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Research Article

Blockchains in Sustainable Supply Chains – A Conceptual Framework Based on Triple Bottom Line Approach

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Abstract

Supply chain sustainability has become a topic of interest for researchers in the last few years. The COVID 19 pandemic has shone the spotlight on the need to inculcate sustainability in supply chains. Blockchain is a new technology that allows each player in a supply chain to communicate authenticated data without the need for a trusted central entity to act as a middleman. Blockchain can bring significant benefits to sustainable supply chains such as traceability and tracking, reducing stages and transaction times, disintermediation, better control over outsourced manufacturing and better supply chain visibility. However, very few studies have been done to analyze if the benefits of blockchain in supply chain do indeed outweigh the challenges in implementation .The present study conducts a thorough review of the available literature on the topic and proposes a conceptual framework of blockchain in supply chains, detailing the impact of this technology on social, economic and environmental performance and sustainability, otherwise known as the Triple Bottom Line (TBL).The study reveals that research into blockchains are showing an increasing trend and blockchains have significant impact on social, economic and environmental performance

Keywords: Blockchain, Sustainability, Supply Chain, Triple Bottom Line

1. Introduction

In the last five years, there has been a lot of interest in using new technology to boost supply chain sustainability. Blockchain is one such technology that has piqued the interest of practitioners and researchers around the world due to its unique features. Satoshi Nakamoto created blockchain technology in 2008 to solve the issue of transacting coins. Bitcoin (Crosby et al., 2016) was the first blockchain network, which allowed users to exchange money using a particular consensus mechanism. Several other technological platforms followed, including Ethereum (Wood, 2014), which enables the use of smart contracts, or tools that automatically activate when an exchange occurs—and Hyperledger, created by IBM (Groenfeldt,2017). According to a recent World Economic Forum study, about 10% of GDP generated will be stored on platforms like blockchain and other related technologies by 2025. Over the period of 2021 to 2026, the Blockchain Supply Chain Market is projected to expand at a CAGR of 81.7 percent (Deloitte ,2020). Important growth drivers for the market include an increasing appetite for supply chain transparency and an

increase in the security of supply chain transactions. Increased automation and the elimination of intermediaries in supply chain management with blockchain will open up opportunities for business development. According to a 2019 Kenco Group study, 40% of supply chain executives intend to invest in blockchain technologies. According to the same study, 46% of respondents plan to invest in sensors and the Internet of Things (IoT).As per the same source, in 2019, supply chain leaders show a greater willingness to take a risk on new technologies, as 46% of respondents say they are willing to spend 10-24% more on innovation, up from 24% in 2018 and 29% in 2017. Due to its multiple advantages, forward-thinking companies are planning to invest when blockchain gets to the point that it can deliver value.

Blockchain can improve supply chain transparency by checking and adding data in real time. A blockchain is a ledger of transactions that is distributed among users, and it maintains a continuously increasing list of transaction records known as blocks, each of which contains a connection to the block previous to it. Every block is a set of records of transactions between each party involved in a financial exchange, or, in as in supply chains, the records of every stakeholder in the chain from suppliers to retailers. At each point of the journey, a new permanent block of information is formed, which can only be read and cannot be changed. After being checked by all supply chain members, each block is attached to the chain. Thus, It's an open record of transactions that is distributed among members and that records information about transactions between two parties in a manner that can be verified and is permanent in nature. The decentralized agreement of a blockchain makes it ideal for the monitoring of business transactions, identity management, incidents, management practices, and medical records. Blockchain does, in reality, alter the way transactions and data are handled. It is possible to ensure greater precision, supervision, protection, and immediate sharing in this manner (Ivanov,Dolgui & Sokolov,2019). Apart from banking, block chains have the ability to revolutionize a variety of sectors, including energy (Li et al., 2019), real estate, tourism, smart cities, e-voting, medical, manufacturing, and supply chain. Distributed ledgers are becoming more widely associated with supply chain systems to address a variety of knowledge sharing issues (Saleem, 2020). Blockchain technology today is one of the most common and innovative ways to distribute financial transactions (ledger) for members of a supply chain. Blockchain can easily integrate quite seamlessly with other new technological innovations such as artificial intelligence (AI), the Internet of Things (IoT) and smart contracts (Sharma, Kamble, Gunasekaran, Kumar & Kumar, 2020). That is why blockchain technology is considered a crucial part of Industry 4.0 along with other innovations including the Internet of Things (IoT) and Big Data etc.

Several research studies on the effect of blockchain on supply chain management (SCM) activities have been performed, but only a handful have concentrated on the impact of blockchains on supply chain sustainability (Treiblmaier, 2019;Wang, 2018). The binomial blockchain and supply chain have received a lot of attention in the literature but there is very little literature on the sustainability aspect. Indeed, today's new technologies are judged on their ability to innovate and perform well in the marketplace. However, in addition to business results, a sustainability assessment will be needed. As a result, scientists and businesses are trying to assess the utility and efficacy of blockchain adoption in supply chains (Pournader et al., 2020). To enhance the understanding of the current research in the topic, this study addresses two research questions: What is the impact of blockchain on supply chain sustainability and how can triple bottom line blockchain affect supply chains. In this paper, an attempt is made to examine the effect of blockchain on supply chain economic, social, and environmental efficiency through a systematic literature review of research papers on blockchain technology in supply chains and a conceptual framework for integrating the triple bottom line block chain into the supply chain is proposed. These three factors are the pillars of supply chain sustainability and are referred to as the Triple Bottom Line (TBL). Thus, this research aims to add a new dimension to the evaluation of this distributed ledger's adoption, primarily its effect on sustainability and, more specifically, the incorporation of block chain technology into the triple bottom line of supply chain sustainability.

