Blockchain Potential for Supply Chain Reconfiguration in Post COVID-19 Era

Marco Ardolino[1][a], Beatrice Marchi[1][b], Maciel M. Queiroz[2][c], Andrea Bacchetti[1][d] and Simone Zanoni[3][e]

[1]*Department of Mechanical and Industrial Engineering, Università degli Studi di Brescia, via Branze 38, 25123 Brescia, Italy*

[2]*Paulista University, Postgraduate Program in Business Administration, 04026-002, Sao Paulo, Brazil*

[3]*Department of Civil, Environmental, Architectural Engineering and Mathematics, Università degli Studi di Brescia, via Branze 43, 25123 Brescia, Italy*

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Abstract: The spread of the coronavirus has had a major impact on the global economy, highlighting the shortcomings and weaknesses of global supply chains. Major issues such as supply disruptions, shortages of raw materials and spare parts, restricted transport, and ineffective exchange of information between actors within the supply chain have resulted. The empirical evidence of these events is widely discussed in the literature, which has brought out the urgent need to rethink the configuration of customer-supplier relations at an overall level. One technology that is much discussed in the literature and potentially useful in supporting supply chain processes is the blockchain technology. Blockchain has been gaining attraction across different sectors, even if there are still few applications in supply chain management, most at an experimental level. The aim of this paper is to analyse the potential applications of blockchain to support supply chain processes, to fill the gaps highlighted during the Covid pandemic. Through the analysis of the literature, the authors aim to give a preliminary overview on the relationships between Covid-19 impacts and benefits achievable by the application of blockchain technology in the supply chain, for an effective supply chain reconfiguration in a post-covid era.

1 INTRODUCTION

The diffusion of COVID-19 started in China in the late 2019, and after few months, it was declared a world pandemic by the World Health Organization. This pandemic has caused unprecedented outbreaks in the supply chains of several industry sectors, with important economic effects at a global level (Chowdhury et al. 2021; Queiroz et al. 2020). Supply interruptions, extended lead times, information asymmetry between parties and a drastic change in consumption habits have led to a real-world crisis (Ino and Watanabe, 2021). In most cases supply chains have not proved enough resilient to this strong external shock, despite the continued and pervasive deployment of digital technologies that could potentially have significantly mitigated these effects (Belhadi et al. 2021). Indeed, supply chain management has been revolutionizing by the introduction of more and more sophisticated ICTs and overall digitalization (Zheng et al. 2020). Among the various digital technologies mentioned by the literature, there is blockchain technology (BT) (Queiroz and Fosso Wamba, 2019). The intrinsic characteristics of Blockchain - reliability, transparency and security - can effectively support the various transactions that take place between the various actors involved (Wang et al. 2019). Despite these potential characteristics for improving supply chain management, many firms are still either

[a] https://orcid.org/0000-0003-3196-8586
[b] https://orcid.org/0000-0002-4856-7300
[c] https://orcid.org/0000-0002-6025-9191
[d] https://orcid.org/0000-0002-7629-8806
[e] https://orcid.org/0000-0001-5324-6117

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sceptical about blockchain opportunities in the supply chain management (Frizzo-Barker et al. 2020). Therefore, while the scientific literature provides many contributions aimed at highlighting the great potential of blockchain to support supply chain processes, there are very few applications in practice and scepticism still prevails. This paper presents a preliminary study aimed at bridging the gap between research and practice regarding the adoption of blockchain for supply chain management. The main objective is to highlight the relationships between the potential benefits of blockchain implementation versus the weaknesses highlighted during the covid-19 pandemic. In terms of organization, Section 2 highlights the main impacts of COVID-19 on the supply chain management while Section 3 presents an overview of the main features of blockchain technology and a list of its main applications to support supply chain management. Section 4 discusses the findings presented in the previous sections, preliminarily highlighting the links between the impacts of covid-19 and potential applications of blockchain. Finally, the practical and scientific challenges are depicted.

