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ORIGINAL PAPER

THE IMPACT OF BLOCKCHAIN TECHNOLOGY ON OPERATIONAL AND STRATEGIC RISKS IN THE SUPPLY CHAIN - A SYSTEMATIC LIT-ERATURE REVIEW

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ABSTRACT. Purpose: Nowadays, the amount of data generated by companies is increasing dramatically every year. More and more processes are being digitised, forcing the use of ever newer techniques. With the growing amount of data, companies are facing the problem of ensuring easy access to data and its security. An increasingly popular solution is blockchain, whose implementation, however, entails a number of risks.
Design/Methodology/Approach: The article focuses on the analysis of the literature on blockchain and its use in the supply chain, regarding the changes and benefits brought by the introduction of the use of blockchain technology. The scope of the literature includes articles found in the Web of Science database, from 2016-2021.
Findings: Authors provides a brief introduction and description of blockchain technology both in general and in relation to the supply chain based on 45 articles. After a static part, the author describes the risks associated with the introduction of the technology and presents possible ways to solve them.
Conclusions: Authors of articles increasingly recognize the importance of blockchain technology to mitigate the risks of doing business. As a result, more and more solutions based on this technology are appearing, also in the supply chain.
Originality/Value: Strategic and operational risks associated with the implementation of blockchain are poorly described in the scientific literature. Through his analysis, the authors expand the supply chain literature with additional theoretical coverage.

Keywords: blockchain, supply chain, operational management, strategic management, blockchain application in supply chain

INTRODUCTION

More and more data is all around us and the amount is growing rapidly. In the 2020 1.7 megabytes of new data was created every second for every human being on the planet and the total accumulated digital universe of data grew to around 44 zettabytes. Because of that, more data was generated in the last several years than in the whole human race history (McCrea, 2017).

To visualize the scale, we can say that Google process more than 24 petabytes of data per day, Facebook upload more than 10 million photos per hour and CERN (European Organization for Nuclear Research) processes on average one petabyte of data per day, with transfer rates of 60 GB/s and 1 exabyte total data storage. (Tan et al., 2020; CERN Data Centre, 2020).

Big amount of data leads to the major issues - how to provide access in real time to them in a secure way. One of a solution resistant to almost any alternation of its data is blockchain (Jagtap et al., 2021). Nowadays many big companies work with blockchain technology or think about how to implement them. IBM in association with Maersk developed TradeLens – a solution for open and neutral supply chain, mainly for the container logistic, as a result of the research in the container shipping. Maersk found that the shipping goods from East Africa to Europe can

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require approval from around 30 officials from different authorities. This situation is turning as a big threat for the whole process of transport, because costs of the physically moving container can be sometimes even equal to the cost of moving - the cost of the trade-related paperwork processing is estimated to be between 15 and 50 percent of the costs of the physical transport. Moreover, due to long time food can spoilage and the documents might be subjected to fraud, so to keep track of all the paperwork companies need to use standardized interface, where every partner is empowered to have full visibility of the container status (Jagtap et al., 2021; Hackius and Petersen, 2017).

American multinational retail corporation Walmart also tried blockchain technology. Their solution works in food supply chain and test the transparency across Walmart's food supply chain for pork and tracing packages of sliced mangoes from its US stores back to its source Mexico farms. For the second one, the results were outstanding and reduced time needed for tracking mango origins from 7 days to 2.2 seconds (Kamath, 2018).

According to Brigid McDermott (IBM's Vice President of blockchain business development) blockchain can solves many business problems by providing data immutability. Therefore, blockchain is a new, promising technology which is called that it "*is poised to become the most exciting invention after the Internet*", resolving the lack of security via network computing (Zhao et al., 2016).

In this article, the authors focus on blockchain control in the supply chain. The main thesis is to determine the impact of blockchain technology on the level of operational and strategic risk in relation to the management of supply chain companies. The aim is to answer the question whether blockchain is able to reduce operational and strategic risks and to look for ways to solve the problems that have arisen. The analysis will be performed based on a bibliometric and network analysis technique and by evaluating 45 articles published in the years of 2016-2021.

