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Literature Review on Blockchain with focus on Supply Chain

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Abstract

In order to understand the applicability of Blockchain technology to Supply Chain, this paper reviews the available literature published within the AISNET's basket of eight journals on the topic Blockchain and a list of selected top IS conferences.

One observation in the results is that authors have been giving more importance to areas related to either fintech or cryptocurrencies. Nevertheless, other applications of blockchain technologies are being approached by these authors. Since the area of focus of this paper relates to Supply Chain, the refinement process of the results, consisted on filtering out those observations.

Hence the approach consists on the research and review of all available publications with the utilization of a unique interpretation framework and focus on the avenues of research provided by these articles. Gathering information in order to create discussion debates, grouped by the unit of analysis identified, within Supply Chain.

Keywords: Blockchain; Supply Chain; Literature Review; Organizational Level; Adoption

1. INTRODUCTION

Nowadays the word Bitcoin is on everyone's lips, due to the explosion of its value in the beginning of 2018 ("Bitcoin (BTC) - USD - Live Bitcoin price and market cap," n.d.). Bitcoin is considered by many the first successful technological envelope of its type to be implemented effectively (Iansiti & Lakhani, 2017). After this first successful launch many variants, based on the same core principals of Bitcoin, such as Ethereum, Ripple, Hyperledger and others, were released and are already being used worldwide, although some are still in test phase and others in small and restricted production environments (Hileman & Rauchs, 2017).

Although Blockchain technology is on its embryonic phase, its potential has already been recognized and there is a growing interest for full production deployments in firms, to optimize their current business processes and to provide, in some areas, the trust and transparency that are still missing.

(“Supporting Members – Hyperledger,” n.d.)(“5 Trends Emerge in the Gartner Hype Cycle for Emerging Technologies, 2018 - Smarter With Gartner,” n.d.).

Currently, topics surrounding blockchain are creating almost spontaneous interest throughout organizations, society and also Academia (“Minitrack Chairs – HICSS,” n.d.). It is believed that the inherent capabilities of this technology contribute to an overall optimization of several processes, such as value transactions (money/currency), ownership of goods, with special emphasis on trust and transparency features of the technology that are crucial in some areas, and for some reason have not yet been accomplished. To consolidate this idea, the statement "*blockchain is an innovative technology in search of use cases*" as recited by Glaser, proves to be very accurate.

Putting aside the potential benefits this technology could bring for the financial sector, there are other areas of great interest and focus, where blockchain could prove itself very useful, such as organizational supply chain processes. Companies are dealing with daunting and complex supply chains where the lack of trust and transparency can undermine the efficiency, create a lack of responsiveness, which compromises the overall profitability that was strategically set beforehand (Kwon & Suh, 2004). Several studies, suggest that a significant number of companies worldwide are willing to use blockchain solutions to address traceability, responsiveness and trust issues (Pai et al., 2018).

Provided the above, this study gathers and analyses the most relevant publications from the most reputable journals and conferences within the scientific IT community, that cover both the Blockchain topic combined with supply chain, providing relevant insights and inputs to both academics and practitioners on how to pursue study works on the topic.

In the following section, we define blockchain and supply chain. In section 3, we describe the followed methodology and analyse the results, and where the selection process takes place. Section 4 presents the most relevant debates about blockchain literature, given the context. Finally, section 5 is reserved to point out limitations and avenues for future researches given the overall discussions and conclusions regarding this study.

2. DEFINITIONS

2.1. Blockchain Definition

A blockchain is an open database constituted by a distributed ledger within a peer to peer network that can be access restricted or not. In the first case the access restricted blockchains are called permissioned blockchains whereas the last ones are the so called permissionless blockchains, like many cryptocurrencies available (Sousa, Bessani, & Vukolic, 2018).

One of the most popular blockchains known to date is Bitcoin. Since one of the pillars of Bitcoin is the fact that the information contained in the ledger is made of immutable sequential blocks, like the links of a chain, the community started to name this technology: Blockchain. Similar solutions based on these same technological principles, started to be addressed as Blockchain technologies (Nakamoto, 2008).