2. Theoretical Background

2.1 BlockChain Technology

Blockchain began as a technology to enable financial transactions, but it has evolved into a modern paradigm of information and data sharing that is critical in a variety of fields (Cammerano, Michelino, Lamberti & Caputo, 2020). As a result, there has been an increase in interest in a variety of industries, including supply chains. One of the most compelling reasons to use blockchain in supply chains is its potential to provide a stable and continuously updated distributed ledger for product tracking (Lezoche et al., 2020). In order to implement unique information, blockchain monitors access and automatically intercepts false and incorrect data thanks to its consensus mechanism (Kamble, Gunasekaran & Arha, 2019). In the one hand, this ensures the final consumer's authentication and certification of an asset; on the other, it removes the need for intermediaries and the process of verification becomes automated (Choi, 2019). Smart contracts, which are computer programs that can automatically perform, monitor, or register legally valid actions or activities according to the terms of a contract, are another important aspect of this technology. Furthermore, since blockchain is an immutable registry that can be checked in real time by anyone, it ensures customer confidence. Immutability, openness, programmability, decentralization, consensus, and distributed confidence are all characteristics of blockchain that raise high standards in logistics and supply chain management (Pournader et al., 2020).Payments and integrated financial transaction records, management of records, tracing and tracking of transactions and even value-added manufacturing are all possible use cases. The blockchain, which is particularly interesting for SCM applications, allows for asset transfers without the use of intermediaries, increasing end-to-end visibility and speed along the supply chain (Treiblmaier, 2019). The blockchain can be used to mitigate risks associated with SCM, such as output quantity volatility, lack of accountability when a producer switches suppliers, unethical middleman actions, and complicated inventory management (Nikolakis, John & Krishnan, 2018). However, there are many possible risks associated with blockchain implementation, including enhanced transparency, the immutability of stored data, the need for widespread acceptance and standardization, and the possibility of a single powerful entity rewriting transaction history (Sissman & Sharma , 2018).

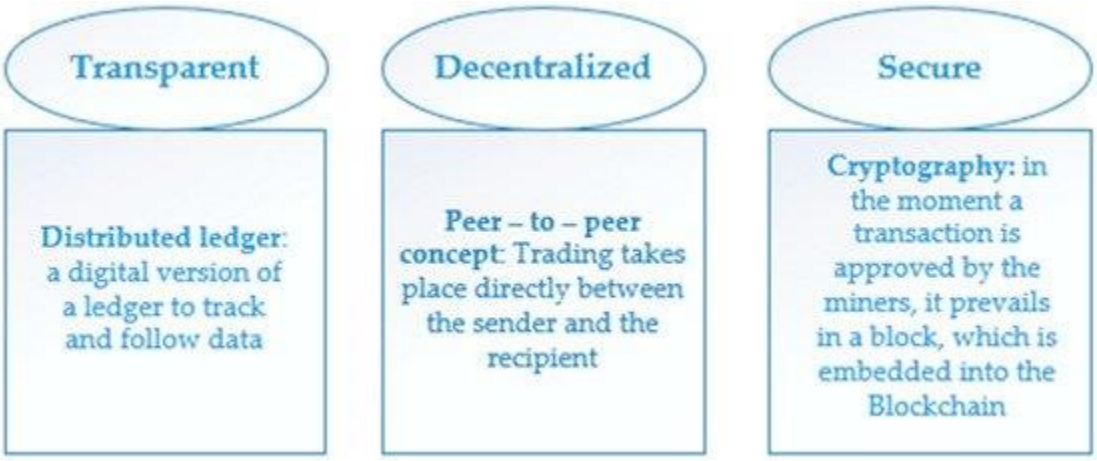

Fig 1.Benefits and Key Characteristics of Blockchain Technology (Edvard et al, 2019)