REVIEW OF THE LITERATURE ON BLOCKCHAIN

What is blockchain

Blockchain was invented by Satoshi Nakamoto, the man who hides their personality, and being unmasked until today (Hackius and Petersen, 2017). The word of blockchain can be divided into 2 terms. First is "block" which is basic unit of blockchain and represents transactions, while second – "chain" links transactions into one chain. This two words combination is not accidental. Each block of blockchain contains a list of transactions which is linked to the previous block in the chain (Jović et al., 2020). Due to blockchain structure these transactions cannot be later modified or removed. That lead to improving the level of trust, because the longer the chain is, the harder to make modifications in previous block (Treiblmaier, 2018).

Blockchain design is different, depending on the technology application. In terms of openness and access to data we can distinguish three most common types of blockchain:

- Private (or permissioned) blockchain is a peer-to-peer network built on a platform managed by a single centralized institution. Users have well known each other and there is no anonymity. Access to the blockchain is restricted to specific participants and can be only granted by the validator of the system.
- Public (or permissioned-less) blockchain is a network with available access and open for anyone who can meet the requirements of blockchain technology. Open access brings anonymous users, usually without any relations with lack of trust among them. Popular example of public blockchain is bitcoin.
- Consortium blockchain is a type between public and private blockchain combining elements from both and refers to a blockchain whose accord procedure is constrained by prechosen hubs. The most notable difference from either system is consensus level (Kouhizadeh and Sarkis,

2018; Park, 2020; Gomathi et al., 2021; Saberi et al., 2018).

Blockchain in supply chain

Basic facts

Interest in blockchain technology has been seen in many business sectors. There is no surprise that this also concern the field of logistics and supply chain management (SCM). The interest in blockchain technology has been growing more and more and can be visible by the activities of practitioners devoted to this topic and journalist describing a new trend in logistics as well (Kummer, 2020). Both of them look at blockchain technology as a disruptive technology, which is poised to play a major role in managing, controlling, and most importantly securing devices (Khan and Salah, 2017).

Table 1. Difference between various type of blockchain

Attribute	**Public blockchain**	**Private blockchain**	**Consortium blockchain**
Access to the blockchain	Anyone	Restricted to single organization	Restricted to multiple selected organization
Consensus	Permissionless operated by anyone who can validate blocks	Permissioned operated by a single entity	Permissioned operates under the leadership of a group of entities
Network type	Decentralized	Partially decentralized	Hybrid between public and private blockchain
Participants know each other	No	Yes	Yes
Transaction speed	Slow	Fast	Fast
Security level	High	Low	Mixed

Source: own work.

Blockchain technology can simplify many procedures by coordinating transparency and documentation in accordance with the provisions. If there is a delay in some part of supply chain, the situation can be easier detected in the network and therefore implemented a contingent plan, to prevent harmful results of a delay in a supply chain. In traditional system multiple level of suppliers, distributors, service providers and retailers lead to inefficient communications record-keeping. In blockchain, numerous emails and telephone communications are replaced by a commonly agreed smart contract, which can save a huge amount of time and resources (Cai, 2018). Blockchain has many advantages which can leads to the conclusion that blockchain has the potential to solve some of the current problems with supply chains (Farouk and Darwis, 2019).

Advantages of blockchain in supply chain

The hotspot for blockchain initiatives in supply chain were food, diamond and pharmaceutical products. (Ghode et al., 2019; Etemadi et al., 2021). For example, for the food supply chain, a combination of radio frequency identification (RFID) and blockchain can track goods in real time based on hazard analysis and critical control point (HACCP) principles. Due to its ability to record events in the food supply chain, blockchain can detect unethical suppliers and counterfeit products (Saberi et al., 2018).

Next potential of blockchain supply chain advantage is secure money transaction. Using blockchain in money transfer of supply chain could reduce the timing of international monetary transactions of this nature to less than an hour. In addition to this blockchain

technologies have higher ability to avoid fraud and generate efficient transactions. Third party during the transaction are not necessary, that is why blockchain reduced transaction cost and improving trust within the supply chain network (Wang et al., 2018; Ghode et al., 2020).

