BLOCKCHAIN-BASED SOLUTIONS FOR HUMANITARIAN SUPPLY CHAIN MANAGEMENT

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Abstract

The outbreak of the novel COVID-19 demonstrates how pandemics disturb supply chains (SC) all across the world. Policymakers and private-sector partners are increasingly acknowledging that we cannot tackle today's issues without leveraging the promise of new technology. Blockchain technology is increasingly being adopted to help humanitarian efforts in various fields. This paper presents conceptual research designed to assess how Blockchain distributed ledger technology can be leveraged to enhance humanitarian supply chain management (HSCM). This paper fills the present research gap on the Blockchain's potential implications for HSCM by proposing a framework built on the foundations of five prominent institutional economic theories: social exchange theory, principal-agent theory, transaction cost theory, resource-based view, and network theory. These theories could be utilized to generate research topics that are theory-based and industry-relevant. This conceptual framework assists institutions in making decisions about how to recover and rebuild their SC during disasters.

Keywords

Blockchain, Supply Chain, Humanitarian Supply Chain Management, Conceptual Framework.

Introduction

Scholars and industry experts have expressed interest in the novel COVID-19's effects on supply chain management. According to Lin et al. (2020), the COVID-19 pandemic has substantially impacted supply chain management and operations. Around 94 percent of Fortune 1000 businesses reported that they experience supply chain delays due to coronavirus. In their report, Deloitte (2020) stated that the pandemic's overall impact on supply chains was yet unknown. We have learned a lot about supply chains from prior epidemics. The necessity of reengineering and adapting SCs to future trade problems for enterprises and organizations was emphasized by the World Economic Forum (2020). For example, short-term priorities would include "transport and production" and "worker movement," while long-term priorities would include developing and implementing facilities and tactics linked to "digital readiness" and "data sharing" for supply chains.

According to Kovacs and Spens (2009), during disasters, either natural (flooding, drought, earthquakes) or man-made (civil war, internal conflicts), SCs are essential components of humanitarian reaction and operations. Humanitarian supply chains seek to allocate and deliver the proper number of goods to the relevant demand locations quickly. According to Mentzer, et al. (2001), the humanitarian supply chain is the network formed by the movement of goods, services, supplies, data, and finances between different stakeholders (donors, beneficiaries, providers, and other humanitarian organizations) to deliver help to recipients. Humanitarian supply chains have more roles and duties than humanitarian logistics (Howden, 2009), including (1) donor relationship management, (2) necessary supply planning, (3) demand forecasting and evaluation, and (4) monitoring, and analyzing the effect of dispersed goods.

Blockchain technologies (BT) are being hailed as game-changing technology that will revolutionize the logistics and supply chain management industries. Supply chain processes are expected to be transformed by BT, which will significantly improve traceability, transparency, visibility, and trust (Pournader et al., 2020). When paired with technical advancements like the internet of things, radio-frequency identification, and data analytics, resilience becomes a reality (Min, 2019).

One of the most crucial tasks in HSCM is to recognize the relevant obstacles. The aim of this paper is to discuss the potential implications of BT for HSCM by proposing a framework based on five well-known institutional economic theories. This paper includes a mixture of focus between a conceptual model and an extensive literature review. The primary advantage of BT is distributed trust. Thus, BT can potentially replace traditional trust-building institutions such as banks and insurance companies.

Conceptual Framework for Supply Chain Management

We analyze the framework of BT-based humanitarian supply chain management based on five well known institutional economics theories, namely (1) Social Exchange Theory (SET), (2) Principal-Agent Theory (PAT), (3) Transaction Cost Analysis (TCA), which is also known as Transaction Cost Theory, (4) Resource-Based View (RBV), and (5) Network Theory (NT). These theories could be used to investigate BT's ramifications (Halldorsson, et al., 2007). From the standpoint of new institutional economics, integrating these five theories permits the simultaneous examination of structural and managerial factors. This framework enables the development of intermediate-range hypotheses and assertions that may be empirically evaluated later and preliminary knowledge of the "inner workings inside important connections" (Stank, et al., 2017). As a result, scholars will be able to investigate the BT phenomenon and its potential implications from several theoretical viewpoints. Figure 1 highlights how the Blockchain's characteristics may be included in the five hypotheses (Treiblmaier, 2018).