2.2 Blockchain in Sustainable Supply Chains

Blockchain is a technology that allows each player in a supply chain to communicate authenticated data without the need for a trusted central entity to act as a middleman. Blockchain can improve supply chain transparency by checking and adding data in real time. Blockchains have the potential to have a major effect on supply chain sustainability. Blockchain offers a number of advantages that no other technology has previously been able to provide to the business community. Since it is a shared database, data is easily accessible to all parties involved in the transaction, ensuring complete accountability. Data's immutability also increases its trustworthiness. As a result, once the data has been generated, it cannot be changed or erased. Every party to a transaction would be aware that it will be carried out according to the protocol that has been agreed upon. Data that is readily accessible and trustworthy often eliminates the need for a third-party intermediary. By reducing the overhead costs of transferring assets and the presence of third-

party intermediaries, blockchains have the ability to reduce total transaction cost and time. Since blockchain eliminates risks like multiple sale of invoices, the cost of invoice factoring, or funding of invoices, can be reduced by as much as 25%. Both parties to a transaction will have access to the reliable, timely, consistent, and complete information they need to make an informed decision. Less time can be spent validating data and more can be spent on delivering goods and services—either improving quality, reducing cost, or both. Blockchains can help businesses can improve their supply chain management through more transparent and accurate end-to-end tracking of goods. It is possible to track the asset from production to delivery or use by the end user and provide greater product history and transparency. This provides more visibility to both businesses and consumers into the products they consume. The transparency and visibility of the product generates trust in the consumer (Montecchi, Plangger & Etter,2019).

In sum, the key applications of blockchain in supply chains are as follows:

- To better inform R&D material selection and allow closed-loop design by gaining greater access to source material data.
- Increase opportunities for suppliers and consumers to collaborate on planning and forecasting, lowering forecast and inventory risks.
- Eliminate the need for intermediaries and improve the certification system.
- Due to its control mechanism, it is able to immediately detect fraudulent and incorrect data.
- Enables tracking of product from supplier to end user.
- Reduce sourcing and operating costs by replacing paper-based processes with smart contracts and blockchain-based transactions.
- Increase visibility and compliance of outsourced manufacturing.
- Provide a clear picture of all product phases in the supply chain path to regulators and end customers.

Since blockchains have numerous advantages for supply chains, many industries, including manufacturing, tourism, retail, pharmaceuticals, and agriculture, are incorporating the technology into their supply chains. Improved visibility, transparency, the elimination of defects, and quicker response to supply chain problems are just a few of the advantages that blockchain technology brings to Supply Chain Management (SCM) (Paliwal,Chandra & Sharma,2020).

3. Methodology

In order to answer a clearly articulated question, a systematic literature review (SLR) recognizes, selects, and critically appraises research (Dewey, A. & Drahota, A. 2016). Before the systematic review is undertaken, the requirements should be explicitly outlined in a clearly specified protocol or strategy. It's a straightforward, systematic search that spans many databases and grey literature and can be reproduced by other researchers. It entails devising a well-thought-out search strategy that focuses on a particular topic or addresses a specific query. Under known timeframes, the analysis defines the type of information searched, critiqued, and published. This study followed the systematic literature review methodology outlined by Booth et al. (2012).

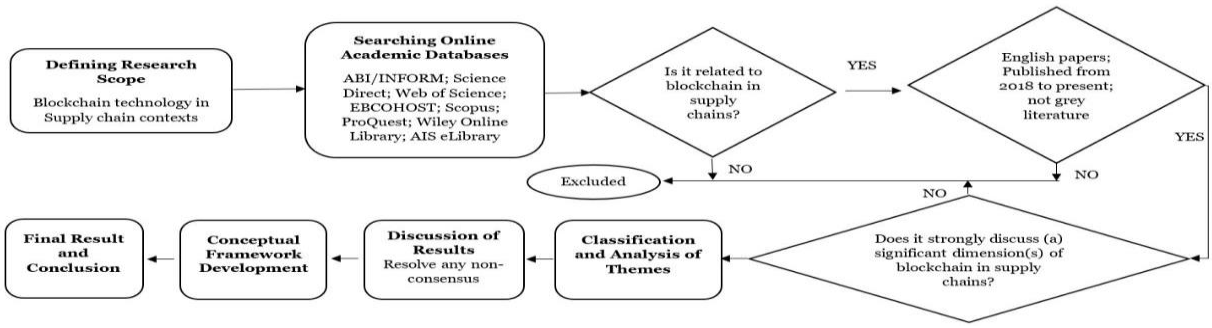

Fig 2. Systematic Literature Review Methodological Framework (adapted from Booth et al, 2012)

The methodology was divided into the following operational steps:

1. A first search string using the terms “Blockchain “ AND “ Supply Chain ” was used to search the Scopus and Web of Science databases to clarify the use of blockchain technology in term of supply chain sustainability. The search yielded 82 results.
2. The papers were examined and classified by author, title, journal, year of publication, topic, objectives, data collection and analysis method, key findings and implications. Any title not appearing to discuss blockchains in sustainable supply chains was excluded. Papers not in English were also excluded.
3. A second search sting using the terms “Blockchain” AND “Supply Chain” AND “Sustainability” was used to search the Scopus and Web of Science databases to identify articles on blockchain on sustainable supply chains. The search identified 36 articles.
4. Using this selection, the papers were analyzed using thematic analysis, resulting in a set of themes. Sustainability was the primary theme has been discussed in three dimensions: economic, social and environmental which consisted of several sub themes.

4. Results

Figure 3 show that there has been an increasing trend in the number of articles published in high impact factor journals since 2018 on the theme of blockchain in sustainable supply chains.