Another advantage can be seen in multimodal transport, where multiple players at different stages of the supply chain generate a lot of data. Each player must have access to the relevant data, which necessitates the use of a system for each player to communicate (Bhushan et al., 2020). The emergence of technologies such as blockchain brings new life to this system. Higher quality real-time information flow can prevent disruption, resilience and the ripple effect (Etemadi et al., 2021). It is also related with security and safety of the data because this technology is false authentication resistant like preventing malicious users from launching DoS attacks or potential double-spending problem (Kshetri, 2017; Fernández-Caramés et al., 2019; Bhushan et al., 2020; Firdaus et al., 2019).

Disadvantages or treats of blockchain in supply chain

However along with the advantages, blockchain has also some disadvantages. Due to the huge total investments by the technology, not every company can afford to these changes. Many small and medium companies along with logistics operators lack knowledge about the blockchain. Building and deploying a private block-chain network requires much knowledge and its complexity and the associated cost are major obstacles for the adoption of the technology (Ismail and Materwala, 2019; Treiblmaier, 2019). In addition, the implementation of new technology is always high risk. (Tan, 2020).

On the other hand, in order to function properly, the logistics industry has to collect and store a large amount of data every day and therefore a high level of energy consumption is required to maintain the network. The development of this technology entails environmental concerns as it violates the original intentions of green development. In addition, when a large number of devices are connected to the system, real-time data collection leads to network congestion, which reduces the quality of service. Therefore, data transmission is also a huge challenge for the logistics industry (Tan, 2020; Wang et al., 2018).

It is also important to mention that any database (including blockchain-based database) is at risk of cyber-attack. One of the factors, which opens a window for cyber-attacks is the latency of transactions. Number of participants accessing to blockchain platform is crucial. Limited set of participants can cause more vulnerability to blockchain based system (Kshetri, 2017; Tribis et al., 2018; Sobb et al., 2020).

RESEARCHING METHODOLOGY AND DATA STATISTICS

Defining keywords

To gather articles, the authors used the Web of Science website. The search was based on several stages shown in the figure below.

The first step was to properly define the criteria. For this purpose, an advanced search was applied using keywords related to blockchain in the supply chain.

After finding articles on Web of Science, the author searched for articles whose topics of work and their keywords indicate a significant similarity with the topic of this article. Selecting a target group of articles, along with removing any duplicates that appeared, significantly narrowed down the number of articles needed to be reviewed. The next step was to read the articles and subject them to a more in-depth analysis, which resulted in a further number of articles being rejected. The final step was to prepare a second round of article searches. These activities were already focused directly on the topic of this article.

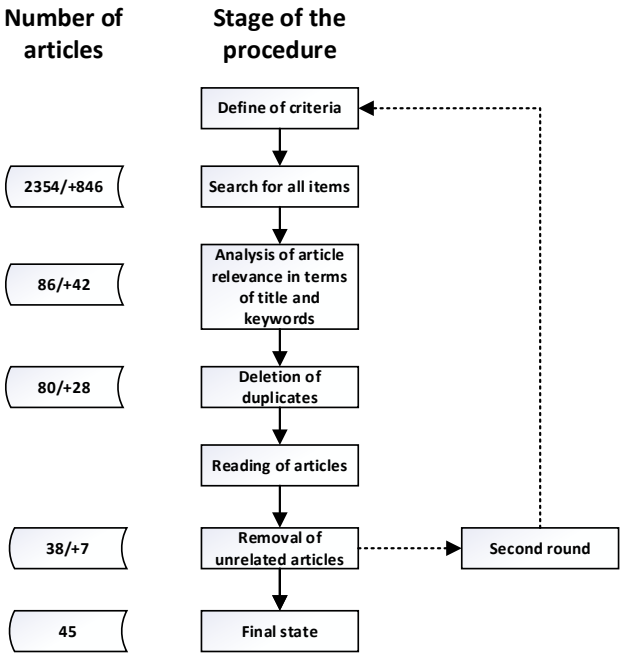

Fig. 1. Author's procedure for the collection of articles

Source: own work.

Table 2. Top 10 contributing countries

Country	Frequency	Country	Frequency
United States	10	Austria	2
China	8	Italy	2
United Kingdom	5	United Arab Emirates	2
India	4	Brazil	1
Australia	2	Croatia	1

Source: own work.