Some other blockchains, like Ethereum (Wood & others, 2014), have enhanced capabilities called smart contracts that are not more than “*orchestration and choreography protocols that facilitate, verify and enact with computing means a negotiated agreement between consenting parties*” (Dai, Mahi, Earls, & Norta, 2017). Smart contracts definition (Szabo, 1997) dates back some years, but it is only now, with the possibilities associated with the usage of blockchain technology, when they are having more practical use. Smart contracts, besides applicability in areas such as finance, authentication, identity and reputation systems, can also be used along with IoT (Internet of Things) applications and devices, where it can be used to track and trace different types of products and materials (Christidis & Devetsikiotis, 2016) and automate routines and actions, therefore be used as a tracking record stored in the blockchain ledger.

Considering the above, and from a non-pure technological point of view, the IS academic community shows to be more interested in cryptography and security related subjects, even though blockchain has for sure room for further study and development, especially when it comes to businesses and the economy in general, specifically in terms of processes, as blockchain usage and adoption represents a ground breaking revolution that could change the way companies and markets currently work as appointed by Swan, (2017).

2.2. Supply Chain Definition

Martin (2011), proposed the concept of supply chain management as, “*The management of upstream and downstream relationships with suppliers and customers in order to deliver superior customer value at less cost to the supply chain as a whole*”. Thus, a supply chain is an end to end process that is reflected on a network between a company and its suppliers, including several activities and respective stakeholders, comprising the moment in which a product or service is in its initial state, to the moment it is being distributed to its end client.

The concept of supply chain has gained significant relevance over the years. It was only once companies detected the benefits of effective collaboration that the term gained its form. It is through collaboration that companies integrate supply and demand, and deliver significantly improved performance, and benefits to its operations (Barratt, 2004).

Consequently, companies have become more specialized and are now searching for suppliers who can provide low cost, quality materials rather than own their source of supply (Lummus & Vokurka, 1999).

As the concept evolved so did consumers' demands. Each of these necessitate closer coordination with suppliers and distributors (Mentzer, Keebler, Nix, Smith, & Zacharia, 2001). With the adaptation of consumers needs to the technological developments, the way product and service ranges reach individuals became disruptive, this process is a consequence of digitalization.

Retailers provide consumers with various digital products and services that are adapted to the use of digital technologies and are simultaneously affected by the new forms of consumption (Hagberg, Sundstrom, & Egels-Zandén, 2016). Digital technology affects everyday businesses across several industries, considering that, a supply chain covers more than just products moving across the network it also covers the amount of information flowing at each step. Performance gains from participating in a cooperative supply network, derive from the information sharing across the chain, highlighting firms' ability to effectively communicate with customers and suppliers (Patnayakuni, Rai, & Seth, 2007) and the relevance digitization of processes has had on this topic.

3. METHODOLOGY

In this section we explore the methodology deployed, based on the proposed definitions and guidelines imposed. The proposed method consists on a structured literature review on blockchain using the top eight peer-reviewed IS journals from the AIS Senior Scholars' Basket as well as a list of selected IS conferences, also from AIS, that could be more promising in terms of content and more generally renowned: AMCIS, ICIS, ECIS, HICSS, ICEB, ISD, CONF-IRM, ICMB, MCIS, PACIS, WHICEB, in order to retrieve relevant information from properly acclaimed sources. The in-depth analysis in this section was conducted following the recommendations of (Webster & Watson, 2002).

3.1. Search and selection

Given the scarce availability of research papers on the topic blockchain combined with supply chain, our intention was to compile a set of papers that (a) focused on the adoption, implementation, or use of blockchain technology and that (b) had applicability to supply chain.

The literature available was considered until March 2019 with the search key "blockchain". This extraction comprised a total amount of 197 potential candidates (Table 1 and 2).