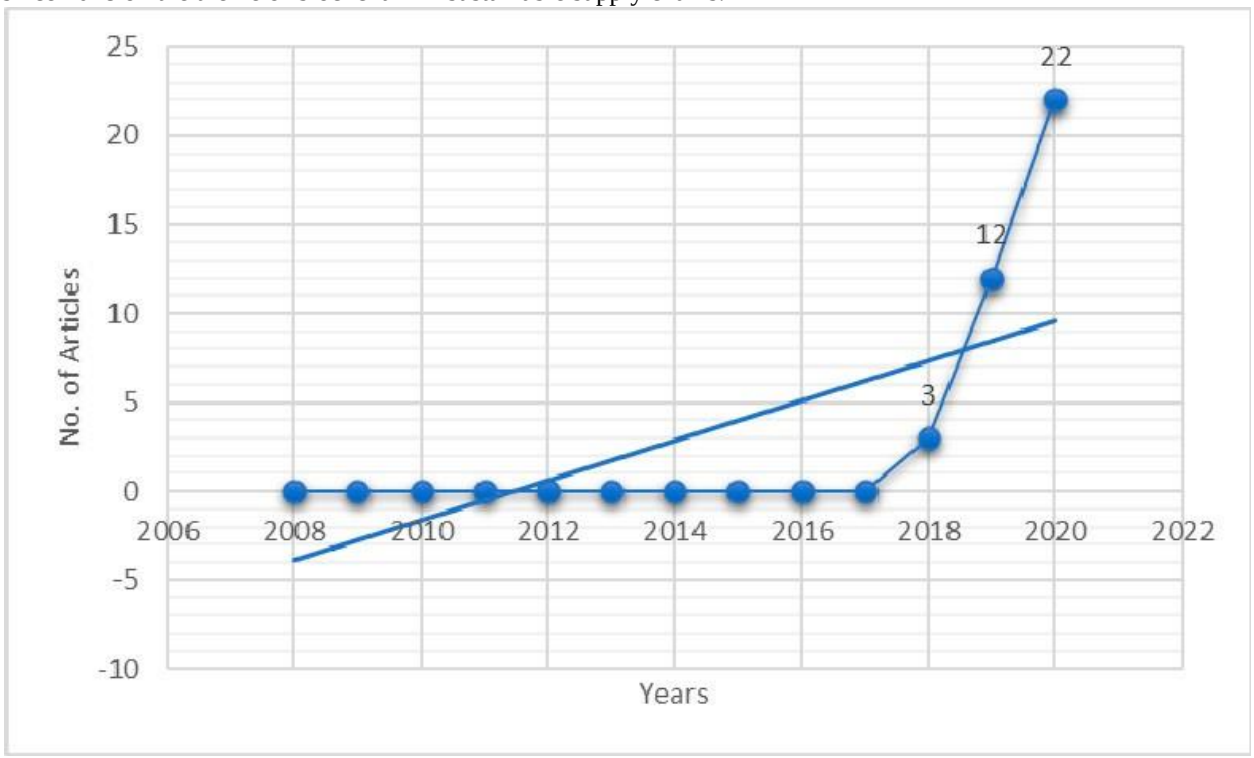

Figure 3. Number of selected papers per year

Table 1 shows the papers that discussed these themes with suitable cross references for each of them.

			Economic issues					Social issues			Environmental issues	
Driver dimensions			Traceability	Flexibility	Cost	Speed	Disintermediation and Opportunism	Trust	Privacy and Security	Provenance	Anti-corruptionIdentificationandVerificationResource-optimiseduseRecycleexchangetokenization	
Kamble et al., (2018)		✓	✓									
Saberi et al., (2018)	✓x	✓	✓	✓	✓x							
Wang et al., (2018)	✓x	✓x	✓	✓x	✓x	✓x						
Verhoeven et al. (2018)	✓	✓	✓		x	✓		x		✓		
Saleem (2018)	✓		✓		✓		✓	✓	✓	✓	✓	✓
Kshetri (2018)	✓	✓	✓	✓	✓	✓	✓	✓	✓x	✓ ✓		x
Lacity (2018)	✓	✓	✓		✓		✓	✓	x	✓		
Treiblmaier (2018)	x	✓	✓	✓	✓				✓			
Queiroz & Wamba (2019)		✓	✓		✓	✓	✓	✓	✓	✓	✓	
Hughes et al. (2019)	✓	✓	✓	✓x	✓x	✓x	✓	✓	✓			
Queiroz et al. (2019)		✓	✓	✓	✓	✓	✓	✓				
Hald & Kinra (2019)	✓	✓	✓	✓x				x				
Lahkani et al. (2020)	✓	✓	✓	✓	✓	✓						
Pournader el at. (2020)			✓	✓	✓	✓	✓ ✓ ✓ x					
Wang et al. (2019)	✓	✓	✓	✓x	x							
Kim & Laskowski (2018)			✓				✓	✓	✓	✓	✓ x	
Montecchi et al. (2019)			✓		✓		✓		✓			
Behnke & Janssen (2019)	x	x	x				✓	✓	✓	x		
Pan et al. (2019)	✓		✓	✓	✓		✓	✓	✓	✓		
Choi et al. (2019)	✓		✓	✓	✓		✓	✓	✓x	✓ ✓	✓	
Min (2019)	✓	✓	✓	✓	✓	✓				✓		
Tönnissen & Teuteberg (2019)	✓	✓	✓	✓	✓	✓		✓		✓		
Xu et al. (2019)		✓	✓		x	x		✓	✓			
Chang et al. (2019)	✓	✓	✓	✓	✓	✓	✓					
Paliwal et al. (2020)	x	✓x	x	✓x	✓	✓x	✓	✓	✓			
Kamble et al. (2019)	✓	✓	✓	✓	✓	✓	x	x	✓			
Kouhizadeh et al. (2020)	✓	✓	✓		✓	✓	✓	✓	✓			
Westerkamp et al. (2019)	✓		✓		x	x	✓	✓	✓	✓	✓	
Jabbar & Bjørn (2018)	✓			✓		✓	✓	✓	✓	✓	x	
Francisco & Swanson (2018)	✓	✓	✓				✓	✓				
Dobrovnik et al. (2018)	✓	✓	✓		✓x	✓				✓		
Treiblmaier (2019)	✓	✓	✓		✓	✓		✓				
Lezoche et al. (2020)	✓	✓	✓		✓x	✓	✓	✓	✓		✓	
Edvard et al. (2019)	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	
Sternberg & Baruffaldi (2018)	✓	✓x	x	✓x				✓	✓		✓	
Akram & Bross, (2018)	✓x	✓x	✓				✓	✓	✓	✓		
Yadav et al. (2020)	✓	✓	✓	✓	✓	✓			x		x	

