

INDUSTRY 4.0: BLOCKCHAIN AND ITS APPLICATION POSSIBILITIES IN MARITIME TRADE

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ABSTRACT

The objective of the current research is to provide an overview of how blockchain can contribute to maritime logistics operations through an analysis of initiatives already carried out in the sector. This is an exploratory, initially bibliographic research conducted by searching the databases of the online journal platforms Scielo, Google Scholar, and CAPES Journals Portal. In view of the novelty of the topic, there was a need to conduct research on different academic databases, such as business forums and search engines. Prospective monitoring of the application of the technology in maritime logistics was therefore carried out. The results point to the use of blockchain were: 1. in bill of lading management (freight knowledge); 2. in a joint venture between Maersk and IBM in the development of the “Tradelens” platform, to facilitate documentation involving the cargo to be transported; and 3. in the consortium formed by AB InBev, Accenture, APL, Kuehne+Nagel, and the European Customs Organization for Blockchain-based solutions.

Keywords: Blockchain, Maritime Logistics, Industry 4.0

INTRODUCTION

The sea is fundamental for international logistics in a world of high connectivity and interconnections. Talking about sea or maritime trade may sound out of place or outdated, but when it is observed that around 90% of world trade has a port as its origin and destination, the importance of the logistics performed by this transport modal is understood.

On the contrary, since the end of medieval times, the range of complexity involving maritime trade has been highlighted by paper documents that were issued by carriers for goods loaded on merchant ships. This practice has grown in complexity, evolving from the issuance of paper receipts and recording of freight on board the ship in a parchment book, passing through the issuance of rudimentary versions of paper bills of lading, acknowledging receipt, and later containing contractual arrangements. Eventually, these receipts took on more sophisticated characteristics and may even be traded on the stock market. These and other “bureaucracies” seem to have crossed the century and are still plaguing maritime logistics transactions today, in such a way that in current circumstances, paper bills of lading are still present in international trade, making transactions difficult.

Thus, it is not only bureaucratic procedures make maritime logistics challenging. Maintaining product quality, facing the challenging environment of the sea, entering and leaving ports with loading and unloading of goods, optimization of routes, and high costs involved in the transportation itself are some of the listed difficulties.

In this context, technological advances have ramifications in logistics, which commonly referred to as Industry 4.0, which can contribute to overcoming the challenges presented here.

Thus, entering the subject matter of this article, it can be said that there is a consensus among researchers in the field of logistics operations that the blockchain concept has great

potential for impact in the supply chain area. A potential advantage that blockchain technology can provide is the availability of more transparent information, enabling the tracking of the chain as a whole, helping companies optimize value creation.

In this sense, the objective of this research is to provide an overview of how blockchain can contribute to maritime logistics operations through an analysis of initiatives already carried out in the sector. This is an exploratory, initially bibliographic research, searching the databases of the online journal platforms Scielo, Google Scholar, and CAPES Journals Portal. In view of the novelty of the topic, there was a need to conduct research on different academic bases, such as business forums, Google search tools, and YouTube videos. Prospective monitoring of the application of the technology in maritime logistics was therefore carried out.

To achieve the general objective, the article is structured in a theoretical framework that encompasses the ideas of logistics, supply chain, Industry 4.0, and the conceptualization and framework of blockchain in maritime logistics. It follows the description of three cases of application of the subject matter as an initial way to monitor the use of the technology in the field of study. Brief conclusions are finally drawn on the subject.

THEORETICAL FRAMEWORK

Logistics

The term logistics refers, in its historical sense, to military activities, with regard to preparation for war, as a way of securing supplies to the battlefield. Such wars required large displacement of personnel and material, which created the need for organization. For this reason, for a long historical period, logistics was basically related to military activity. However, after the World War II, it was then that the term became popular within civil activities (Ballou, 2010).

