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Original citation:
Zhang, H., 2021, September. Blockchain Facilitates a Resilient Supply Chain in Steel Manufacturing under COVID-19. In *European Conference on Knowledge Management* (pp. 964-972). Academic Conferences International Limited.
http://dx.doi.org/10.34190/EKM.21.058

ISBN: 9781914587061

Publisher: Academic Conferences International Limited

Blockchain Facilitates a Resilient Supply Chain in Steel Manufacturing under COVID-19

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Abstract: The impact of COVID-19 caused a crash in the supply chain across almost all manufacturers, retailers, and wholesalers and now dramatically impacts many of the processes in the manufacturing sectors. In particular, the steel industry, as an energy-intensive industry, is being urged to adopt digitalisation technology to achieve optimization and sustainable production. Industries are fortunate to showcase an opportunity to advance the supply chain towards sustainability to deal with such a crisis. It is acknowledged that digital technology like blockchain can provide intercession by discovering real-time problems to perform certain Sustainable Development Goals related to procurement, production and processing, logistics and transportation and the environment. However, the data structure which requires implementation by blockchain technology in the steel supply chain is restricted. Blockchain technology has the outstanding position to transform the supply chain. The main challenge is that tracing border activities in the steel supply chain has not well been monitored. The digital system is drastically required to develop advanced technology to handle the disruptions and build a resilient supply chain. Using blockchain technology can capture the goods movement across the entire supply chain to verify the quality and product provenance. Furthermore, the rapid technology innovation in the steel sector involves the continuous update of skills and personnel. This study aims to explore the role of blockchain technology in the steel supply chain industry, such as inter-organizational trust, data transparency and immutability, interoperability and product type, and social influence and behavioural intention. A qualitative research approach was adopted on exploring multiple-case studies. The study reveals that blockchain technology contributes to a resilient steel supply chain in reducing risks and uncertainties with its transparency and immutability function. In the future, an integrated technology implementation framework should be developed to deploy Artificial Intelligence and Blockchain technology in manufacturing industries to accelerate the digital transformation.

Keywords: Blockchain, Supply chain, COVID-19, Steel, Sustainability

1. Introduction

The world has suffered heavily from health and global economic downturn during the outbreak of the COVID-19 (Azevêdo 2020). It is urged to emerge innovations alongside the current situation. The COVID-19 pandemic dispensed extreme experience in supply chain and resource fragility (Sarkis et al. 2020). The supply chain challenges are in goods scarcity, product inability, transaction structure difficulties, and a mismatch and demand of logistics (Queiroz et al. 2020). Thus, it provides an opportunity to reflect on the crises to improve the existing supply chain. Due to COVID-19, most companies are required to focus on shaping a visibility supply chain that needs a more digitalized approach compared to they have used previously.

To reach supply chain interdependencies in seamless, modular, distributed, cross-functional form, companies are suggested to digitize their assets, inventories, operations, and supply chain activities (Vendrell-Herrero et al. 2017). Nowadays, blockchain technology is named as "*an enabler of fundamental innovation and disruption*" among supply chain scholars across industries because it presents the nature of decentralized consensus, information-sharing and incentivizing (Saberi et al. 2019). Blockchain technology is a novel technology to contribute to a digital supply chain transformation within the nature of a distributed and decentralized ledger. Blockchain technology adopts in a supply chain by tracking the real-time operation process of goods and services in an organization. It can facilitate transparency in the entire procedure. Blockchain technology has been used in some applications such as financial services (Hyperledger Peersafe), food industry (IBM Food Trust), pharma supply chain (Novartis), and steel industry (Government of Canada), etc. IBM (2020) defines blockchain applications for supply chain in three main benefits, namely: increasing supply chain transparency, building a resilience supply chain, and streamlining suppliers. It is agreed, that blockchain technology accomplishes a reliable supply chain system.

Supply chain scholars have just embarked on assessing the impact of blockchain thoroughly on various organizational activities, while there are very few relevant studies on blockchain technology in the steel industry. Notably, blockchain potentially promotes a series of the United Nations (UN) Sustainable Development Goals (SDGs) through several studies (Kim and Huh 2020). However, the existing literature is chunk because most

relevant studies closely concentrate on the transparency and traceability advantages of blockchain technology in supply chain alternately specific design interventions that provide such advantages. The scarcity of research to scrutinize blockchain technologies' position in promoting SDGs, particularly to highlight the steel industry and compose an obvious gap in the relevant literature. The data exchange faces the main obstacle between companies to record and analyse data. There is no inclusion for processing data. Therefore, company data or other inefficient methods are usually put in place. In consequence, the entire production chain cannot underpin sufficient data exchange. They also present blockchain technology as a very promising method. A few related studies deliver predominant supply chain discussions on the sustainability advantages of blockchain in the steel supply chain while bypassing research on existing solutions for uncertainties in planning and supply chain scheduling issues in the steel manufacturing process (Eudero et al. 2019).