Table 1. Benefits and challenges of blockchain in supply chains

4.1 The Triple Bottom Line Approach

Following sustainable practices while achieving better environmental and financial results is a challenge for companies. The social output necessitates an open design that safeguards the interests and needs of all stakeholders. The promotion of sustainable development goals, also known as the triple bottom line, has long-term benefits. A company should participate in activities that have a positive impact on environment and society while increasing its competitive advantage (Kumar, Talasia & Pasumarthy, 2020). This is something that needs to be looked at in terms of supply chain operations. The flow of information, goods and services and financial transactions have to be as smooth as possible, and for this collaboration is essential. Participants in the supply chain frequently have competing interests and goals. There is also a technical obstacle in the form of incompatible tracking systems used by different parties. Sustainability should be integrated into a company's overall plan to resolve these issues. Firms would be able to have a positive effect on the economy, culture, and climate as a result of this. Beginning with the monitoring of products from raw materials to finished goods, the role of blockchain is to serve as an inter-organizational mechanism in the supply chain. Use of electronic tokens, protocols on low energy consumption and smart contracts are all examples of how blockchain can boost the efficiency of supply chains. Economic, social and environmental performance are the bedrock (Figure 3) of sustainability and this metric is commonly referred to as the Triple Bottom Line (TBL). The three Ps: people, planet and profits are the dimensions of the TBL.

Fig 3. The Triple Bottom Line

4.2 Conceptual Framework of Triple Bottom Line Blockchain in Supply Chains

The themes that arose from the analysis were further conceptualized and developed around the three pillars of the Triple Bottom Line namely, People (social), Profit(economic) and Planet (environment).The themes were synthesized into a cohesive framework that proposes an approach to integrate and embed blockchain in supply chain operations while focusing upon the social, economic and environmental performance of the supply chain.