Ballou (2010) states that, despite the primacy in logistics in the military sphere, its greatest evolution occurs from the spin-off to the business sector, in line with the scientific community, which, in the search for processes that would enable greater competitive advantage, promoted a series of researches, which under a first perspective, resulted in the evolution of concepts for the emergence of the “Chain of Supply”, referred to in the literature as supply chain.

In this way, Ballou (2010) defines logistics as a process related to the activities of movement and storage and of facilitating the flow of products from the initial collection points, such as raw material acquisition, till arrival at the point where final consumption will take place. This concept also includes information flows that allow products to have accurate times and movements. This dynamic needs to be aimed at maintaining the appropriate service levels for customers (whether internal or external) based on a reasonable cost balance. Thus, logistics is an element that becomes a value-adder for products and services, which unfolds in high levels of customer satisfaction.

Conversely, Pozo (2007) states that logistics

(...) deals with all handling and storage activities, which facilitates the flow of products from the point of acquisition of the raw material to the point of final consumption, as well as the information flows that set the products in motion, in order to provide adequate service levels to customers at a reasonable cost (p. 17).

There is also the classic explanation coined by Ballou (2001) that defines the logistics activity of placing the right products at the right time in the right place and at the lowest possible cost as the main goal of this activity.

In this sense, costs turn out to be the most difficult factors for correct logistics management. If it were not for the costs, the concern would only be to maintain the level of logistical service, but that is not the case. Ballou (2001) argues that the logistics cost is the second largest expenditure of a company, being lower only than the cost of the product, given the relevance and importance of logistics activities. Reducing logistical costs is therefore of paramount importance for the success of an organization.

In view of the above, it is understood that the logistics system is highly complex. The management of its variables, which are often conflicting from the point of view of optimizing logistics processes, requires in-depth knowledge, not only of logistics as a whole but also of its subsystems, business functions, as well as the factors that influence the organization's relationship.

Supply Chain

While logistics has the role of focusing on operations within the organization itself, the supply chain ends up expanding this view by observing the processes from the first to the last links of the supplier and customer chain (Machline, 2011).

In this view, since 1963, the Council of Logistics Management, currently called and known as the Council of Supply Chain Management Professionals (CSCMP), aims to spread awareness of the meaning of the supply chain for companies and the economy. The most up-to-date concept of the CSCMP points to the supply chain as the link that connects suppliers, service providers, and customers, starting with the manufacturing of raw materials to be transformed until the use of finished products, comprising, throughout this logistical process, the exchange of materials and information (CSCMP, 2013).

The supply chain can thus be also understood as a set of geographically dispersed facilities interacting with each other. Examples include raw material suppliers, production plants, distribution centers, and retailers (Leal et al., 2005). In addition, in the supply chain, it is understood that the logistical functions may be repeated several times until the product or service reaches the last point in the chain (Ballou, 2006).

Finally, in view of the benefits presented to organizations, there are two main obstacles that can be envisioned in the supply chain: reconciling the reduction of costs with the maintenance of the service level and the reduction of uncertainty in face of lack of accurate demand predictability. However, regarding the uncertainties, the accuracy of the forecasts is not sufficient to solve the problems, which end up leading to delays in deliveries, manufacturing difficulties, delays in transportation times, and other specific factors that impact the supply chain (Moori, 2011).

Ports, Logistics and Maritime Transport

The ports are ordered with a view to meeting logistical strategies and end up operating with connections between ships, national and international production systems, intermediaries, until reaching consumer markets, having a core function to eliminate or reduce the intertwining between the port bureaucracy and the next mode of transport, after all, the port is hardly the final destination of the goods. In this way, the port system becomes a strategic factor in the performance of the stakeholders of a national economy, namely: terminal operators, port authorities, cargo and production agents and society in general. Therefore, ports have become a

strategic element in the process of creating networks to develop and carry out the activities of these actors (Lee-Partridge; Teo & Lim, V. K, 2000).