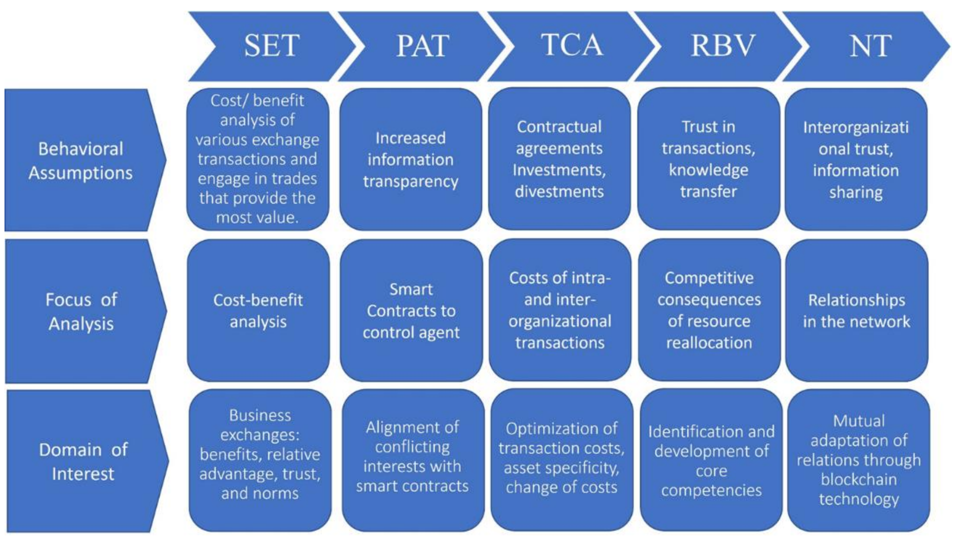

Figure 1. Blockchain-Based SCM Theoretical Framework

According to previous studies, the logistics field could take advantage of adopting theories from other disciplines (Stock, 1997). We expand on Halldorsson, et al.'s (2007) theoretical framework, which examines and integrates four prominent ideas that are frequently utilized in social science and economic research. They resolve issues about organizing and managing a supply chain from both an institutional and socioeconomic standpoint. Following studies have proven that these ideas and modifications of them have been successfully implemented in a wide range of supply chain management situations (Swanson, et al., 2017). They have been effectively utilized to define, explain, and forecast changes in supply chain management induced by disruptive technology.

The framework for integrating commercial organizations and exploiting their resources in emergency operations was conceptualized using Social Exchange Theory (SET), which illuminated the dynamics behind the formation of exchange relations among businesses. It is a significant social interaction theory that has its origins in sociology as well as early theorists' work like Homans (1958) and Blau (1964). Stakeholders assess the relative costs and advantages of several exchange transactions in particular and participate in transactions that maximize value (Homans, 1958). SET also considers the importance of rules and standards in relationships and how mutual trust develops over time. Lambe, et al. (2001) used the critical research articles on SET to identify and corroborate the following fundamental premises: (1) benefits, (2) relative advantage, (3) trust, and (4) norms that apply to individual/ corporate exchanges.

Within Principal-Agent Theory (PAT), the entirety of the principal's monitoring charges, the agent's bonding fees, and residual loss is referred to as agency costs (Jensen and Meckling, 1976). They arise when the principal wishes to monitor, oversee, and manage the agent for the latter to act in the principal's best interests. Because the principal has limited knowledge about the agent's actions, he or she must rely on the agent to some level. Fayezi, et al. (2012) found 86 SCM-related papers that dealt with agency theory and principal-agent interactions, 19 of which they investigated more closely. The principal's biggest problem is finding the proper agent and forming a trusting relationship with them. Prior principal-agent studies on SCM have looked at topics like Sarbanes-Oxley impact on OBS supply chain activities, enhancements in performance, price competition, the uncertainty of demand, quality control in the supply chain, and buyer-supplier interactions; there is a chance that quality will deteriorate, and lowering the supply risk.

Various governance systems, including markets or hierarchies, may arise contingent upon the market transaction costs (Strebinger and Treiblmaier, 2006). TCA offers a solid theoretical foundation for supply chain management, and measuring tools, recommendations, and research proposals have been established to look into issues such as outsourcing vs. purchasing, investment allocation, coordination, integration, and dissemination of the supply chain (Grover and Malhotra, 2003). TCA is applied in SCM, for example, in the context of sharing information, environmental practices used by suppliers, portfolio management in purchasing, the efficacy of relational and contractual governance in terms of performance, and risk perception in transactions.