From an academic viewpoint, Treiblmaier (2019) interpreted blockchain technology as enabling constant data recording and promoting a shared data sight throughout the supply chain. A theory-based research agenda is set to exploit rigorous academic research and an industry-related one. From a technical viewpoint, the sustainable steel supply chain logistics service industry drops behind the development of e-commerce logistics owing to a large amount of storage bulk, low turnover rate and expensive transportation, and operating costs (Lv et al. 2020), while a supply chain scarcity of a data-driven theory in product layout and distribution efficiency. The outline of the paper is as follows: Section 2 illustrates an overview of blockchain technolgy and the blockchain-based supply chain. Section 3 provides the systematic literature review method to indicate the list of articles for analysis. In Section 4, two case studies on the Government of Canada (Peer Ledger and Mavennet) are studied in blockchain application in the steel supply chain platform. A summary for future suggestions is provided in Section 5. The paper will focus on the blockchain-based technology in a resilient steel supply chain in COVID-19 by offering solutions for future supply tracking, tracing, responsiveness, and overall improvements. A systematic literature review will be used in blockchain-centric supply chain method to identify future opportunities to improve a sustainable supply chain. Solutions suggested are adopted among the individual, organizations, supply chains, and governments.

2. Blockchain in the steel supply network

The key research of supply chain with blockchain technology is reviewed in the end-to-end steel supply network. The blockchain contains the following functions in Table 1, which may be counted on the platform used (Garrod 2019, Tang et al. 2019).

Table 1: Blockchain functions

Shared ledger	Permissioning	Smart contract	Consensus
To share data structure among different participants and distribute locally	To ensure data privacy and transparency via secured and authenticated transactions	To implant commercial terms in the database and realize via transactions	To ensure immutability and tractability of data and authorize by relevant

2.1 Blockchain-Based Supply Chain

Blockchain technology is renowned for the transparency, traceability, and security to diminish global supply chain issues. Blockchain technology as a potential and disruptive technology in overcoming supply chain obstacles is classified with four types of barriers: inter-organizational, intra-organizational, technology, and external barriers. That incorporating in a blockchain tamper-proof record helps foster a sense of trust that can secure the commercial viability of the end-to-end supply network. In a digital era, the data consistency among companies in a specific ecosystem can promote the value acquisition of all stakeholders. Therefore, the supply chain process needs to be (re)designed to adapt to the data requirements and specifications related to the blockchain (Ghode et al. 2020).

The supply chain shifts from the front end in distribution to the back end in transportation and warehousing through extraction, materials, made-in process, completed commodities, the third parties, customers, and three R (return, reuse and recycling). The supply chain stakeholders prefer information to be used in enhancing performance in inventory, transportation, warehousing, and communication-related costs (Wan et al. 2020). The supply chain controls the movement from suppliers to end-users, and it is a process from raw materials to customers with the distribution. The study will explore blockchain technology's effect on supply chain and,

external barriers. It summarizes the nature of blockchain-based supply chain: traceability, immutability, compliance, and sustainability.

2.1.1 Traceability

Blockchain can locate real-time movements of goods in the supply chain. By providing a database, blockchain can record supply chain transactions that track along with the motion of a supply chain in real-time. In the steel supply chain, the properties could be noted on a blockchain system namely: mineral fingerprints, steel provenance at certain supply chain points, life cycle assessment (LCA), bill of lading, and transfer locations (RCS Global 2017). By traceability in the supply chain, the technology can track product provenance from the initial suppliers to end-users. For example, the steel supply chain is traceable when it is possible to know the exact date, time, and place where the product has altered hands among the participants in the supply chain.

2.1.2 Immutability

Blockchain is a distributed and decentralised ledger which means there are more tamper-proof records than in other databases. The data information on each node can be signed, timestamped, and immutably recorded in the blockchain. A transaction or 'block' on the supply chain is time-stamped and validated to minimize fraud (RCS Global 2017). Blockchain enables secure transaction validation, purity verification, and authenticity. Each new information is implanted into the blockchain and it is encrypted to secure the resource authentication (Gammelgaard et al. 2019).