Data analysis

In this section, the author focuses on the statistical approach to the articles used in the paper. The aim is to further deepen the analysis and to identify the main trends followed by authors of articles around blockchain technology use in the supply chain.

Based on a table comparing the number of publications by authors in the countries concerned, it can be said that the top four definitely stand out. The results of the list indicate that these countries are crucial in shaping the theoretical view of blockchain in supply chains.

The number of publications in relation to the year of publication indicates a significant interest in the topic in 2020. The years 2018 and 2019 also stand out. Such a high share of articles over these years may be the aftermath of the increase in interest in blockchain technology in recent years, which only highlights the importance and timeliness of the topic under analysis and the dynamically developing cooperation between the business and scientific spheres, resulting in more and more solutions based on blockchain technology.

The above figure showed a graphical visualisation related to the keywords used across all the articles analysed. As it turns out, the results are heavily mixed. However, most of the keywords resulting from blockchain are related to logistics, supply chain, business and social economy, science and technology or technology in general.

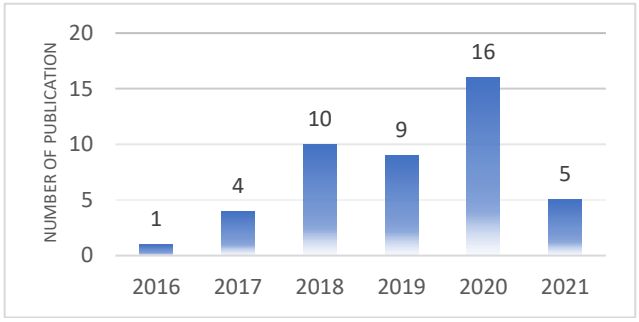

Fig. 2. Number of publications over the years

Source: own work.

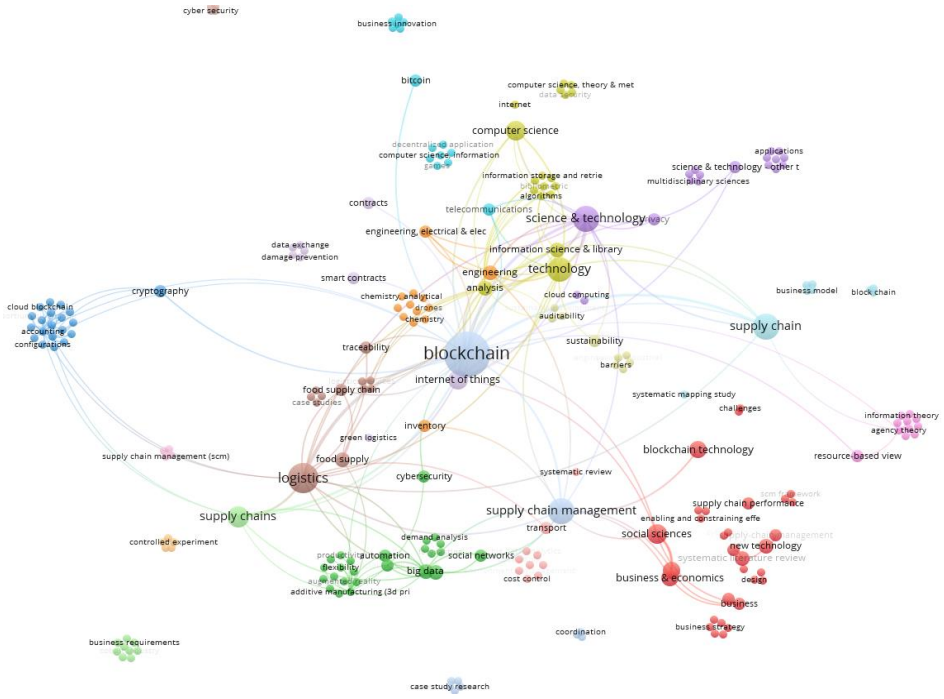

Fig. 3. Network visualization for keywords

Source: own creation.