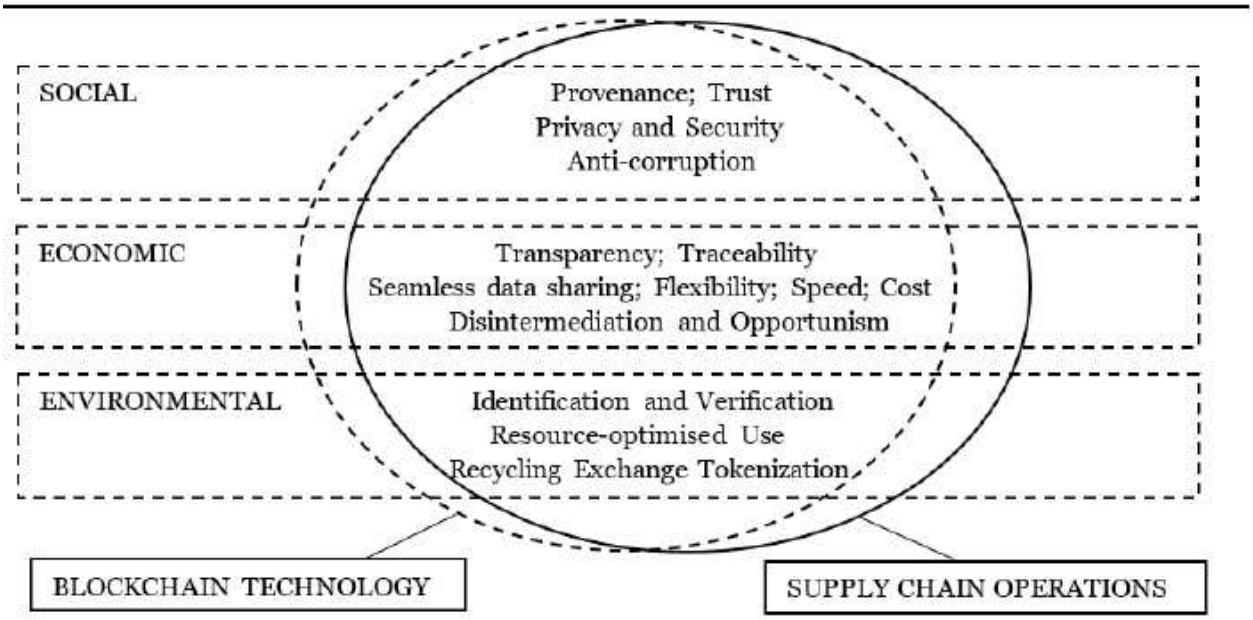

Figure 4. Conceptual Framework of Triple Bottom Line Blockchain in Supply Chains

4.2.1 Impact of Blockchain on Economic Performance

While sustainability was once considered a cost in supply chains, especially logistics, it is now viewed as a critical factor in efficiency and profitability (Tan et al.,2020). Blockchain has the potential to address certain supply chain issues while also improving economic sustainability. It is possible to build a peer-to-peer collaborative market using blockchain, which enables traders to exchange while preventing fraud and opportunistic conduct (Tan et al., 2020). As a result, businesses that use blockchain will be able to more effectively validate knowledge about their suppliers and ensure that all participants follow sustainable practices. It is possible to provide a competitive advantage to the network's companies in this manner. In reality, suppliers and sub- vendors cannot be seen by the ultimate consumer, but they may pose environmental hazards and provide poor results. It is also possible to determine which ecological support the suppliers need in this manner (Kamble, Gunasekaran & Gawankar, 2020). Furthermore, smart contracts can be used to record the information that is shared between suppliers on the blockchain. The data collected is used to evaluate the success of supplier growth initiatives. Therefore, this can also lead to the selection of suppliers who are environment – friendly and follow the norms of sustainability (Bai & Sarkis, 2020). Blockchain can also help to improve supply chain activities such as fulfilling orders, transportation and payments, thus enabling sustainable operations. Blockchain can solve several supply chain problems such as: real-time communication, fast payment processing with reduced transaction fees, lower product costs, reduced delivery times (Bai& Sarkis,2020;Saberi et al.,2019). Furthermore, the blockchain can reduce potential losses due to human error and the use of unnecessary bureaucratic activities (Bai&Sarkis, 2020). Transparency is described as "the extent to which actors within a supply chain have access to or share information that they consider to be key or useful to their operations and that they believe will be of mutual benefit." Transparency allows for the tracking of goods and processes from the point of origin to the final customer, including price, date, location, quality, and certifications. Complex goods necessitate sophisticated traceability systems, but manually written records, which have a high risk of human error, are still common in supply chains. As a result, the most significant problems in global supply chains are synchronized digitalization of supply chain operations and electronic data management systems (Galvez et al. 2018). The food industry is an excellent example of supply chain traceability. For example, in the event of a disease outbreak caused by contaminated food ,

retailers must track down the source of contamination as well as any contaminated goods. Data such as batch numbers of food consignments, point of origin, processing data , expiry dates and information on shipping can be saved on the blockchain and can be accessed by all members of the network.(Helo & Hao, 2019). The blockchain's unique ability to disintermediate reduces costs and processing times, eliminating waste in the supply chain (Kouhizadeh, Sarkis &Zhu). Furthermore, blockchain can ensure data security and validity while lowering the cost of data protection. However, this may be at the cost of decreased efficiency and increased risks to the supply chain (Saberi et al.,2019). Managing product details and demand predictions will help you save money. Inventory management can benefit from blockchain technology, which ensures accurate accounting and scheduling of clients' assets and transactions. This will ensure the long-term viability of the B2B supply chain. As a result, the use of blockchain would boost efficiency, minimize duration of process management, boost competitiveness, and provide incremental income to B2B businesses (Lahkani, Wang, Urbanski & Egorova, 2020).

Conversely, the use of blockchain in supply chains causes some issues in terms of long-term economic viability. First and foremost, blockchain implementation necessitates both a fixed and an ongoing expense (Choi & Luo, 2019). The fixed cost applies to all network members' technology infrastructure and system implementation (Saberi et al., 2019). Additionally, the value of managers' skills and those involved in the technology's maintenance and operations is factored in (Kamble, Gunasekaran & Arha, 2019). Finally, the running costs are determined by the amount of energy and resources used during the daily use of the technology depending on the number of transactions completed (Esmaeilian, Sarkis,Lewis & Behdad, 2020). Furthermore, conflicts of interest may occur among the network's various participants. This can happen when an individual performs opportunistic actions based on data from the distributed ledger, which can cause financial harm to other members of the network.