JOURNAL	RESULTS
European Journal of Information Systems	0
Information Systems Journal	5
Information Systems Research	2
Journal of AIS	3
Journal of Information Technology	0
Journal of MIS	0
Journal of Strategic Information Systems	1
MIS Quarterly	0
Total	11

Table 1 – AIS Senior Scholars' Basket of Journals

CONFERENCE	RESULTS
Americas Conference on Information Systems (AMCIS)	44
International Conference on Information Systems (ICIS)	48
European Conference on Information Systems (ECIS)	28
Hawaii International Conference on System Sciences (HICSS)	35
International Conference on Electronic Business (ICEB)	10
International Conference on Information Systems Development (ISD)	1
International Conference on Information Resources Management (CONF-IRM)	1
International Conference on Mobile Business	0
Mediterranean Conference on Information Systems (MCIS)	9
Pacific Asia Conference on Information Systems (PACIS)	9
Wuhan International Conference on e-Business	1
Total	186

Table 2 – AIS Senior Scholars Conferences

However, the majority of papers returned were essentially focused on cryptocurrency related topics. For that reason and because those papers did not meet the imposed criteria they were automatically discarded from further analysis. Other than the areas of focus stated above, Fintech, Initial Coin Offerings (ICO), Healthcare, Social Media, were filtered out of the analysis, for these last ones in specific, an empirical analysis lead to the exclusion of what would be the first round of the filtering process, resulting in 61 potential candidates. This round also took into consideration the type of papers to be analyzed, meaning those that did not cover enough topics such as: Panel, TREO Talk Paper, Forum Paper, Tutorial, were discarded, and also those that used blockchain as a mere illustrative example of a technology application.

The 2nd and final round of the process consisted on defining papers that presented relevant content for the study, therefore papers that included blockchain applied to supply chain. The analysis required an in-depth study of each candidate, which lead to a total of 10 potential candidates for further debate. Figure 1 shows, in a detailed manner the overall process.