In this sense, it is worth evaluating port management as a maximizer of the maritime logistics operation with the aim of increasing the profitability of the business through the optimization of the port operation, which involves the use of berths, equipment and cargo handling, in order to obtain the best possible use of the turnaround time. Thus, checking the ship's time in port allows managers to detect possible bottlenecks, space conflicts, operational use and capacity problems. (Branch, 2007).

Supply Chain Performance and Optimization

One of the main objectives of performance management for supply chains is to provide an understandable and updated overview of data on information about the performance of a business. The important contribution of a supply chain performance monitoring and evaluation model is to be able to detect the weaknesses of the business and make a decision on how corrective actions may be implemented in order to assess the impact of these actions on the performance of the whole (Kueng et al., 2001).

In this sense, performance measurement contextualized to supply chains is proving itself to be fundamental. The reason for this is that organizations tend to seek ways to improve their operational performance through an improvement in the integration of operations in the value chain. Thus, the ability to measure and evaluate the performance of operations can be seen as a business need, given that enormous resources are spent over the years to develop systems for measuring performance for this purpose (Kueng, 2000).

Finally, the implementation of new technologies in the supply chains, including those that have disruptive potential, allows the implementation of adequate means to carry out this process through performance evaluation, in order to achieve supply chain optimization.

Industry 4.0

The term “Industry 4.0” or “4th Industrial Revolution” emerges at the Hannover fair in 2011. This proposal arose in view of the necessary development of an approach that would follow a competitive path for the German manufacturing industry, given the Asian pressure due to the dominance of the sector, given the low cost of labor in that world region (Hermann et al., 2016).

In the following year (2012), the creators of the Industry 4.0 project, Siegfried Dais, from Robert Bosch GmbH, and Kagermann, from Acatech, developed a report of recommendations for the German Federal Government in order to plan how the implementation of Industry 4.0 would take place. In 2013, at the same Hannover fair, there was finally the last edition about this new industrial perspective (Silveira, 2017). The trend of this new industrial model is based on the digitalization and intelligent automation of the manufacturing environment (Oesterreich and Teuteberg, 2016).

The fourth industrial revolution is not only a linear evolution of an ongoing third revolution but a disruption in the status of what is known as the production of products and services, as it offers the opportunity for more agile ways with regard to governance, integration, and economy of scale to transform the *modus vivendi* of humanity. Thus, emerging technologies may provide benefits to industry and society, remembering, however, the negative social impacts of previous industrial revolutions that may also take place in this new stage (Schwab, 2019).

Silveira (2017) points out that the basic rationale of Industry 4.0 is that by connecting systems, machines, and assets, companies can create, including among themselves, intelligent networks; hence, the production modules will be autonomous and self-controlled.

Zawadzki and Zywicki (2006) state that this new industrial model is the synergy of the development of various technologies that end up connecting the concrete world and the real problems to the virtual world. Thus, this is a model in which innovative solutions to problems along with strong use of technology are sought.

The fourth industrial revolution, however, is not just about intelligent and connected systems and machines. Its scope is much broader. Waves of new discoveries happen simultaneously in areas ranging from genetic sequencing to nanotechnology and from renewable energies to quantum computing. What makes the fourth industrial revolution fundamentally different from the previous ones is the fusion of these technologies and the interaction between the physical, digital, and biological domains (Schwab, 2017).

Lasi et al. (2014) address the bases of Industry 4.0, outlining the present paradigm as follows:

1. Self-organization with decentralization of manufacturing systems;
2. Use of different channels, in a more individualized way for distribution and acquisition systems;
3. Open innovation, intelligence, and memory approaches in the development of products and services, generating a more personalized offer;
4. Adapt to human needs and innovative solutions to problems that were not seen by the client; and
5. Social responsibility with a focus on sustainability and efficient management of resources in manufacturing processes.