2 COVID-19 EFFECTS ON SUPPLY CHAIN CONTEXT

The impacts of COVID-19 have not only been health-related, but also economic, as the pandemic has simultaneously impacted the global supply chain in all its nodes (Paul and Chowdhury, 2020). Figure 1 presents the main impacts of the diffusion of Covid-19 on the worldwide supply chain activities.

Figure 1: Covid-19 impacts on supply chain management.

Several companies around the world have experienced supply chain interruptions because of the Covid-19 outbreak, mainly caused by production disruption of raw materials and spare parts, and setbacks in logistics (Taqi et al., 2020). At the beginning of the pandemic, managers of manufacturing companies experienced challenges, especially in obtaining inputs for production processes (Rapaccini et al., 2020). Therefore, Covid-19 has represented an external shock of unprecedented magnitude, affecting the supply and demand sides alike, and revealing the fragility of most supply chains (Harris et al., 2020). Moreover, disastrous have been the impacts for all those companies engaged in exclusive agreements with suppliers (Juergensen, Guimón, and Narula, 2020). The spread of Covid-19 had also a significant impact on society and the lifestyles of people worldwide, fostering behavioural change in consumers (Ivanov and Dolgui, 2020; Queiroz et al., 2020). People drastically reduced the number of visits to physical shops due to the fear factor by increasingly exploiting shopping online (Borsellino, Kaliji, and Schimmenti, 2020; Seetharaman, 2020). Therefore, Covid-19 pandemic effects have also shed light on the need to think about the social impacts of individuals. One of the most important emotional impacts has undoubtedly been panic buying, that is an accumulation of goods that happens in periods of severe uncertainties which increases the demand for certain essential items (Borsellino, Kaliji, and Schimmenti, 2020; Ibn-Mohammed et al., 2021). The spread of Covid-19 virus has also pushed governments to introduce policies addressing the national control of supply chains in unexpected ways through, for example, export restrictions on some medicines and medical equipment (Xu et al. 2020). Crisis response arose in the worldwide mass production of single-use and other disposable products such as gloves, masks, face shields, and other equipment (Diaz-Elsayed, Morris, and Schoop 2020). This massive source of plastic waste could become an environmental disaster if not managed effectively. Moreover, an increase in online shopping has also provoked a surge in the production and demand for packaging materials, thus causing a significant increase in the amount of waste generated (Liu et al. 2020). In some cases, emergency and supply shortages have led to the relaxation of certain product controls to facilitate rapid procurement. The relaxation of regulations has certainly brought benefits, but there is also the other side of the coin since fraudulent products claiming to cure, treat or prevent COVID-19 have been on the rise (Fairgrieve et al., 2020).

3 BLOCKCHAIN

3.1 Blockchain Technology

BT is a decentralized peer-to-peer system without a central authority, which can disrupt traditional operations management by providing a transparent, open, trusted platform (Hibbert, 2017; Yoo and Won, 2018). The chained structure consists of a time sequence of blocks, which are a collection of data containing transactions-related information and records. The key concepts of blockchain are (Marchi et al., 2019): (i) peer-to-peer distributed shared ledger, (ii) consensus, (iii) cryptography, and (iv) smart contracts. Several benefits can be introduced using the blockchain technology (Hibbert, 2017), such as transparency of trades tracking (automation allows the real time updating of transactions information), data protection, accuracy, and security (providing a single shared view of information in the nodes, stored transactions cannot be duplicated, altered, or deleted without parties' consensus which foster trust among them), resilience (the distributed nature of blockchain allows to avoid single points of failure), efficiency (reduced transaction-related cost mainly due to the absence of third-party intermediaries and to the reduction of the complexity that should be managed), risk reduction (shared information allows to better manage risks and to reduce their impacts). Furthermore, faster transactions can be enabled, reducing the probability to incur in delays which come at a cost. BT has, thus, a great potential to support companies in managing the complexity and to change the human-to-human and business cooperation model.

3.2 Blockchain Applications in the Supply Chain

BT has a wide range of application and the potentialities to disrupt several sectors (Figure 2). Specifically, in the supply chain and logistics activities, it can offer new ways of monitoring and managing the different flows (i.e., materials, information and financial) through the entire lifecycle of the goods.

