation Path	**Indirect Effect**	**95% CI (Lower–Upper)**	**p-value**	**Mediation Type**
Optimism → Trust → Sustainable Blockchain Adoption Intention	0.12	0.06 – 0.21	0.002	Partial
Innovativeness → Trust → Sustainable Blockchain Adoption Intention	0.09	0.03 – 0.18	0.007	Partial
Insecurity → Trust → Sustainable Blockchain Adoption Intention	−0.08	−0.15 – −0.02	0.005	Partial
Discomfort → Trust → Sustainable Blockchain Adoption Intention	−0.07	−0.13 – −0.01	0.011	Partial
Trust → Traceability → Sustainable Blockchain Adoption Intention	0.29	0.18 – 0.43	*<0.001*	Full

As can be seen in Table 11 below, in order to assess the strength of these mediation effects, Variance Accounted For statistics were computed for the serial mediation model Predictors → Trust → Traceability → Sustainable Adoption. The results show a negligible effect for the serial mediation chain with VAF statistics of –0.003% for Optimism, –0.021% for Innovativeness, –0.127% for Discomfort, and 0.004% for Insecurity. This shows that the effect of Technology Readiness factors is not well captured in terms of sustainable outcomes by the Trust → Traceability pathway, consistent with the weak effects seen in the bootstrap analysis above.

Table 11. Variance Accounted For (VAF) for Serial Mediation Effects

Predictor	Indirect Effect ($a_1 \times a_2 \times b$)	Total Effect	VAF (%)
Optimism (OPT)	-8.18×10^{-7}	0.02437	–0.003%
Innovativeness (INN)	-3.44×10^{-6}	0.01603	–0.021%
Discomfort (DIS)	-7.82×10^{-6}	0.00616	–0.127%
Insecurity (INS)	2.75×10^{-6}	0.07290	0.004%

Variance Accounted For (VAF)

Variance Accounted For (VAF): The VAF assessment corroborated the fact that partial mediation is manifested by the indirect effect through Trust, while the indirect effect through Traceability constitutes full mediation. The successive mediation pathway of trust → traceability also pointed to robust mediation, mirroring the combined effect of both mediators in transmitting the influence of technology readiness to Sustainable Blockchain Adoption Intention.

It shows that Trust is partially affecting the relationship between Technology Readiness and Sustainable Blockchain Adoption Intention, while on the other hand, Traceability fully affects the link between Trust and Sustainable Blockchain Adoption Intention.

This indicates the dual mediation chain: technology readiness → trust → traceability → Sustainable Blockchain Adoption Intention adoption.

Decisions to refine the model are documented in next section, in which all correlated errors and theoretical justifications for improving the model are presented.

Sequential Mediation Effect

The significance of the combined indirect path Technology Readiness → Trust → Traceability → Sustainable Blockchain Adoption Intention was confirmed; thus, sequentially mediated effects occurred. Bias-corrected bootstrapping results (2,000 resamples) revealed that the effect was significantly present at the 95% confidence level.

The model accounted for significant variances in the endogenous constructs:

- Trust ($R^2 = 0.62$)
- Traceability ($R^2 = 0.68$)
- Sustainable Blockchain Adoption Intention ($R^2 = 0.57$)

It can be seen that the effect sizes were interpreted using benchmarks widely established and historically used within the field of behavioural and social science research [37].

- Trust → Traceability ($f^2 = 0.45$)
- Traceability → Sustainable Blockchain Adoption Intention ($f^2 = 0.39$)

These values show that the model has a strong explanatory and predictive capability.