According to a report by PwC, entitled “Industry 4.0: Building the digital enterprise” (PwC, 2016), the term Industry 4.0 can be better understood as a new system of organization and control of the value chain, from the perspective of the product life cycle, focusing on increasingly individualized customer requirements. A cycle begins with the conception of a product, going through the request of purchase orders, and extending up to the delivery to the final customer in after-sales rounds, not forgetting about the services arising from these processes. The key words here are interconnection, interconnection, and interaction. Thus, it can be said, according to the report, that the main pillar of the fourth industrial revolution is the availability of all relevant information in real time, connecting all the instances involved in the value chain. In addition, the improvement in the ability to identify value-adding steps at any time is also central to the process to succeed in a safe and transparent manner, taking into account efficiency and effectiveness.

In addition, among the existing technologies, Schwab (2017) identifies blockchain as one of the technological innovations that will provide scope to the fourth industrial revolution, being one of the technologies with easy scalability and rapid deployment. Along the same lines, PwC’s report “The Future of the Industry: Breaking Barriers and Expanding Boundaries” also points to blockchain technology as one of the drivers of Revolution 4.0 (PwC, 2017).

Blockchain

The same PwC report states the following regarding blockchain:

(...) it removes the need for institutions that guarantee reliability in financial, contractual, and other activities that require authentication and verification. Reliability is distributed along the chain (blockchain). The technology has the potential to disrupt a wide variety of transactions that occur through the traditional payment system. Why can this happen? Because blockchain records and authenticates all stages of a transaction, and, in principle, can be used to secure and verify any type of transaction, making it useful for industries in various sectors (PwC, 2017, p. 6).

Iansiti and Lakhani (2017) state that blockchain is a network that supports an open and decentralized database in a kind of a fully verifiable “ledger” that can record transactions between two parties in an efficient, verifiable, and permanent way, in addition to being able to program it to activate the transactions automatically.

The blockchain is like a digital ledger, since it is a transaction record database that is maintained through a network of connected computers, which also maintain all transactions, in order to avoid fraud and guarantee the uniqueness of the transaction, that is, so that there is no same unit of currency being traded twice (Nakamoto, 2008).

This process of public registration of transactions is a chain of blocks (blockchain) characterized by a decentralized model, depending on the use of a peer-to-peer network, enshrined in the P2P term. In P2P networks, the nodes or points of the network perform the function of client and/or server, allowing decentralized operations, with no single server or central authority in data control (Nakamoto, 2008).

Schwab (2017) points out that blockchain can, in fact, often be described as a “distributed ledger,” through a secure protocol in which a computer network, the so-called miners, collectively and by consensus verify a transaction before registering and approving it in the “block.” The technology thus creates trust, allowing people who do not know it to collaborate without having to go through a neutral central authority, for example, a banking institution or even a central bank, that is, a depository or central ledger.

According to Tapscott and Tapscott’s (2018) viewpoint, blockchain is, in fact, a kind of an encrypted protocol of trust that establishes, through an algorithm, distributed and decentralized calculations that end up ensuring the integrity of the data exchanged between “billions” of points without going through a trusted third party.

In this context, Bitcoin is the most well-known blockchain, given the speculation surrounding the digital currency. However, this is the “tip of the iceberg.” This research demonstrates this by highlighting the use of blockchain in activities other than bitcoin.

Abdellatif (2018) analyzes that blockchain technology can be applied in various solutions to existing problems and risks in asset management (supply chain management and energy market) or data management (e.g., registration, identity management). Thus, smart contracts that amplified the functions of the blockchain, expanding it to new areas and applications, were introduced.

It is notorious to point out that blockchain applications are not limited to cryptocurrencies but to a technology that can be possibly applied to several other areas and new forms of transactions. For example, the application of smart contracts with blockchain technology has become a technology known for carrying out transactions, not only financial, in which the

validation of the criteria for their effectiveness is carried out in a decentralized way, auditable, involving data integrity, trust, and security (Yli-Huumo et al., 2016).