Product Traceability. Given its unique characteristics, blockchain help managing product traceability within the supply chain (Behnke and Janssen, 2020). In some contexts, the need to implement a traceability system within the supply chain is crucial. Consumers' sensibility is increased,

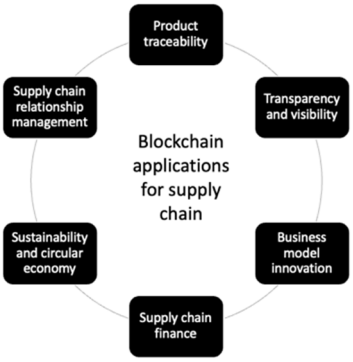

Figure 2: BT applications in supply chain management.

especially in food and pharmaceutical sector (Behnke and Janssen, 2020). For this reason, in many cases, national and international regulations have become much stricter with improved quality controls. Therefore, suppliers might want to show their products' origin and quality to consumers and to comply with regulations. Traditionally, traceability has been managed by independent actors whose task was to carry out the appropriate checks and verify the authenticity of the information provided (Lu & Xu, 2017). These solutions generally rely on centralized systems and are characterized by the high risk of suffering of data manipulations because of lack of transparency and trust. The blockchain overcomes these problems as all blocks are cryptographically connected, minimizing all possible risks of data manipulations (Sunny et al. 2020). In addition, since it is a distributed ledger, it is possible at any time and in real time to find out information about a product and its entire history such as: timestamps, location, and environment characteristics (Kim et Laskowski, 2017). Therefore, BT has the potentiality to improve traceability of products thanks to the immutability of stored transactional data, and the maintenance of only one version of the transactional database without a third-party intermediate "accountant" (Tapscott and Tapscott, 2016).

Transparency and Visibility. The traceability applications offered by blockchain technology have positive repercussions in supply chain transparency and visibility (Kamble et al., 2020). Traceability helps gathering the history of a product within the supply chain and this might drastically improve visibility (Agrawal, Sharma, and Kumar, 2018). Transparency involves the overall visibility of the supply chain among the different players and is enabled by traceability through tracing and tracking (Sunny et al., 2020). Transparency is guaranteed by complete visibility, that is the capability to access or

share information across the supply chain. Ben-Daya et al. (2019) describes supply chain visibility as "the ability of a firm to collect, access, assess and share useful, accurate, trusted, secure and timely information across its internal functions as well as the supply chain partners and market". Supply chain visibility does not involve only information availability but requires accuracy of data and a shared structure that enables all the nodes to make decisions in a timely manner. Traditional centralized systems are generally inefficient in achieving an adequate supply chain visibility. Indeed, third-party involvement might cause longer transaction times and high cost with several issues concerning integration of physical and digital worlds (Reddy et al. 2019). In a global context where business environments are becoming more and more decentralized, blockchain applications may create collaborative environments for improving supply chain performances (Sunny et al. 2020). BT also helps improving transparency by eliminating the lack of trust in the supply chain (Kamble et al., 2018). The potential benefits are evident in the management of the delivery cycle, reducing discrepancies regarding information flow, and the quality of product delivered (Haoyan et al. 2017). Therefore, structural characteristics of the blockchain are set in a way such that security and transparency is effectively achieved (Dutta et al. 2020). BT thus improve visibility, making the supply chain reactive to external changes.