4.2.2 Impact of Blockchain on Social Performance

The process of tracking and monitoring the societal aspects of the supply chain that link society and business has been termed as “provenance” by several researchers. (Allen et al. 2019; Verhoeven et al. 2018). Provenance covers aspect such as equitable and fair job opportunities, respect for human rights and dignity, fair pay and reporting the use of child labour. (Saberi et al. 2019). Things like raw materials, components, product packing etc. have to be monitored to ensure that they comply with the environmental regulations(Garcia-Torres et al. 2019; Saberi et al. 2019). According to Cole et al. (2019), supply chain accountability to track back roots may have a negative effect on an organization's image because illegal or low-quality manufacturing standards affect the entire supply chain. Many studies put forward and examine the effect of transparency and immutability of blockchain on business and social interrelationships, such as reducing confidence pressure (Cole et al. 2019), segregating the supply chain relationship (Hald and Kinra 2019), or proposing relationships between trust and technical automation to address various scenarios (Cole et al. 2019). It's also conceivable that using embedded smart contracts for automated transaction processing could emerge as a new form of trust (Treiblmaier 2019; Wang et al. 2018).

Distributed and permanent ledgers provide protection by storing records of transactions in each touchpoint or block in public blockchain or related nodes in private and consortium blockchains and are better than centralized database systems in providing network security from hacking attacks (Edvard et al. 2019; Saberi et al. 2018; Wang et al. 2018). Blockchain user have the option of either revealing their identity or remaining anonymous, which helps in privacy protection (Wang et al. 2019). Many professionals' concerns about exchanging sensitive information can be alleviated by using on-chain and off-chain data principles (Akram and Bross 2018; Wang et al. 2019). Sternberg and Baruffaldi (2018) recommend using private blockchains to improve the privacy and protection of SC networks and reduce information transparency conflicts. According to Hughes et al. (2019, since blockchain relies on “public key encryption for authenticating transactions and a private key to protect an account, if a group loses the key or it is mistakenly published then there is no recourse. Corruption is a social variation of opportunism in which people participating in a supply chain unlawfully extract personal benefit from it, such as by paying kickbacks. A blockchain network, according to Kamble et al. (2019), is a "incorruptible chain." A blockchain-based supply chain's increased

transparency may be able to expose unethical practices. According to Saberi et al. (2019), blockchain technology has the potential to significantly reduce nefarious agents' ability to commit frauds and cheating. Wang et al. (2018, 2019) also suggest that a supply chain system based on blockchain will help to reduce corrupt practices , especially in places where these practices are rampant , such as developing countries and supply chains engaged in humanitarian causes. This is a significant societal ability of blockchain that has received little attention in the literature.

4.2.3 Impact of Blockchain on Environmental Performance

In many ways, blockchain will aid sustainable supply chain activities, especially with regard to environmental sustainability. Blockchain is a decentralized, transparent ledger that prevents transactions from being deleted. This allows for complete monitoring of all activities, ensuring that they are both verifiable and controllable (Pederson et al, 2019). Indeed, the accountability gained from tracking goods from their source to the end user will help to minimize carbon emissions and wasteful practices (Manupati et al, 2020). More than ever before, traceability can be used to verify the origin of goods and transactions thus simplifying the study of environmental impact on supply chains (Saberi et al. 2019). The traceability feature of supply chains can help the supply chain sector to identify the origins of green products and check environmental benchmarks and standards (Dobrovnik et al. 2018; Saberi et al. 2019). For example, information such as pesticide levels in agricultural products and other such related information are given to customers at the end of the SCs (Francisco and Swanson 2018; Galvez et al. 2018; Kshetri 2018; Saberi et al. 2019). This data also helps companies monitor and calculate their product's carbon footprint in real time (Saberi et al. 2018), as well as choose renewable suppliers and maintain their supply chains (Dobrovnik et al. 2018; Queiroz et al. 2019). Substandard goods can be tracked back into the supply chain, resulting in less rework and recalls, as well as lower resource consumption and greenhouse gas emissions (Saberi et al. 2019).

In addition to the financial advantages of resource optimization for businesses, blockchain innovations have shown the potential for environmental consumption benefits such as paperless transactions (Wang et al. 2019) and traffic reduction to save electricity, fuel, and emissions (Treiblmaier 2019). The energy needed to run the blockchain, on the other hand, is an additional expense and may be a major environmental issue (Kamble et al. 2019; Queiroz et al. 2019; Wang et al. 2018). One application of blockchains is to use tokenization to improve supply chain recycling performance. Saberi et al. (2019) address a blockchain use case in Europe, where cryptographic tokens were introduced in exchange for depositing recyclable materials (i.e., plastic containers, cans, and bottles) as financial incentives to eliminate plastic waste. Waste management is another method that can be changed within supply chains. People and organizations are usually uninterested in participating in recycling projects. People may be enticed to store recyclable materials such as plastic containers, bottles, or paper by receiving financial incentives in the form of tokens (Treiblmaier, 2019). Blockchain enables and speeds up money transfers, and transactions are permanently registered in the network so that they can be audited. Using this technology, a reputation-based framework would be developed, in which all participants would be encouraged to enhance environmental practices because they would gain both a financial profit and a better reputation (Esmaeilian et al, 2020).