Therefore, several applications to the technology can be applied, as in the case of the study in the area of logistics.

Analysis of Blockchain Cases Related to Maritime Logistics

VeChain, a cryptoasset linked to logistics. VeChain is a blockchain platform with a focus on supply chain. The cryptoasset was launched in June 2016 and aims to use blockchain as a distributed governance system and integrate it with the Internet of Things technology to create an ecosystem for solving existing bottlenecks in the supply chain (Coinmarketcap, 2021).

VeChain is a digital asset with a market capitalization of USD 5.07 billion and ranked 20 in the global cryptocurrency market share rating, with an average daily transaction volume of USD 432.11 million, and is listed under the acronym VET on the main crypto exchanges (Beincrypto, 2021).

The technology adapted from the blockchain exists to be disruptive, in view of the traditional supply chain model that has experienced only incremental changes in recent decades, such that the crypto asset tries to use the transparency, decentralization, and governance power of the technology to increase the efficiency and traceability of supply chains, reducing costs and making processes autonomous. There are also security gains by facilitating the tracking of products in a supply chain. On the contrary, cost reduction occurs via the “trust without trust” (trustless) system, in which the confirmation of authenticity and veracity of transactions along the chain occurs without the need of human intervention (VeChain, 2021). Finally, the following are two practical examples of asset functionality.

In June 2019, the result of joint work among Walmart China, VeChain, and PwC, the Walmart China Blockchain traceability platform was launched on the VeChain platform. This is how it works: through a QR code, customers can acquire detailed product information, such as origin, transportation, veracity verification of the information, providing visibility, and management efficiency of the entire chain of the chosen products, using decentralized blockchain technology and tamper-proof (Boxmining, 2019).

ASI Group, in a tripartite collaboration with VeChain and DNV, started the first cross-continent logistics and commerce solution with the VeChain ToolChain™ technology for the food and beverage industry called Foodgates. It is the first solution of its kind, as it is powered by a public blockchain with verified and certified information of the entire life cycle of the products being tracked, such as cow selection, slaughter, packaging, and continental shipping to restaurants for meat products (VeChain, 2021).

Global Share Container Platform (GSCP). Blockshipping’s GSCP is already, unlike VeChain, a cryptoasset directly linked to maritime logistics, as it was designed to create processes using blockchain for global container management significantly more efficiently than the current practice. The idea is to take stakeholders from key processes in a shared container management system. Stakeholders include manufacturers, carriers, marine terminal operators, governments, as well as proprietary freight agents in order to achieve cost savings with real-time knowledge (Blockshipping, 2021).

The project, in short, actively monitors and tracks containers. Peter Ludvigsen, who was previously the CIO of Maersk and the founder of the crypto asset company, explains in a video that the material transported in containers results in an approximate annual value of USD 12 trillion; however, there is no unified record of their movement, and there is lack of real-time

tracking, resulting in a range of unnecessary movements of them. Ludvigsen also argues in the same video that container transport accounts for about 60% of all global maritime trade but faces serious operational problems (Blockshipping GSCP, 2018). Likewise,

(...) the GSCP tends to be kind of a global trading platform for all types of services related to container handling among all players in the maritime transportation sector. The use of our platform will allow the global shipping industry to reduce its costs by up to US\$5.7 billion annually (Computerworld, 2021).

In face of the presented prospects, some considerations on container transportation are noteworthy. In a survey conducted in the United Nations Conference on Trade and Development (UNCTD) database, called UNCTDSTAT, this author verified the historical evolution of container handling in ports by TEU, which resulted in the following graph see figure 1.