Business Model Innovation. Business model brings together the main features of a business through which inputs are transformed into outputs creating and delivering value for customers (Teece, 2010). Generally, it is crystallized using specific tools (e.g., the business model canvas) that help practitioners assess the business and evaluate appropriate innovations (Osterwalder and Pigneur, 2010). The impact of BT on the configuration of a business model can be potentially disruptive, offering the opportunity to create genuine new business. BT might transform the business model enhancing the whole process in a transparent and trustworthy way (Shahzad, 2020). Parida et al. (2019) focused on the potentialities of blockchain in innovating the value-capture component of business model exploiting the characteristics of smart contracts. BT also offers the opportunity to revolutionize the world of the sharing economy by ensuring greater reliability and security in the exchange of information between the actors involved. A further potential application of blockchain is to support businesses that offer the sharing of production resources through paradigms such as distributed, cloud or shared manufacturing (Yu C. et al., 2020). It is therefore possible to have considerable improvements in efficiency, avoiding brokerage expenses, especially in those contexts where two parties are involved, such as a buyer and a seller (Morkunas et al., 2019). This, together with the functionality of smart contracts, provides opportunities for general innovation in value propositions in different areas, based on the provision of product and advanced services combinations (Wenngren et al., 2020). In fact, in recent decades, there has been an increasing development of the mindset that exploiting the opportunity, to earn revenue for non- physical aspects of products, such as consulting and maintenance. This phenomenon goes under the term of servitization (Vandermerwe and Rada, 1988), which then, following the introduction of digital technologies, evolved into the concept of digital servitization (Kohtamaki et al. 2019; Eloranta et al. 2021). The adoption of blockchain in this sense can be of enormous value as it guarantees a more effective management of information relating to the state of the machine in maintenance contracts (Chang et al., 2021).

Supply Chain Finance. Supply Chain Finance (SCF) can be defined as "the inter-company optimization of financing as well as the integration of financing processes with customers, suppliers, and service providers in order to increase the value of all participating companies" (Pfohl and Gomm, 2009). SCF, through the joint coordination of the financial flow together with the product and information flows, allow to provide visibility and control over all cash-related processes within a supply chain, to optimize the management of financial flows at an inter-organizational level and to implement a set of solutions which can result in lower debt costs, new opportunities for obtaining the required capital (especially for weak supply chain players), improved profitability and reduced working capital within the supply chain (Wuttke et al., 2013, Caniato et al., 2016). The SCF mechanisms can be grouped as (Marchi et al., 2020): supplier-based finance (e.g., trade credit), buyer-based finance (e.g., reverse factoring), or both depending on the specific case (e.g., revenues sharing contracts). Traditional solutions of SCF can be further improved when firms make better use of digital technologies (Gelsomino et al., 2016). Advanced use of those technologies will result in innovative solutions and more benefits to the supply chain. BT can support SCF by securely storing, selling, and accessing the huge volume of data generated through IoT devices in the supply

chain, speeding up cash-flow exchanges, and allowing instant payments with smart contracts which shortens the cash payment cycle (Wang et al., 2019). In practice, some application of BT-SCF can also be observed (Li et al., 2021): Chained Finance, launched by Foxconn, the financial services arm of iPhone manufacturer, and Dianrong, the Chinese online lender, claims to be the first-ever blockchain platform for SCF by securing funding for SMEs in China that were otherwise unable to secure needed capital. IBM, together with the Chinese firm Sichuan Hejia Co., Ltd., in 2017, launched a BT-SCF platform for pharmaceutical procurement to improve efficiency, transparency and operation of SCF. This platform is beneficial to SMEs which often find it difficult to raise funds due to underdeveloped credit systems and a lack of established credit evaluation and risk control. Research that bridges blockchain and supply chain finance is nearly non-existent. Hence, it represents a noteworthy research stream that should be investigated.

Sustainability and Circular Economy. Supply chains are experiencing a high pressure from the society to implement sustainable business practices. BT can offer a great potential for bringing supply chain to higher levels of sustainability in terms of reduced environmental and social impacts. Thanks to the enhanced traceability, BT allows to effectively reduce waste using smart contracts, to trace dangerous products and materials preventing environmental damages and to monitor the environmental compliance along the supply chain (Kouhizadeh and Sarkis, 2018). BT can also trace defected items precisely, so the need of rework and recall can be reduced, which means decreased waste and resource consumption (Saberi et al., 2019). The tracing of the materials, the authentication of involved actors for recycling purpose, and the use of smart contracts for financial transactions support reverse logistics and facilitate circular economy activities (Kouhizadeh and Sarkis, 2018; Böckel et al., 2021). BT also offers a solution for the energy management that fits the new energy paradigm and allows to increase the energy efficiency of the system by automating the process of energy supply contracts, and lowering energy losses and, consequently, consumptions, and to increase the shares of renewable sources (Marchi et al., 2019). Since information in blockchain cannot be altered without the permission, BT can improve the social dimension of sustainability (i.e., social justice) preventing the corruption of individuals, governments, or organizations from seizing the assets of people unjustly. Moreover, it can provide better assurance of human rights and fair work practices. For example, a transparent record of product information assures buyers that the product being purchased is supplied and manufactured from a verified ethical source (Mahyuni et al., 2020).