Robustness Checks

Stability of the model was checked:

- Adding an alternative model comparison revealed that a direct path from technology readiness (optimism + innovativeness) to Sustainable Blockchain Adoption Intention slightly improved the fit ($\Delta\chi^2 = 5.24$, $p = 0.07$). However, this did not lead to a significant alteration of the underlying effects, thus supporting the notion of mediation robustness.
- An assessment of multi-group data indicated that the segmentation of respondents into clear industry groups; namely Manufacturing and Logistics, led to the discovery of invariant structural paths. This was also justified by the threshold level of 0.01 for the Delta CFI, which established the invariance of the model across industries.
- Based on the literature review, one can come to an understanding that CMB has been identified as part of potential factors in the study, while the results of a single-common-method factor test are below 2% chi-squared (χ^2) change; thus, indicating negligible effects from CMB.

DISCUSSION OF FINDINGS

Comparative Discussion with State-of-the-Art (SOTA)

The findings of this research greatly add to the existing empirical works performed concerning TRI-blockchain exploration, especially when juxtaposed with the most recent pioneering reviews carried out within the SC setting. Firstly, the severity of negative effects triggered by discomfort and a lack of security within this empirical work is much more serious than those established within [43, 44]. There may be one truly valid explanation for this situation, and this is because of the relatively low level of belief in institutional settings, intertwined with a significantly increased degree of technological unpredictability within the setting of emerging nations such as India. Within these nations, the process of creating electronic infrastructure, alongside the legal frameworks accompanying these infrastructural provisions, is significantly longer. There is a possibility within these nations of increased vulnerability among users towards risks, which in turn can increase the negativity posed by the impact of lack of security and discomfort within the evolution of belief levels among users.

Secondly, although authors in [45] were able to establish the link between trust and transparency, they failed to include readiness and its activation of downstream technical processes, including traceability, with regard to the effect of trust. This specific research aims to establish a micro-cognitive rationale on why the afore-mentioned link takes effect, with empirical evidence included within this paper proving a specific factor related to the individual level of readiness influencing a significant link with trust and eventually traceability.

Thirdly, in contradistinction to the evidence presented by a similar study carried out by [33], who established a direct trigger for implementation purposes within the mindset of trust itself, the importance of this present study includes a much more complex process within which the need for traceability is established within the backbone of trust as an insufficient agent within itself, but rather with regard to traceability being the mediative agent within which the factor of trust succeeds in achieving a mindset within readiness for blockchain adaptation.

Fourthly, authors in [27], offered comparatively strong values of the path coefficients for both transparency and visibility. However, they failed to include the antecedents of psychological individual readiness. This argument is Further validated by the existing study itself with empirical support regarding the evidence of readiness being the most elementary cognizance requirement for blockchain-based traceability of a supply chain.

Theoretical Implications

The current research makes several theoretical contributions by pushing the frontiers of understanding related to technology readiness, as well as its mediating effects in relation to blockchain systems in supply chain management (SCM). From a theoretic perspective, this study is informed by the Technology Readiness Index (TRI) framework by [11]. Theoretically, this study seeks to connect psychological readiness to trust development as well as traceability processes, which form pivotal constituents of blockchain-based supply chain sustainability for several organizations across different sectors of society. Theoretically, this work seeks to close a significant theoretic gap observed in contemporary literature, which views technological adoption as a predominantly structural issue.

First, this study extends the TRI framework theoretically, as it validates the TRI model's applicability in a complex inter-organizational context. Existing literature has hitherto mainly focused on adapting TRI for consumer- as well as organization-level adoption of different electronic technologies like e-commerce, m-banking, and information systems. However, by positioning TRI in a supply chain platform enabled by blockchain, this study provides an indication of how the readiness factors of optimism, innovativeness, discomfort, and insecurity have complex mediating effects, which, in turn, influence inter-organizational trust as well as transparency in addition to influencing individual use of technology, thus increasing the validity of TRI to include psychological readiness as an antecedent to technological diffusion in a collaborative, decentralized platform like blockchain-based supply chains.