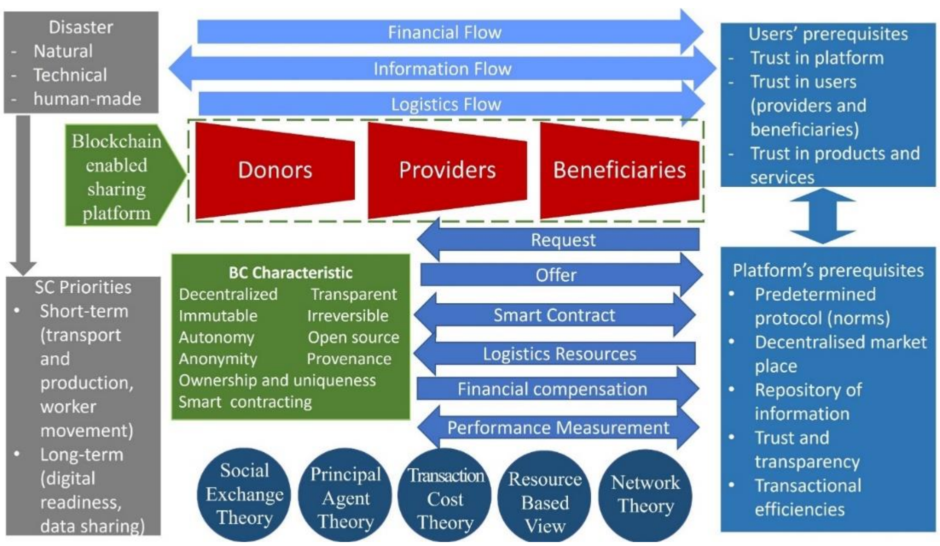

Figure 2. A Blockchain-Enabled Conceptual Framework for Resources Sharing

The Resource-Based View (RBV) arose as a reaction to the positioning school that stressed the significance of strategy for a specific company (Porter, 1980). The RBV, on the other hand, claims that a tiny fraction of a company's resources gives it a competitive advantage, and an even smaller subset gives a greater long-term performance. Limited resources create a competitive advantage that can last as long as the firm can preserve its resources and no alternatives arise (Barney, 1991). According to Halldorsson, et al. (2007), only a few papers in the area of supply chain management have used the resource-based view (RBV). However, an increasing number of studies have shown that this theory, as well as closely related ideas like the resource-advantage theory, might be beneficial in supply chain management research (Hunt and Davis, 2008). Recent supply chain management studies have looked into the influence of a company's resources and skills on logistics performance, as well as the function of market knowledge in providing transportation providers with an informational advantage, inter-organizational learning, closed-loop supply chain designs, and supply chain information integration antecedents, have all been studied.

Network Theory (NT) concentrates on the human relationships among the groups. Mutual trust is established via cooperative relationships and exchange procedures to better understand the dynamics of inter-organizational relations (Halldorsson, et al., 2007). Companies must build partnerships to obtain access to external resources. This results in stable and evolving networks on a broader scale. Exchange processes and adaptation processes are two types of interactions that aid in the establishment of permanent linkages within a network of businesses, forming manufacturing joint ventures, Antecedents of network centrality in an environmental supply chain management project, the operation of strategic partnerships and networks, and in the software business, there are two types of companies: networked and non-networked (Wichmann, et al., 2015). Figure 2 shows a blockchain-enabled sharing platform that allows consumers and suppliers of logistical services to connect and trade directly.

Humanitarian Supply Chain Management

There is a pressing urge to create more effective, efficient, and durable methods to surmount HSCM hurdles that will eventually improve humanitarian supply chain performance. In comparison to the faster application prospects in commercial supply chains, BT technology is slowly being adopted by humanitarian relief organizations throughout the world (UN agencies are included). According to Riani (2018), the BT has the potential to be utilized in humanitarian activities for information management, assistance coordination, supply chain tracking, cash-transfer programming, and increasing humanitarian finance. He claimed that BT technology could help overcome current hurdles in humanitarian relief, such as transparency and accountability. In the HSCM environment, there are currently just a few BT applications.

There are some examples of BT systems being used in humanitarian operations, such as the World Food Programme (WFP) for financial transfers to beneficiaries (World Food Programme, 2018). In addition, the Start Network (2016) as a private BT among 42 non-governmental organizations that use Bitcoin as a multi-signature e-wallet for contributions and insurance (Helperbit), in Nepal (Sikka), digital assets are used in the humanitarian supply chain, and Kenya (IFRC–KRCS), a multi-chain audit database is used to ensure cryptographically secure transactions (Coppi and Fast, 2019).