Blockchain, on the other hand, causes certain environmental issues. Blockchain's energy consumption is one of the most serious issues with its long-term viability. Hundreds of megawatts of energy are consumed by the high computational power needed by the proof-of-work consensus scheme. Increased energy consumption equates to increased carbon emissions. To preserve data protection, decentralized ledgers necessitate more computing power and capital, resulting in higher energy consumption (Kouhizadeh et al, 2020). Mining is an operation that increases the cost of energy use by requiring more and more hardware resources to operate. Furthermore, depending on the algorithms used and the duration of the smart contracts, energy consumption will skyrocket (Esmaeilian et al, 2020).

5. Discussion

Through undertaking a systematic literature review of the most recent publications, this paper summarizes the latest understanding of the potential benefits and disadvantages of blockchain technology in the supply chain context. Blockchains have been integrated into supply chains as recently as 2017, hence there is very little research and

literature available on the topic. Using the concept of the Triple Bottom Line, the common themes were woven into a unified conceptual framework. The framework that has been created aims to bring attention to the social and environmental aspects of blockchain implementation apart from the profit motive. The developed framework provides business professionals with a more comprehensive view of blockchains in supply chains. Practitioners can use their resources to look at not just the possible economic benefits of blockchains, but also the social and environmental benefits and impacts.

Other related technologies on the market lack features that blockchain does. To begin with, blockchain can be thought of as a decentralized database in which everyone can store data. The unique aspect of these transactions is that they are immutable and verifiable by everyone with the access keys. This helps us to know the current state of affairs in real time and from any place, and to take appropriate corrective action. Furthermore, due to its operating mechanism, this register cannot be altered, making it safe and secure. Its working mechanism enables greater precision, power, protection, and immediate sharing of any operation. Blockchain integrates perfectly with other emerging technologies like artificial intelligence, Internet of Things (IoT), sensors and smart contracts. All these factors make blockchain the most suitable for supply chains.

From the sustainability point of view, the use of blockchain in the supply chains can guarantee a high level of transparency and better management of resources. In fact, from an environmental point of view, introduction of blockchain enables traceability of product origins which in turn will increase the visibility of the supply chain .Blockchains can also reduce carbon emissions, reduce use of paper, and improve recycling and exchange. The use of cryptographic tokens can help in improving the recycling performance of supply chains. Traffic can be reduced and this in turn helps to reduce fuel consumption and vehicular emissions. Blockchains can result in complete monitoring of all activities, thus helping in verification and control. From the economic point of view, the use of smart contracts in blockchain would allow for a reduction in transaction costs by removing the need for intermediaries. Besides that, the ability to monitor goods and resources allows for waste reduction, which leads to financial savings. It is also possible to have open partnerships between the chain's partners thanks to the distributed ledger's maximum visibility. This will result in higher earnings and a better understanding of the market. Speed, flexibility, transparency and ability to trace goods are some of the added economic benefits that accrue from integrating blockchains into the supply chain. From the social point of view, introduction of blockchain technology helps to bring provenance to supply chains, which results in increased levels of trust. Corruption can be checked due to the immutability of the data stored in the nodes of the chain. Blockchain will raise labor standards by improving working conditions and preventing fraudulent practices such as child exploitation. These advancements can be seen in developing countries where illegal activities are common. The conceptual framework developed in the study helps to highlight all these critical factors of the supply chain within the context of the triple bottom line approach to sustainability.

6. Limitations and Conclusions

In spite of the various advantages of using blockchain technology and its positive impact on the sustainability of supply chains, there exists certain drawbacks as well. The implementation of the whole architecture, as well as the study of relevant skills, are the two most pressing issues. Since blockchain implementation skills are highly specialized, they are difficult to come by. Since the technology is still in its infancy, not all businesses are able to make major investments. Like any technological system that automates an operation, blockchain can eliminate a large number of jobs. Machine learning and artificial intelligence algorithms are destined to eliminate middle management and purchasing manager jobs, resulting in a rise in the unemployment rate. Thus, it is now important to understand whether the advantage of using this technology exceeds the costs. Current research on the evaluation of environmental, economic, and social impacts of blockchain in supply chains is inconclusive. Some studies have used decision-making systems to evaluate the technology's long-term viability within the supply chain (Bai & Sarkis, 2020; Yadav & Singh, 2020), but they tend to be merely expert assessments. There are no studies in the literature that correlate the various benefits and drawbacks of using blockchain from a sustainability standpoint, with many of them being theoretical and depending solely on hypotheses. Several issues, such as the weights and effects of the sustainability on the supply

chain system and their effect on firm performance remain unanswered. Furthermore, the sustainability metrics obtained with conventional supply chain processes—such as warehousing, transportation, and order management—must be compared to those obtained with the addition of blockchain to the supply chain. A cost – benefit analysis is truly needed to find the answer to these questions. As the current work shows, there is an obvious problem of measuring the impacts that blockchain can carry out. The main reason for this lack is that the blockchain era in supply chains is still in its early stages. There is a need for case studies and quantitative metrics that represent blockchain in the business world. Subsequently theories on the positive and negative aspects of blockchain, as well as the three dimensions of sustainability, can be developed and tested. Academics and entrepreneurs can only understand the real utility of technology in this particular field in this way. Once the actual impact of the technology on supply chains becomes visible, then the conceptual framework can also be empirically tested and further refined or expanded.

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