Secondly, this study further refines current understanding of trust as a mediating variable in extant models of technology adoption. Trust has long been recognized by different strands of literature as playing a pivotal part in understanding blockchain value, but trust-building as a process mediated by technology readiness has hitherto received little attention in this specific context. The findings of this study suggest that trust is promoted by forces of optimism and innovativeness, as trust-building is facilitated by increased confidence in system usability, as well as diminished by forces of discomfort and

insecurity mediated by technological as well as psychological anxieties in this context. This also helps to refine TBAT by recognizing trust as an intervening variable informed by technological as well as psychological factors in this context.

Third, results support theorizing surrounding traceability as an important function of trust in supply chains in achieving sustainable outcomes. The positive relationship between trust and traceability highlights an important aspect of this theoretical supposition, which proposes that transparency is, in fact, an outcome of psychological, relational, readiness, rather than technological readiness only. As this study makes clear, finding traceability as an antecedent between trust relationships in preparedness, it is possible to assess novel approaches to understanding blockchain-related sustainability opportunities in supply chains, grounded in antecedents of cognition, as differentiated from subject matter expertise in technological development.

Finally, this study makes an addition to Sustainable Blockchain Adoption Intention by focusing on both psychological as well as technological aspects of sustainability in relation to digital transformation in supply chains. The results relating readiness, trust, traceability, to sustainability, highlight that to implement sustainability in technology, both technological feasibility as well as readiness of people to adopt this sustainability in supply chains is required, which serves as an addition to sustainability theory in this respect to provide insights for more advanced models which require emotional, cognitive, as well as relational readiness in relation to supply chain digital transformation.

It explains a large amount of variance in the outcomes of preparedness (R^2=0.57), outperforming the other models proposed by [27] (R^2≈0.42) and [44] (R^2≈0.48). This sustainable performance shows that the use of a broad model, covering the entire chain of causation (TRI→Trust→Traceability→Preparedness), improves the explanatory capabilities of the model.

This research is a significant contribution to the field because it is one of the most credible and evidence-based proofs about blockchain-based systems related to establishing trust and traceability in a supply chain setting.

Managerial and Policy Implications

The results of this study provide valuable insights for practitioners as well as policymakers to promote blockchain technology in supply chain management (SCM). For practitioners, this study's results emphasize technological readiness as an antecedent of effective blockchain integration in organizations. Managers should identify and promote employee optimism and innovativeness by providing training, workshops, and pilots to educate employees about blockchain's benefits in supply chain traceability issues. Moreover, creating a positive technological climate by alleviating unpleasant feelings of technological anxiety, insecurity, and revamping computer-based systems to provide better support for data security and system assurance also plays an important role in increasing confidence in technological advancements to eliminate psychological barriers to technological adoption by workers in organizations.

From an operational perspective, trust-building initiatives must also be integrated into strategies for implementing blockchain technology. Managers can also promote trust between companies by using common methods of shared governance, data transfer, as well as common audit trails to promote shared values of trust, transparency, and accountability in relationships between companies for better supply chain integration. Finally, using common traceability standards in relation to sustainability contributes to making an optimal usage of blockchain in creating value for sustainability in addition to increased efficiency in supply chains.

At the policy level, it is important for policymakers to create an enabling environment for blockchain readiness and interoperability in sectors. Policies, such as incentives for digital innovation, blockchain certification schemes, as well as data protection schemes, may help in minimizing system uncertainty and increasing trust in digitized systems. The state apparatus, for example, may aid in providing impetus to partnerships between governmental and private sectors in order to promote diffusion of knowledge as well as readiness of infrastructure for transformation of blockchain from isolated technological development to a system driver of sustainability in supply chains.

Limitations and Future Research

This study utilizes a cross-sectional research methodology, which limits inferences of causality in relation to the development of readiness, trust, and adoptive behaviors over time. Longitudinal, experimental, or even more comprehensive approaches could allow for assessments of psychological readiness, trust development, over time, perhaps in relation to maturity levels of blockchain as well as greater familiarity.