OPERATIONAL AND STRATEGIC RISK IN BLOCKCHAIN BASED SUPPLY CHAIN

Introduction

Implementation of a new technology is almost always subject to risk. Blockchain's implementations are also not without challenges (Wang et al., 2020). In supply chain there are many non-predictable factors which can influence both goal definition and methods to ensure goal achievement. That is why strategic and operational planning in logistics management are difficult processes with high strategic risk. Many firms face the problem of external pressure which leads on the one hand to push the introduction of technology due to competitive pressure and on the other hand to delay its adoption when there is no support from top management. On the other hand, high organisational readiness and information and communication readiness are the main factors enabling firms to adopt new technologies in the supply chain (Sternberg et al., 2020).

Moreover, for analysing strategic sustainability and a complex cyber-physical system it proves necessary to implement more modern methods. Blockchain – one of the

proposed solutions - can accelerate assessing the strategic risks even during the first steps of strategic creation and depending on the environment yields a smaller level of operational risk compared to the traditional supply chain counterpart (Raikov, 2019; Choi T-M, 2020).

In addition to analysing the many benefits of blockchain technology and the decisions of other supply chain participants to adopt and integrate this technology, particular attention should be paid to highlighting the barriers and operational and strategic risks, in adopting this technology. The authors of the article (Sternberg et al., 2020) and (Hopkins and Hawking, 2017) point to many barriers. Some of these are:

- Lack of standardisation and technological issues,
- Possible attacks,
- Information exchange,
- Necessity and trust,
- the "garbage in, garbage out" - (GIGO) problem (Sternberg et al., 2020; Hopkins and Hawking, 2017).

Further analysis will be based on the listed risks for operational and strategic management in the supply chain.

Lack of standardisation and technological issues

Fraud in supply chains is a serious problem for both organisations and their customers (Falcone et al., 2020). One of the main sectors dealing with fraud is pharmaceutical market. According to the World Health Organization (WHO), in 2017 alone, counterfeit drugs had a significant 10% share of the pharmaceutical market in low- and middle-income countries (Pournader, 2020). The challenge is exacerbated in the case of internet sales. The online drug market remains highly unregulated, but blockchain can help prevent illicit product from entering companies' supply chains. Theorists have already proposed a blockchain-based model for drug supply chain management to create transparent data on drug transactions and implement network surveillance and thus solve some challenges such as poor traceability or lack of real-time information. Blockchain-based traceability systems can help companies comply with regulations and record ownership transfers (Hastig and Sodhi, 2020; Xue et al. 2020). However, to prevent fraud it is necessary to structure the medicines market and introduce clear business requirements regarding traceability. Therefore, European Union (EU) has passed the Falsified Medicines Directive, which forces the pharmaceutical firms and other actors in their supply chains to implement full traceability by 2019. Similarly in the United States, Drug Supply Chain Security Act (DSCSA), gives a deadline for 2023. As it turns out, the elimination of the supply chain of counterfeit medicines is essential in order to increasing control of the adverse effects of these medicines, which have a significant impact on increasing resistance to medicines among patients, not treating or may even cause the death of the purchaser. This in turn leads to a risk of human error in operational management and subsequent allocation of the wrong medicine. Using blockchain (or other technologies) in the supply chain to digitise and automate transactions could improve the responsiveness and operational efficiency of pharmaceutical companies (Pournader, 2020; Hastig and Sodhi, 2020).

Possible attacks

From an operational risk perspective, it is important to mention the impact of blockchain technology on resilience or limiting the negative impact of a system-wide failure. The decentralised form of blockchain results in a better solution to these risk factors due to the dispersion of information and security among many participants rather than the concentration on a single player. As past events have shown, the introduction of blockchain technology could protect against cyber-attacks on Equifax or the US National Security Agency, where millions of customer records were stolen. One giant attack vector from millions of data points in the old model becomes millions of attack vectors, making it much less cost-effective to hack end users one at a time. This in turn leads to a transfer of risk to endpoints that are responsible for managing their own digital assets (Etemadi et al., 2021; Hald and Kinra, 2019).

Access and exchange of information

Another risk in supply chain management is related to information flow. The right approach to running a business necessitates the appropriate exchange of information, which, as a fundamental element of dynamic supply chain capabilities, can affect business performance. Previous technologies that used common data structures risked a lack of control over data and systems. Due to these issues and the need to ensure data is accurate and up-to-date, businesses are increasingly turning to blockchain-based solutions. In addition, some customers and consumers may start to turn to suppliers that provide more complete information about the history of their products, and this could lead to radical changes in the market and force some sectors of the supply chain to adopt the new technology (Falcone et al., 2020; Hald and Kinra, 2019).