BT technology has been employed by the Building Blocks Project of the World Food Program to make money transactions to beneficiaries via vouchers that are efficient, transparent, and secure, as well as to increase cooperation within the humanitarian supply chain (World Food Programme, 2018). To aid Syrian Civil War refugees, the initiative employs Ethereum-based BT technology. Ten thousand individuals in Jordan's Azraq refugee camp receive food based on claims documented on a BT-based computer network. To buy items from local businesses in the camp, refugees utilize an eye scan instead of cash, coupons, or e-cards. (World Food Programme, 2017). This pilot study has provided helpful information for potential benefits to humanitarian supply chains. It could improve humanitarian agility and reactivity, which is a critical success element in dangerous settings (Oloruntoba and Gray, 2006).

Another example is the BT Open-Loop Payments Pilot Project launched by the International Federation of Red Cross, Red Crescent Societies, and the Kenya Red Cross. The project aims to assess how BT technology could improve the transparency and accountability of cash transactions programs by introducing independent digital identities (Coppi and Fast, 2019). Moreover, Stathakis (2019) highlighted the critical viewpoints on whether BT implementation might improve transparency and equality in humanitarian initiatives and if these technologies can protect beneficiaries' privacy.

For example, UNICEF and the World Food Programme are keenly interested in such prospects, particularly in terms of digital identity and financial transactions (Zwitter and Boisse-Despiaux, 2018). In terms of real-world applications, BT technology is being utilized to track assistance funds to combat corruption (Kenny, 2017) by creating secure digital identities (Kewell, et al., 2017), digital vouchers (Gorey, 2016), and smart contracts that are automated (Verhulst, 2018).

The BT has been used to combat poverty and provide fairer and speedier payments to small-scale producers in the food and beverage business. Even though 80 percent of the world's coffee is grown by 25 million smallholder growers, many of them struggle to make a livelihood from it (Fairtrade.org, 2018). Moyee Coffee and the FairChain Foundation established a pilot initiative in Ethiopia to offer all stakeholders (including growers, roasters, and customers) access to data (including pricing) across the entire supply chain. This resulted in a significant shift in the conventional coffee supply chain. However, it also had significant social value: it provided opportunities for small businesses and addressed the imbalance of power between small growers and major wholesalers. This allowed for a more equitable allocation of value across the supply chain and hence contributed to poverty alleviation.

The movement of in-kind aid to afflicted regions, the information and data flows for order transmission, control, and the unilateral transfer of funds from donors to organizations are all examples of humanitarian distribution routes (Charles, et al. 2016). These three flows, which are described as logistical, information, and financial flows, are critical for every supply chain (Wang, et al. 2019). According to Rodrguez-Espndola, et al. (2018), Figure 2 illustrates these movements in a traditional humanitarian supply chain, starting with financial and logistical flows from specific donors and ending with the resources being transferred to the recipients. Simultaneously, data is created in-demand regions and sent to stakeholders, including donors. Decision-makers have traditionally vetted information before it is distributed through mass communication channels. With the introduction of social media, this dynamic is shifting since it eliminates mediators in information management and allows information to be shared through a variety of channels.

Figure 3. Humanitarian Supply Chain Management Barriers

One of the most crucial tasks in humanitarian supply chain management is recognizing the relevant obstacles. As a result, we thoroughly assessed the pertinent literature and developed a complete barrier set. Then we compared the degree of relevance to the BT and the benefits to the BT. Barriers could be classified into four major groupings based on their qualities as follows: (1) organizational barriers, (2) inter-organizational barriers, (3) barriers to donors and beneficiaries, and (4) regulatory barriers, as shown in figure 3.

Blockchain-Enabled Supply Chain Management

Supply chains have learned a great deal about how to operate in accordance with nature and social goals (sustainability). In addition, ways to make themselves more resilient in the face of severe natural or man-made calamities. Furthermore, the process of recovery and management of the repercussions of their lean, responsive, and globally integrated structural designs (Dolgui, et al., 2020). Moreover, how to make use of the benefits of digital technology in supply chain management.

Several studies have previously recommended BT for use in managing a sustainable SC (Saberi, et al., 2018a, b). However, before employing any technology, it is necessary to fully grasp the technology to embrace it. The database in use, the types of partnerships, access control, and transaction types, all have a role in determining which form of BT to employ. Table 1 shows the properties of BT that distinguish it from other technologies and make it attractive for future industrial applications.