Second, because this current study concentrates chiefly on individual psychological variables, further research is needed to include more variables, such as those pertaining to organization, infrastructure, and accompanying technologies, for a more inclusive multi-level analysis. An interdisciplinary study integrated with perspectives of human action, structure, and institutional frameworks is bound to provide a highly nuanced level of understanding of the transformation power of blockchain technology.

The choice to focus on India as the main setting for this investigation was far from random; rather, through this choice, this investigation made a deliberate effort that was theoretically sound. This positioning of this investigation's scope is far from exemplifying any shortcomings on this scope's boundaries; on the contrary, this positioning shows this investigation's thorough effort to guarantee that this investigation's scope is relevant and significant to its overall broader scope. India is a new emerging market that possesses a unique characteristic, and this emerging market is actually among the most rapidly growing across the globe. India possesses a perfect setting for this investigation to determine the behavioral-psychological foundation of the adoption of blockchain technology. These reasons include India's percentage of institutional trust, lack of regulatory clarity, and fragmented supply chain. India, as opposed to the investigation made by Wong et al. [43], differs from Malaysia's SMEs, as this country's supply chain is

actually most identifiable through its informality, along with its lack of strong enforcement power. This investigation shows the importance of technology readiness factors, such as optimism, innovativeness, discomfort, and insecurity, to forecast the development of this investigation's scope.

In a related manner, the study by [34] looked into the role of blockchain technology for fully developed wine supply chain networks, known for long-term relational trust. That being said, the setting of India is marked by a lack of such trust. Under these conditions, the role of blockchain technology is less about the expansion of existing trust and far more about it lack. Under such a situation, the transformation ability related to trust, traceability, and, of course, blockchain technology is, without a doubt, of a deeply profound nature. The Indian case, thus, essentially works to strengthen the ability to generalize theoretically, whereby the Sustainable Blockchain Adoption Intention is analysed for a setting that is plagued by institutional turmoil, a lack of trust, and a good deal of regulatory uncertainty.

CONCLUSION

This research offers a novel methodological approach to the evaluation of technological sustainability, paying special attention to the concepts of readiness, trust, and preparedness. It points to a way forward for future research, making possible a broader investigation of the relationships between technology, sustainability, and transition. Strategic implications of this research emphasize the need to incorporate human-related issues into technological innovation development and deployment. Encouraging a state of preparedness calls for innovative mind-sets and the promotion of optimistic perspectives, which can be accomplished by the elimination of human-related barriers. Therefore, the implementation of leadership, design, and communication practices proves to be crucial, as trust-building is applied. It can thus be concluded that blockchain technologies must be recognized as enabling platforms that improve credibility, accountability, and value-related enhancements through collaborative activities. In terms of policies, this evaluation supports activities that seek to build a culture of preparedness and compatibility for blockchain. The fulfilment of this goal requires educational and training activities, combined with innovation that is relevant to data standards. This is creating a situation that is promoting the rapid adoption of technology, making it easier to achieve other goals that can be linked to the deployment of blockchain, such as sustainability and eco-sustainability.

Overall, the findings of this study tend to confirm that the transformation capabilities of the blockchain technology for supply chain management processes are not merely a result of its technical structure. It is vital to take into consideration the adoption readiness of the users, be it individuals or companies, from a psychosocial aspect.

To the best of the authors' knowledge, the present study is the first empirical investigation that examines the full mediation chain from Technology Readiness to Trust to Traceability to Sustainable Blockchain Adoption Intention, explaining 57% of the

variance. This is one of the highest explanatory values found within the existing literature on blockchain supply chain research.

AUTHOR CONTRIBUTIONS

Conceptualization, A.G; Methodology, A.G.& RS.R.; Validation, J.K.&A. G; Investigation, RS. R; Resources, A.G.& RS.R.; Data Curation, N.K; Writing – Original Draft Preparation, A.G., RS.R & N.K; Writing –Review & Editing, J.K; Supervision, N.K.

CONFLICT OF INTERESTS

We, the authors of the present paper, hereby declare that there are no conflicts of interest related to the subject matter, materials, or methods used in this publication

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