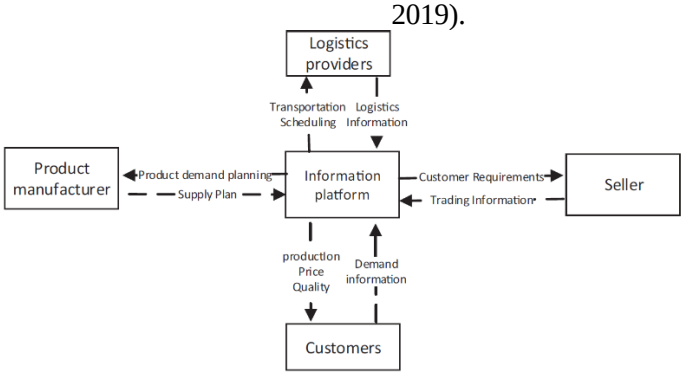

Fig. 5. Information sharing structure

Source: Xue et al. 2020

The supply chain is sensitive to changes in demand. This is particularly evident in long supply chains consisting of many links, where a small change in a customer's order can lead to radical changes in the chain's businesses. Blockchain can lead to the resolution of the bullwhip effect, which in a traditional system could lead to demand for predictive failure and blind production. Blockchain technology plays an important role in promoting the creation of a customer-centric information exchange structure and the implementation of information exchange in the supply chain. The key to eliminating bullwhip is to implement proper information exchange in the supply chain, which in turn will reduce information distortion. However, the implementation of blockchain technology in supply chain partner networks is complex because the full use of the technology is only revealed when partner companies choose to implement the new technology and share information, and employees actively use the technology's capabilities (Falcone et al., 2020; Xue et al. 2020).

The "garbage in, garbage out" - (GIGO) problem

Data falsification by employees or by an IT system is one of the next risks in supply chain management. This action can be intentional or the result of human/system error. Blockchain technology, as an embedded software agent, provides continuous validation, verification and distribution of transactions in real-time based on specific processes that are encoded into the system of all transactions in the block, making data and transaction fraud significantly more difficult. Blockchain only performs those operations that have been coded, defined and applied by their designers, so that participants, data controllers and accountants across the supply chain will only perform the tasks that have been designed for them. Because traditional third parties - such as banks, brokers and other organisations - are driven by human intervention, there is the potential for opportunism, favouritism and bias. In addition, the use of smart contracts without a centralised entity (e.g. banks or logistics providers) to control operations, along with their digitisation with assets, allows for a trading environment free of intermediaries

with full transparency and trust among each group of stakeholders involved in the trade (Falcone et al., 2020; Pournader, 2020).

However, for blockchain to work properly it is necessary to provide the right data. A human error during data entry, such as a supply chain link reporting a lower inventory level than it actually is, will lead to a smart contract automatically placing an order. Such data, if incorrect, is relatively difficult to correct and requires additional time. In addition, there is always the risk that the private key of a node in the blockchain (in this context, a node represents a tier of the supply chain or transport intermediary) is lost or corrupted and prevents the use of the blockchain (Pournader, 2020).

Confidence and trust building

Trust between supply chain participants allows for joint decision-making and therefore better responsiveness of the entire supply chain to movements or trends, or market disruptions. This problem became crucial during the COVID19 outbreak, where it is necessary to increase operational supply chain flexibility, improve response traceability, real-time coordination and the ability to reconfigure resources during recovery phases and ensure a robust and resilient supply chain. Blockchain technology eliminates some of the above issues and ensures secure information exchange while building trust. This is due to many factors, the most important of which is the visibility of data to participants and the reduction of fraud. Additionally, a blockchain-based data chain, unlike a traditional central mechanism, updates and maintains its database in a distributed form, which in itself enforces, to some extent, increased trust between participants in the new technology (Teodorescu and Korchagina, 2021; Etemadi et al., 2021; Sternberg et al., 2020; Hastig and Sodhi, 2020).