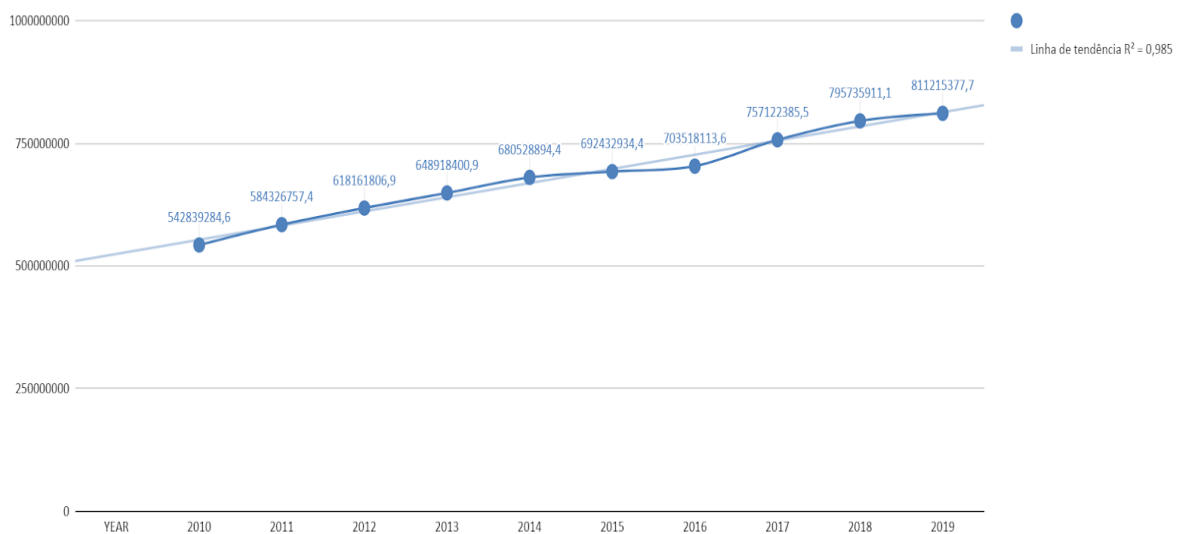


Figure 1
ANNUAL CONTAINER HANDLING

Source: Prepared by the author himself, based on UNCTDSTAT data

The graph shows the trend of annual increase in container handling, leading to the belief corroborating the linear trend line, with a coefficient of determination R^2 of 0.985, the increasing marginal addition, year by year, in this type of movement; therefore, it is essential to obtain ways to perform better management of this material transportation tool.

The use of blockchain in bill of lading management. As described, the advent of blockchain technology has been inaugurating changes in maritime logistics, among which there is the long-awaited change in paper bills of lading. Port centers, including Singapore's vigorous port, are exploring the possibility of digitizing trade and maritime documentation, such as bills of lading, using blockchain technology (Ong, 2018).

However, the problem lies in what is called the managerial gap, that is, the gap between legal aspects and disruptive technological solutions. Therefore, there is considerable uncertainty regarding the legal value of blockchain-based bills of lading, to the point that this issue dominates the discussions about maritime trade and the presented technology, such as electronic bills of lading (NGO, 2018).

The fact stands that if there is no adherence by public authorities, electronic bills of lading in the registration model are not suitable for use as bills of lading in jurisdictions governed by law. This is the point under the spotlight and of attention.

The next two topics are intertwined with this one, as they present developments regarding the discussion of the use of blockchain in the management of bill of lading (freight knowledge).

The joint venture between Maersk and IBM in the development of the “Tradelens” platform to facilitate documentation involving the cargo to be transported. At crucial stages of the logistics chain, difficulties may arise from obtaining credible information about the concreteness or estimation of remittance data. On the contrary, the absence of documents, combined with customs bureaucracy, can impact the maritime transport of supplies.

In this sense, the TradeLens platform, an IBM and Maersk partnership, presents a more comprehensive and consistent view of data on remittance events, in addition to composing the corresponding documents in these shipments, which are delivered directly to the sources participating in the process.

It is a central source of shared information powered by partners with permission, who are part of the supply chain to promote collective success (Dartamars, 2020).