2.1.3 Compliance

Mining and metals companies have made a critical advance in supportability and compliance, they must proceed to improve and remain up to date. The measurements and preferences of blockchain can be utilized to create applications that address compliance, straightforwardness, and responsibility. All parties including the exchange can be certain of the latest information (Deloitte 2021). To enhance supply chain efficiency, achieve regulatory compliance, one possibility is to build on an innovative blockchain system and to which level material should be traced on the blockchain.

2.1.4 Sustainability

Blockchain plays an extremely significant role in sustainable development. It has showcased four main functions to support a sustainable and resilient supply chain: I, Blockchain reduces product retraction by the tracking potentiality; II, Blockchain charges the accurate amount of carbon tax from each company by the real-time footprint of products; III, Blockchain cultivates behaviour through stimulating individuals to participate in; IV, Blockchain improves the efficiency of emission trading blueprint to reduce fraud and enhance the system (Macrinici et al. 2018, Casino et al. 2020).

2.2 Blockchain-Enabled the Steel Supply Chain

Blockchain is one of the major ways to facilitate the metal industry's digital transformation. Blockchain-based solutions can significantly improve the performance and secure the steel-technology sector by decentralising processes. Blockchain technology facilitates a digital tracking system on the steel supply chain operations from extraction to production to sales to achieve green steel. The outstanding function of blockchain supports supply chain transparency effectively. At a manager level of an organisation, it is crucial to estimate the most appropriate blockchain. Blockchain system has highlighted its potential application as the technology enables transparency, traceability, and trust in the end-to-end steel supply network.

2.3 Steel chain and steel industry

2.3.1 Steel chain

The metal industry suffers from global demand decreasing, trade flow disruptions, workforce skill supply chain scarcity, and downgrade resource quality. The steel industry challenges the Environmental, Social, and Governance (ESG) risks. The challenges threaten the interests and capital investments in the metal industry. Digital transformation is leading the way to transform the metals industry to meet the challenges. By considering ESG issues, the steel industry will bring a positive outcome during all supply chain activities (WSA 2019).

2.3.2 Steel industry

The steel industry aims to process iron ore into steel. Steel is mainly used in seven primary market sectors; building and infrastructure, mechanical equipment, automotive, metal products, other transport, domestic appliance, and electrical equipment. A few examples of literature are as below:

1. Kushnir et al (2019) use a technology innovation system to perform hydrogen direct reduction in the Swedish steel industry. The study deploys quantitative empirics methodology and a framework of the technology innovation system.
2. Pinto (2019) aims to integrate the current and future interactions within the European steel industry to provide political support towards sustainability and circularity for future steel in the European Union. It locates the European steel industry as a case study to investigate the LCA in its system dynamics.
3. Pinto and Diemer (2020) show that the environmental issue constraints the development of the steel industry.
4. Conejo et al (2020) have reviewed energy consumption, carbon dioxide emissions, and water consumption in the steel industry globally. It has also reviewed new emerging technologies in iron and steel making.

2.3.3 Implementation and adoptability

Blockchain is considered as many lists of blocks including data and information in transactions, records, and events. The existing literature often ignores the structure of collecting and transmitting data and the need to redesign the blockchain-based supply networks. A few examples of blockchain adoption are as below:

1. Blockchain enhances transparency along with the supply chain through information sharing among participants to reduce largely or avoid the Bullwhip effect in supply chains (Babich and Hilary 2019).
2. Blockchain can reduce uncertainty in business environment to improve coordination efficiency specially in transaction (Huang and Chiu 2018).
3. Blockchain creates a secure decentralized database and improves trade speed and reliability and transparency of data transmission in the e-commerce supply chain to reduce the total cost, time, and risk in international commodity transactions (Lahkani et al. 2020).
4. Blockchain-based technology in cross-border supply chain is deployed by IBM with Maersk to achieve information transparency (Chang et al. 2020).

2.3.4 An integration of Knowledge Management

Knowledge Management (KM) creates value from the knowledge to transform into the firm. KM faces the challenge in managing technology, supply chain, and human resources in companies. Regarding the supply chain, KM supplies data generated by supply chain managers and the customers by providing the tools (Olson 2018a, Olson 2018b). The entire supply chain includes sourcing, logistics, production, and retail delivery to end-users. The operations are not only requiring knowledge management but information systems technology. In return, Knowledge Management enhances supply chain performance efficiency (Schniederjans et al. 2020). Knowledge management contributes to supply chain management in responding to internal and external stakeholder needs. As it is recognized, Knowledge Management in supply chain management is recently adopted and the digitisation eco-system in Knowledge Management requires to be fully explored.