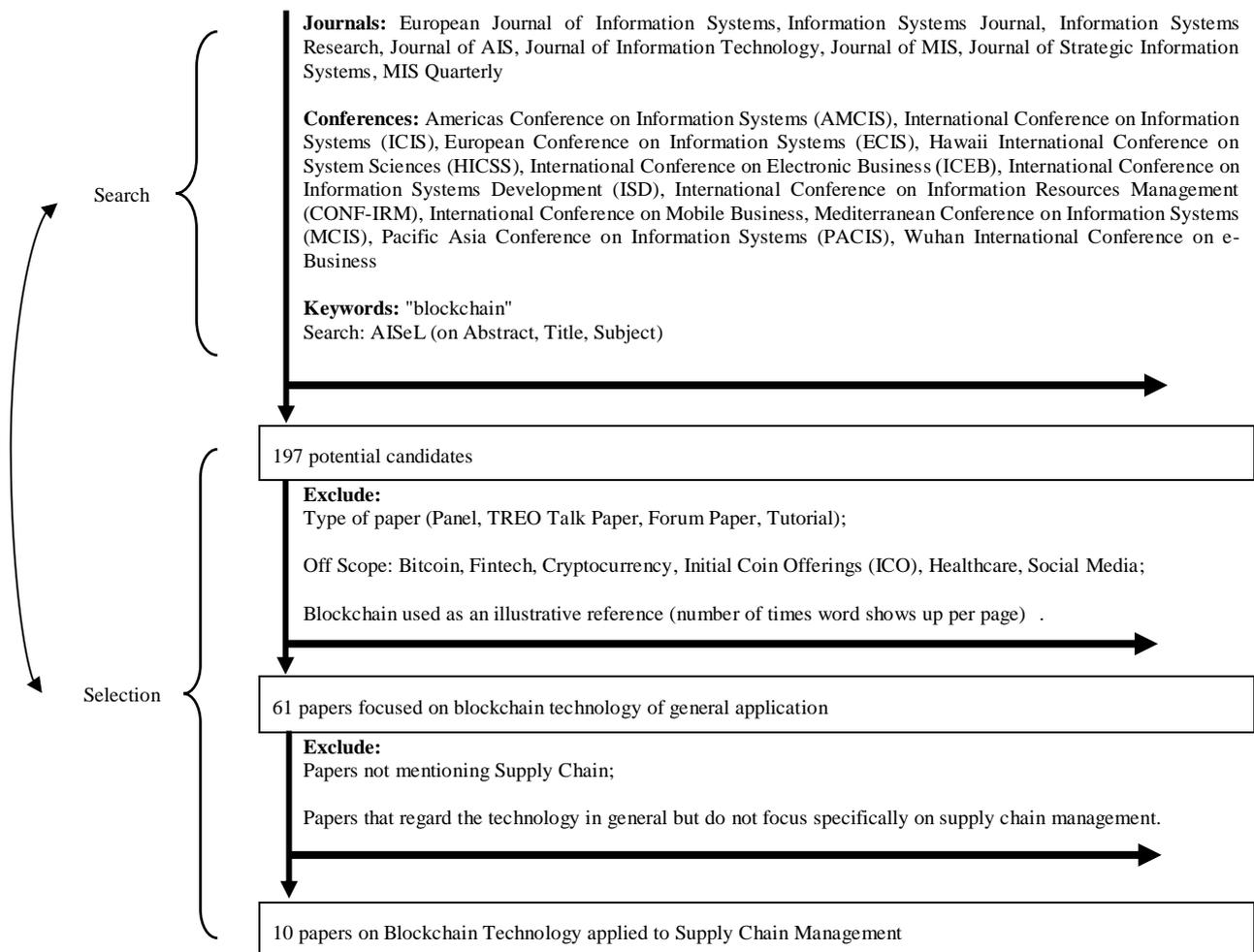


Figure 1 – Search and Selection Method

3.2. Analysis and synthesis of the literature

In order to extract value from the verified candidates, we followed a grouping approach of the results based on content similarity, much like other research papers that follow an archetype categorization (Greenwood & Hinings, 2018). To identify clusters, this paper focused on extracting valuable insights from similar literatures that could generate some sort of debate amongst the results. This grouping was developed to identify, and debate contrasts and semblances found in each segment that consisted on 3 debates. Taking into consideration the methodology of review used by Webster, that is to consider Blockchain and Supply Chain combined as a concept and the debates within each topic as units of analysis. Each debate was created in order to understand where blockchain technology should be positioned in the supply chain management process.

The rationale behind the labels attributed to each debate (Figure 2), where conclusions and main findings will be compared and consequently discussed in the following section, was based on the area of focus and unit of analysis in question. To support the previous statement, allusive references common to the articles were extracted.

For the Industry Specific domain, four real use cases of blockchain applications in supply chain were verified. The first one focuses on the automotive industry [A]: *“The results of this study can be a guideline for organizations involved with the automotive industry to apply Blockchain technologies to the organization operations and make them acquire the influential factors that affect the acceptance of the Blockchain technology application of the Thai automotive industry.”* (Supranee & Rotchanakitumnuai, 2017), and the following study relates to the application of the technology on the diamond trading industry [B], which is once again applied to a specific transactions’ market: *“We explore how blockchain technology changes the need for and the role of trust when trading high value physical goods.”* (Loebbecke, De, Lueneborg, & Niederle, 2018). The third one, within the Industry Specific group, analyses the shipping industry [C] with a well-known implementation, pertaining the world's largest container shipping company, Maersk (Katona & Sarvary, 2014): *“We identify the need to investigate blockchain applications for decentralized, inter-organizational environments that have already been implemented. To address this deficit, we plan to further develop our findings into more mature design principles as part of an ongoing collaboration with Maersk.”*(Naerland, Müller-Bloch, Beck, & Palmund, 2017). The last article reports findings from an *“ongoing development effort focusing on transparency in the transport industry”* (Baruffaldi & Sternberg, 2018) [D].

Regarding the Business Relationships domain and the articles reviewed, different study approaches were used: One is a generic blockchain literature review focusing on supply chain that points out that *“distrust among partners, transaction fees and restrictions plague consumers in marketplaces and they have no insight into the supply chain of their valuable products”* (Schlegel, Zavolokina, & Schwabe, 2018) [E]. The other is based on a case study approach focusing on *“business networks, and specifically business-to-business (B2B) relationships within digital supply integration”* (Korpela, Hallikas, & Dahlberg, 2017) [F].