Summary

The introduction of blockchain technology into a business must always be analysed in advance in terms of the benefits of its implementation. Changing standard operating procedures and policies can be a difficult and risky task. The change must also include new business processes. The scalability, interface and speed of the new technology must also be taken care of. From an operational efficiency perspective, blockchain is able to automate the verification of transaction attributes in an inexpensive way, and the operational risk of a blockchain-supported supply chain brings a lower level of operational risk compared to a traditional supply chain counterpart (Fernández-Caramés et al., 2019; Choi T-M, 2020).

However, from a strategic management perspective, there are significant risks before the introduction of blockchain. The technology does not address all the problems in supply chains. It is therefore not a one-size-fits-all solution. Blockchain is a new technology, so companies need to assess whether they want to be at the forefront of change or wait until the technology matures. It is important for players to identify the right network and underlying platform to participate in, as it involves different levels of risk to business strategy as well as the limitations of the supply chain ecosystem. Additionally, companies also need to pay attention to how entities will be impacted after the shift to blockchain. Some companies believe that they will need to implement blockchain in the near future to have a competitive advantage, although in reality there is not always a need (Hastig and Sodhi, 2020; Choi T-M, 2020).

DISCUSSION&CONCLUSIONS

The literature review conducted showed that blockchain allows to reduce operational risk, thus supporting supply chain management. The impact of blockchain on the strategic risk of supply chains is significantly lower. However, risk mitigation alone is usually not enough for companies to decide to redesign their business structure.

To achieve true efficiency in the use of blockchain or any other technology, it is necessary to redesign, not just automate, existing processes (O'Leary, 2017). This is particularly important because research indicates that 80% of the effort to implement blockchain relates to changes in business processes - only 20% of the effort is to implement the technology itself. The

division of effort suggests that companies can implement most of the traceability activities through process changes before implementing blockchain (Hastig and Sodhi, 2020). Such a change is therefore both time-consuming and costly. Furthermore, the currently available blockchain case studies lack a common standard, making it difficult to systematically transfer these cases to industry programmes. The reason for this is largely due to the immature nature of the technology. For many researchers, access to early initiatives can be a major barrier (Patelli and Mandrioli , 2020; Wang et al., 2020). Furthermore, most larger companies have already invested in ERP, APS, CRM or other IT systems that they use. Therefore, a blockchain-based solution would need to integrate with these existing systems to varying degrees. Furthermore, these companies and their supply chain partners would need to redesign the processes involved in using these systems (Hastig and Sodhi, 2020).

On the other hand, the purpose of blockchain is not just to mitigate risk. The main value that makes more and more companies decide to implement it lies elsewhere and depends mainly on the company and the industry it is in. For Walmart it has been to increase transparency across the food supply chain, for Maersk and IBM it has been to reduce the time and cost of documenting cargo movements and prevent fraud, while DHL, together with Accenture, is focusing in using blockchain to track pharmaceutical products from origin to consumer and prevent tampering and errors. It can therefore be seen how broadly blockchain technology is used. The literature review shows that blockchain will have a significant impact on the development of businesses in the coming years.

By accelerating turnover, increasing efficiency and facilitating relationships with partners through digital platforms, blockchain will lower barriers to entry across the supply chain - driving innovation and momentum in the industry and enabling reverse logistics at no additional cost (Farouk and Darwis, 2019). Blockchain can support decision-making on everything from warehousing to delivery to payment. The technology has gained attention mainly due to its combination with smart contracts (Kumar et al., 2019).

Currently, blockchain is still in its early stages of development. An example of 10 practical applications of blockchain in supply chains, described within the Appendix, shows that some of the examples are at the design stage or in the early stages of existence. The wide range of application possibilities makes it difficult to introduce clear standards of practice for the transformation of businesses and the implementation of blockchain applications into them. This in turn does not accelerate the development of the technology itself. Despite this, it is noticeable that there is considerable interest in blockchain technology especially by large enterprises, which are becoming precursors of development. The advantages of blockchain technology, led by: increased security of the technology, prevention of cyber-attacks, making it more difficult for data falsification and mistakes to be made by employees, increasing trust between supply chain participants, facilitating the flow of information, increasing the transparency of the entire supply chain, all of which impact on risk, will be one of the key benefits to implement blockchain to companies. The next few years are probably crucial for the companies and the direction in which the blockchain technology will develop.

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