3. Methodology: Systematic Literature Analysis

The study explores blockchain in the supply chain in the steel industry by using a systematic literature analysis method. Two steps are implemented: First, collect selective articles with relevant keywords and conduct the trend in the articles. The keywords are considered includes ‘blockchain’, ‘supply chain management’, ‘blockchain-based supply chain’, ‘a resilient supply chain’, ‘sustainability’, ‘COVID-19’, ‘pandemic’, and ‘steel’. It is preferable to examinate peer-reviewed journal articles, academic books, and business-related news articles via Google Scholar and the university library (e.g Lanchester Locate) from 2019 to 2021 by considering the outbreak of the pandemic at the end of 2019. The chosen articles are listed in Table 2.

Table 2: Literature

No.	Author	Year	Keyword	Journal	Title
1	IBM	2020	Electronic data interchange, supply chain optimization, blockchain supply chain, managed file transfer	N/A (IBM)	What is supply chain management?
2	Chang et al	2020	Supply chain management, logistics, global trade, blockchain	International Journal of Production Research	Blockchain in Global Supply Chains and Cross Border Trade: A critical Synthesis of the State-of-the-art, Challenges and Opportunities
3	Kim and Huh	2020	Blockchain, artificial intelligence, UN sustainable development goals, carbon trading	Sustainability	Blockchain of Carbon Trading for UN sustainable development goals
4	Treiblmaier	2019	Blockchain, distributed ledger technology, logistics, sustainability	Logistics	Combining blockchain technology and physical internet to achieve triple bottom line sustainability: a comprehensive research agenda for modern logistics and supply chain management
5	Lv et al	2020	Steel, smart logistics, data-driven design, layout planning	Sustainability	Data-driven design and optimization for smart logistics parks: Towards the sustainable development of the steel industry
6	Kamble et al	2018	Blockchain, technology management, technology acceptance model, supply chain management	International Journal of Production Research	Understanding the blockchain technology adoption in supply chains-Indian context
7	Eudero et al	2019	Steel industry, supply chain scheduling, uncertainty, review	Applied Sciences	Planning and Scheduling with uncertainty in the steel sector: a review
8	Shniederjans et al	2020	Digitisation, knowledge management, forecasting, supply chain	International Journal of Production Economics	Supply chain digitisation trends: An integration of knowledge management
9	Casino et al	2020	Blockchain, classification, applications	Telematics and Informatics	A systematic literature review of blockchain-based applications: Current status, classification and open issues
10	Macrinici et al	2018	Smart contract, blockchain	Telematics and Informatics	Smart contract applications within blockchain technology: A systematic mapping study
11	WSA	2019	Environmental performance, social performance, economic performance	N/A (World Steel Association)	Sustainable Steel Indicators 2019 and the steel supply chain

No.	Author	Year	Keyword	Journal	Title
12	Wamba et al	2020	Blockchain, supply chain, transparency, digital disruption	International Journal of Production Economics	Dynamics between Blockchain Adoption Determinants and Supply Chain Performance: An Empirical Investigation
13	Esmaeilian et al	2020	Blockchain, supply chain, sustainability, circular economy	Resources, Conservation & Recycling	Blockchain for the future of sustainable supply chain management in Industry 4.0
14	Espindola et al	2020	Disruptive technology, blockchain, artificial intelligence, disaster management	International Journal of Production Research	The potential of emergent disruptive technology for humanitarian supply chain: the integration of blockchain, Artificial Intelligence and 3D Printing
15	Kushnir et al	2019	Technology innovation system, direct reduction, steel, CO2 emissions	Journal of Cleaner Production	Adopting hydrogen direct reduction for the Swedish steel industry: A technology innovation system (TIS) study
16	Pinto	2019	Life cycle assessment, supply chain integration, servitization, circular economy	Economics and Finance	Sustainable Resources Management in European Steel Supply Chains
17	Pinto and Diemer	2020	Steel, Supply chain integration, circular economy, closed loop supply chains	Resources, Conservation & Recycling	Supply chain integration strategies and circularity in the European steel industry
18	Conejo et al	2020	Steelmaking, energy consumption, environment, societal challenge	Journal of Environmental Management	A review of the current environmental challenges of the steel industry and its value chain
19	Magdalena et al	2020	Supply chain, Industry 4.0, sustainability, shipbuilding supply chain	Sustainability	Assessing Sustainability in the Shipbuilding Supply Chain 4.0: A Systematic Review
20	Ledger Insights	2020	Chinese steel sector, problems with finance, blockchain applications, consortium blockchain	N/A (Ledger insights website)	China working on blockchain platform for steel industry

Second, it explores systematically literature reviews (see Section 2) and case studies (see Section 4). Although blockchain function can be seen in the supply chain, the contribution variables are not fully developed. Blockchain technology focuses on contributing a resilient steel supply chain in the study.