TradeLens gathers data in a global supply chain ecosystem, having as actors shippers, port operators, and shipping lines, replacing manual and paper-based documents with blockchain-enabled digital solutions (DP World, 2020).

It is worth mentioning that the collaboration between DP World, a multinational port administrator, and the TradeLens platform accelerated the digitalization of global supply chains. With the technology, DP World can connect all of its 82 sea and land container terminals as well as feeder companies and logistics divisions with TradeLens. In 2019, DP World terminals handled 71.2 million TEU (20 foot equivalent unit) of containers from around 70,000 ships (DP World, 2020).

In short, TradeLens is an interconnected ecosystem of supply chain partners: cargo owners, sea and land carriers, freight forwarders and logistics providers, ports and terminals, customs authorities, and any other stakeholders connected to the platform through execution of a permission matrix and blockchain, ensuring that each part of a shipment has access only to their pertinent information and a secure audit trail of all transactions (Tradelens, 2021).

In figures, TradeLens is already handling more than 700 million events and 6 million documents a year, streamlining decision-making, and reducing administrative hassles in trade (Tradelens, 2021).

Consortium formed by AB InBev, Accenture, APL, Kuehne+Nagel, and the European Customs Organization for Blockchain-based solutions, in order for companies to reduce costs by reducing the number of printed shipping documents. The consortium formed by AB InBev, Accenture, APL, and Kuehne+Nagel, in addition to a customs organization in Europe, developed a blockchain-based solution. Through this technology, costs are reduced by reducing the number of printed shipping documents (Accenture, 2020).

The solution does not require the physical or digital exchange of documents so that the relevant and interesting data for the participants is shared and distributed using blockchain technology, having as a pillar the unique property determined by the type of information.

Through a detailed review of the current documentation processes, in this sense,

The shipment of goods abroad in sectors such as Automotive, Retail, or Consumer Goods generally requires more than 20 different documents—many of these on paper—for the transfer of goods from the exporter to the importer. More than 70% of this data can be replicated. The size of these documents limits data quality and real-time visibility for everyone involved in the negotiation, which can delay the necessary financial adjustments. In this solution, you can accelerate the entire flow of transport documents, reduce data entry requirements by up to 80%, simplify data changes throughout the shipping process, speed up necessary verifications, and reduce the burden and risk of fines related to customs compliance imposed on customers (Ribeiro, 2018).

According to Accenture's global leader in Freight and Logistics practice, Adriana Diener-Veinott, tests for the replacement of document issuance by secure sharing take place successfully within the platform. Herewith, companies have a great opportunity to save time and money while improving the service offered to their customers (Accenture, 2021).

CONCLUSION

The process of using blockchain in maritime logistics is already underway and tends to deepen in the very near future. There is, in fact, a turning point in history where companies either develop to the point of becoming advanced technological industries or lose competitiveness and may even become obsolete.

However, as a technology still under development and not mature in the market, there are some barriers to widespread use, such as lack of extensive knowledge of the general public, engagement of chain actors, customs regulations, data integration, and interface of different blockchain networks.

There are also performance aspects in which already-established database systems are at the forefront of private blockchain structures. Considering the current phase of development, it is not yet possible to check performance indicators that confirm the benefit of using blockchain for the object of study. However, tacitly, and in view of the extent of the proportions that the technology has been deploying, which is a high disruptive value, there is no denying the benefits generated in a logistics chain.

Finally, it is important to highlight that the present article had a prospective look in order to monitor how such technology positions itself in the development of maritime logistics. There is no idea, therefore, of closing the matter; on the contrary, the end of this article aims at the continuity of research that monitors and analyzes the practical developments of blockchain in the presented subject matter and its future impacts. What was finally observed is that this is no longer a preliminary issue or a vague future possibility. Blockchain is already present in maritime logistics, with a strong possibility of future mass use, with considerable gains in scale in operations.

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