Supply Chain Relationship Management. Blockchain, thanks to the distributed ledger and the smart contracts, enhances the ability to communicate and collaborate between supply chain actors and fosters interactions among the entities in the system, without any need of intermediary in the market system (Kasten, 2020). This will address the asymmetrical issues among economic participants and allow peer-to-peer asset trading reducing the operational costs and increasing the speed of transactions. BT allows also to increase the trust between SC partners, which has a positive impact on supply chain relationship management and on the risks associated with collaborative activities (Wang et al., 2019). In a blockchain platform, entities spontaneously interact in a well-defined context, and are prevented from behaving unethically or opportunistically since any corruption or unethical behaviour will be readily visible to al network participants. The increased trust supporting collaboration between participant can also support the implementation of SCF solutions.

4 DISCUSSION AND CONCLUSIONS

The previous sections have shown the main effects of COVID-19 on the supply chain, highlighting the causes that led to a global crisis that affected so many sectors of the manufacturing world and beyond. In fact, the spread of the coronavirus has highlighted many potential weaknesses in global supply chain management. The potential adoption of blockchain in this area could have partially mitigated this impact. The trust and reliability that characterises the blockchain technology makes the relationships between actors involved within the supply chain more effective, facilitating the exchange of information and reducing potential opportunistic behaviour. The applications supporting traceability also ensure full real-time knowledge of the positioning of incoming goods, providing all the information needed to take corrective action in the event of delays in the lead times. BT also supports Supply chain Finance and supplier development which allows to reduce the

financing issues, especially for SMEs, by providing the platform and by increasing trust and collaboration among SC partners. Lack of supply of some nodes of the supply chain can lead to an increase in indebtedness, causing outbreaks that can have cascading repercussions on the entire supply chain, with significant effects on SMEs. The application of supply chain finance, with the support of blockchain technology, can certainly mitigate these effects. Traceability applications in the blockchain are also useful in effectively identifying the introduction of counterfeit products, or products that have not passed any quality controls. This is especially important for health products or even in the agri-food sector. Certainly, in very chaotic contexts such as that of a pandemic, having a reliable technology at one's disposal can prevent the introduction of potentially harmful products onto the market. This opportunity, however, is always valid especially in those contexts where the supply chain is very long and the possibility of having an effective control is scarce. This reduces the likelihood of the so-called bullwhip effect. These applications also reduce the need for national control by governments, avoiding restrictive policies that occurred during the covid-19 pandemic. The use of BT-enabled smart contracts is an important resource with precise clauses linked to the fulfilment of certain conditions set by the parties involved. The adoption of blockchain can also be a valuable support for the continuing waste increase, the repercussions of which have been stressed even more by the pandemic measures of social distancing and use of personal protective equipment. It is therefore clear that the application of blockchain technology has the potential to strengthen and make more effective those elements of supply chain management that have been challenged by the deployment of covid-19.

This paper aims to present the results of a preliminary study whose objective is to bridge the gap between research and practice regarding the application of blockchain technology to support supply chain management processes. The main limitation of this paper lies in the methodological framework of the preliminary study, as the relationships between the impacts of COVID-19 and blockchain applications are not supported by any reference framework. Moreover, the considerations made are purely theoretical, without concrete validation through empirical methods. Future research directions will be addressed to make the methodology of this research more robust, with the aim of demonstrating empirically how blockchain technology can support the reconfiguration of the supply chain in the post covid-19 era.

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