4. Case Study

4.1 Government of Canada- Peer Ledger and Mavennet

The Canadian government has contracted Peer Ledger and Mavennet companies to initiate blockchain applications to trace the steel supply chains. By integrating with blockchain technology, it aims to supervise product quality and verify the country of origin. The two companies have deployed blockchain and AI

technologies in the Canadian steel supply chain within a proof-of-concept for digital traceability to refine the prototype.

4.1.1 Peer Ledger

Peer Ledger has innovated the blockchain-based MIMOSI SaaS platform to trace gold and metals supply chain, verify medicine and drug provenance, and preserve intellectual property. Halifax-based Peer Ledger is funded by the government initiative to support the development of Canadian small business. Peer Ledger leans on a proof-of-concept (PoC) to shape a digital steel supply chain traceability by implementing blockchain technology. The initial platform focuses on Canadian steel and will also expand into the North America steel supply chain. The transaction data in Peer Ledger is encrypted on blockchain because it is a digital ledger to enhance data security. Data is secured in distributed locations to improve overall resilience.

4.1.2 Mavennet

Mavennet relies on blockchain technology and AI to transform entire industries such as financial services, supply chain, energy etc. Mavennet connects the AION blockchain to provide solutions for organizations such as Deloitte, Vodafone, Moog, and the Toronto Stock Exchange (Ledger Insights 2020). Mavennet provides the space of decentralized identities underpinned by the deployment of a traceability platform that allows end-to-end visibility of assets. Blockchain technology permits Mavennet digital transformation by setting standards and APIs to enable seamless integration with other suppliers in the systems (DIACC).

4.1.3 The impact of blockchain in Canada steel digital supply chain

Considering a steel supply chain operation, Magdalena et al (2020) underline the dominant position of the supply chain in organizations attempting to enhance market competition and profitability. Blockchain technology tracks materials in the entire steel supply chain to prove the provenance of products. blockchain also provides transparency among all the participants in the supply chain to ascertain more quality and price in the whole process. Furthermore, blockchain generates real-time data during delivery. The positive expectation of blockchain impacts the Canada steel digital supply chain as below (Government of Canada 2018, Deloitte):

- Commit real-time insights and information
- Secure the sensitive information among the participants
- Confirm data accuracy and transparency
- Easy connect government and industry digital infrastructures

Blockchain technology adoption in the Canada steel industry contributes to manufacturing digital transformation and the movement of physical goods through the global supply chain. For example, improve data security and asset provenance by distribution of application development, enhance transactions efficiency by agreement on the blocks, and drive efficiency and transform supply chain operations. In the steel manufacturing industry, blockchain creates a consensus mechanism to guarantee a product provenance efficiently. Peer Ledger and Mavennet are the pioneering examples in a consensus mechanism in the Canada steel industry to verify a product's country of origin. The companies provide a digital platform of steel products to be recorded on a blockchain-based system. It guarantees the provenance of steel products is legal to ensure trade compliance.

5. Conclusion

Covid-19 treats manufacturers across many industries in managing the pandemic's growing impact on their supply chains. Unfortunately, many of them are facing a supply and demand balance crisis that stems from weaknesses in their sourcing strategies but could have been corrected years ago. The coronavirus epidemic stresses a robust supply chain which is crucial for companies' performances. It is realized, KM implements a supply chain management (SCM) practices at the level of firm performance. Companies require to absorb knowledge as an important implication in strategic direction. An efficient firm performance comes from KM capabilities and SCM practices. Therefore, KM capabilities along with building a sustainable relationship with supply chain partners will become a promising initiative to respond to firm performance efficiently. KM can be considered as a leverage system to integrate supply chain in such as intra and inter-firm relations, supply chain strategy, product development, procurement, and customer relationship management, and supply chain collaboration.

The literature and two case studies have suggested that blockchain technology facilitates a resilient supply chain. However, the correlation and identifies of a blockchain-based supply chain within a resilient performance are

not analysed. It is evident, that blockchain applications among companies are growing, and it could be a promising research topic with theory development in estimating the impact of bblockchain on a resilient supply chain in the steel industry.

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