Characteristic	Description
Decentralized	Multiple systems could access, monitor, store, and update the data on the system.
Transparent	Data is captured and kept on the network with network consensus, and it is accessible and traceable during its entire life cycle.

Immutable	To provide immutability, BT offers timestamps and restrictions.
Irreversible	Each BT keeps a precise and verifiable record of every transaction ever made.
Autonomy	Each BT node has the ability to safely access, send, store, as well as update data without the need for a third party.
Open-source	With a notion of hierarchy, BT gives everyone in the network open-source access.
Anonymity	As data is sent across nodes, the individual's identity stays hidden.
Ownership and uniqueness	Every document transferred on the BT has a unique hash code that tracks who owns it.
Provenance	Every product has a BT-based digital record document that verifies its validity and provenance.
Smart contracting	It is a little automated software that assists with contract execution. It does away with the need for a typical contract while also increasing security and decreasing transaction costs. Rules, penalties, and actions are frequently incorporated into smart contracts and applied to all parties involved in the transaction. Smart contracting enables supply chain operations to respond quickly.

Table 1. Characteristics of Blockchain

A two-step block building approach employing distributed technology, in which block reservation and data production are split into two phases, can boost blockchain deployment and interaction with SCs even further (Gao, et al., 2017). This technique will aid in the reduction of latency, scalability, and interoperability when "adding a new block." It also offers distributed ledgers with suitable access controls. Blockchain and the Internet of Things (IoT) may be used to create instrumented, networked, and intelligent SCs. As an example, specialists worldwide have formed consortiums like Central Baltic Sea Region (CBSR) to use Blockchain to supply chains (Gromovs and Lammi, 2018). Table 2 summarizes how blockchain technology is being used in major SC functions.

SC functional aspects	Details
Resilience	• Reduces the effect of interruptions by using "preventive and proactive" risk management methods and offering multi-layer SC network security. • The Blockchain's hierarchical architecture aids in the capturing of both organizational and network hazards.
Provenance	• Assists in determining the granular origin of physical items that are manufactured and delivered in complex, inter-organizational, or globally spanning SCs. • Provides product information with certifiability, traceability, verifiability, and tractability.
Reengineering	• SC is more transparent and visible, and process automation is possible. • Traceability, privacy, and data management approaches eliminate middlemen and enable real-time tracking.
Security enhancement	• Authentication, secrecy, privacy, and access control of data, as well as service integrity assurance • When used with IoT and RFID, Blockchain improves security, consensus mechanism for dynamic data storage, transparency and data protection, dependability, and cost control.
Business process management	• Smart contracting allows for effective business process management by combining inter-organizational business activities' control flow and business logic. • They are effectively utilized for asset management and customer-order-process management, resulting in increased order efficiency, traceability, and visibility.
Product management	• Its interaction with SCs improves cycle time, productivity, and quality while also allowing for product differentiation. • In end-to-end SCs, it aids in product deletion and pricing tracking during product distribution.

Table 2. Blockchain-Enabled SC Functions

The current literature on Blockchain revealed a variety of possible benefits and advantages of this technology, which might have a significant influence on HSCM. Table 3 lists the names and extensive explanations of Blockchain's possible advantages.

Potential attribute	Description
Auditability	• Data verification which refers to data accountability and provenance tracking is ensured by blockchain technology.
Processing speed	• The time it takes to produce the next block of transactions in a chain is known as network latency. • Blockchain technology deals with supply chain transactions and improves transaction speed. • Automatic communications created by smart contracts help to speed up transactions.
Traceability	• Blockchain technology makes decentralized, visibility, traceability, and authenticity possible. • All transactions on the Blockchain may be viewed by the general public.
Trust	• Blockchain technology allows network members to see their transfer possibilities. • As a result, trust is dispersed among these members, who securely authenticate transactions using blockchain infrastructure's mathematical procedures. • To put it another way, trust facilitates verification through a set of protocols.
Security	• Since data is saved as blockchain transactions, blockchain technology provides a high level of security. • It can manage all data supply as transactions, with smart contracts validating the data.
Disintermediation	• In contrast to traditional centralized procedures, which require humans or extra technology to provide confidence, blockchain technology eliminates the need for middlemen or third parties inside the blockchain process. • Intermediaries, or at least their existing duties, may become obsolete as a result of blockchain technology.
Immutability	• Being an essential feature of a blockchain system. • Immutability reduces the requirement for reconciliations by giving a reconciled historical version of the truth. • It also means that editing a chain entry would be difficult.
Transparency	• Members of the network benefit from the transparency provided by blockchain technology. • Transparency is necessary for enhancing transaction traceability as well as guaranteeing transaction validity and legality. • Every network member has access to all transaction and activity records.
Automation	• The Blockchain's operating mechanism necessitates automatic interactions between network participants. • One of the most significant benefits of a blockchain system is the automation of manual procedures. • This automation covers smart contract transactions in particular.

Table 3. Potential Attributes of Blockchain

For example, disintermediation is of value to HSCM since it prevents self-serving intermediaries who siphon off products from the supply chain. In a similar vein, traceability is an important feature of BT in HSCM since it empowers charitable contributors to monitor their humanitarian shipments. This fosters personal connection, as opposed to a commoditized shipment where the personal identity of the contents is unknown. More importantly, it enables auditability of goods and services in an HSCM.

Bai and Sarkis (2014) propose a performance metrics framework based on supply chain transparency and technological features that analyses how blockchain technology might assist supply chains in meeting key objectives. Table 4 shows the performance and choice criteria for blockchain technology, with many of the qualities fitting into a Technical, Organizational, and Environmental (TOE) framework. These variables include a variety of sustainable supply chain transparency (organizational and environmental contexts) and technical features (technology contexts) aspects that should be taken into account when evaluating inter-organizational blockchain technologies.

Categories	Attributes	Overview
Sustainable supply chain transparency	Participation degree	It is a measure of all stakeholders in the supply chain's capacity to participate.
	Scope of operation, environment, and social information	It's a metric that shows how open organizations are in sharing all necessary information with other participants.
	Tracking product components	It's a metric for tracing and tracking the sources of a product.
	Tracking product process	It is a measure of product process traceability and recording, as well as freight route traceability and recording.
	Tracking product sustainable information	It's an indicator of a product's long-term information traceability and recordkeeping.
	Participant operations and situations information	It's a metric for the traceability and documentation of participant-handling activities and circumstances.
	Participant sustainability conditions	It is a metric for participant traceability and tracking of sustainable activities and circumstances.
Technical characteristics	Cost	It's a metric measuring the potential expenses (direct and indirect) of using blockchain technology.
	Time	It is a measure of how long it will take to implement blockchain technology.
	Adaptability	It is a metric for the supply chain's connection with outdated systems.
	Neutrality and interoperability	It is a metric for the platform that is independent of the blockchain technology's design.
	Throughput capacity	It refers to the maximum number of transaction submissions per second that each node and the entire network can handle.
	Scalability	It is a measure of how system performance has changed as a result of an increase in the number of nodes, transactions, users, and geographic dispersion.
	Security	It's a metric for blockchain data that can't be forged or forgotten.
	Reliability	It's a metric for the flaws in the blockchain system.
	Complexity	It's a metric for how difficult blockchain technology is to build, maintain, and operate.
	Partner support	It's a metric for how well supply chain partners, including customers, assist one other.

Table 4. Overview of The Performance and Decision Criteria for Blockchain Technologies

Conclusions, limitations and further research

Donors and government agencies in the humanitarian sector are increasingly requesting the development of blockchain-enabled swift-trust and improved collaboration between diverse humanitarian stakeholders to increase the openness and traceability of disaster relief goods, information sharing, and fund flow in disaster relief supply chains. This paper presents a conceptual framework using five institutional economic theories.

The coverage of behavioral assumptions from the unique perspective of blockchains would improve supply chain management transparency and trust in HSCM. For example, price/value discovery under SET (using reliable, immutable data) and transparency without violating privacy for PAT. For the Resilience SC function, HSCM usually operates under conditions of poor network connectivity or interruptions in power (through lack of utility infrastructure), more so than the normal SCM. BT's resilience through distributed architecture is of great value in such cases. There is a danger of sub-standard or close-to-expiry products being earmarked for humanitarian efforts for the Provenance SC function. For humanitarian reasons, this would be morally unacceptable. BT is uniquely suited to establish provenance to ensure high-quality products are delivered through HSCM.

The limitation of this paper is little empirical research and case studies. Further research is required to better comprehend, forecast, and, if necessary, create blockchain solutions that assist HSCM. To get a better knowledge and identify the most relevant difficulties for HSCM, many methodological techniques, such as generalizable empirical investigations, can be applied. Strong collaboration between academics and practitioners will generate the most satisfactory outcomes for mutual benefit in this contemporary study field.

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