For the last domain, Comprehensive Approach is where all the nonspecific blockchain and supply chain related topics, resulting from the analysis of the remaining papers fit in. The authors of the first paper propose *“a structured approach to assess the application landscape of blockchain technologies”* (Salviotti, De Rossi, & Abbatemarco, 2018) [G]. Another relevant insight from the following paper was that *“the impact of the structure and setup of business networks on successfully applying blockchain technology, remains largely unexplored”* (Seebacher & Maleshkova, 2018) [H]. In one of the studies, authors for this domain also considered *“the effect of blockchain technology on market structure of online business”* (Zhang, 2018) [I], and the last author focused on *“linking between the capabilities of blockchain technology and trust, privacy and transparency”* (Akram & Bross, 2018) [J].

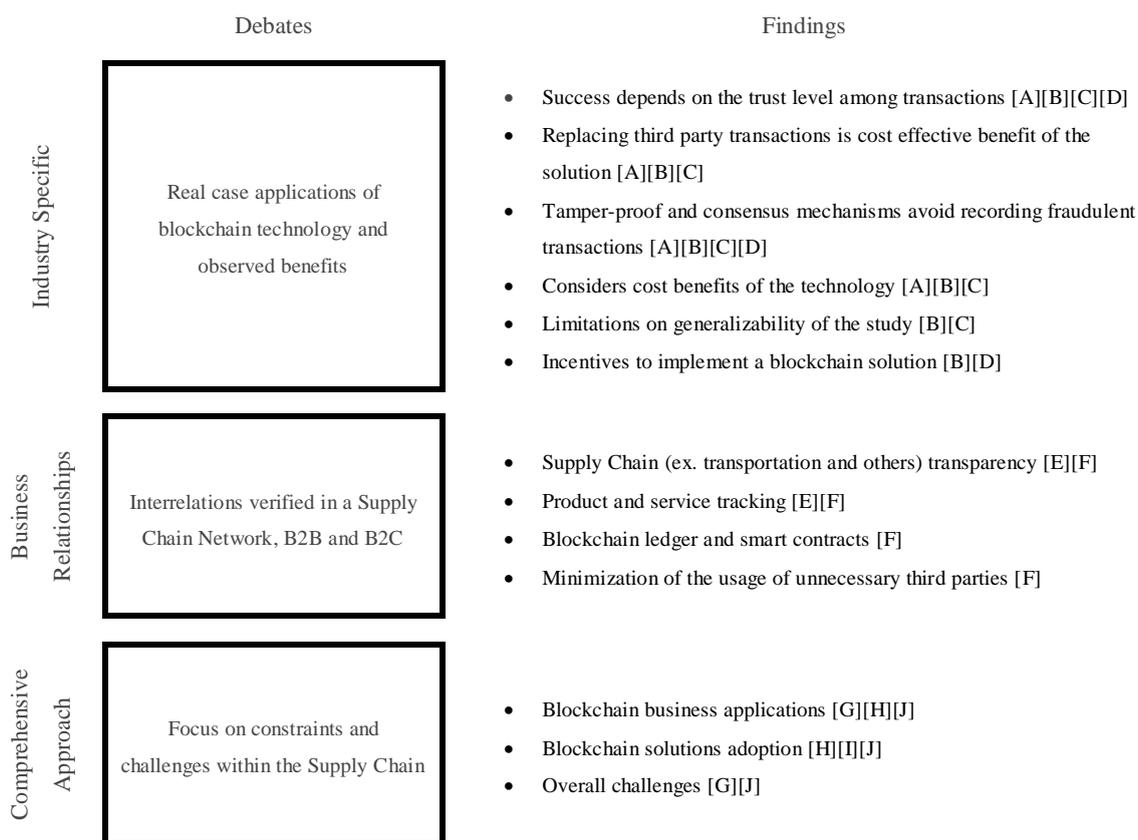


Figure 2 – Summary of debates related to blockchain applied to supply chain.

4. DEBATES ABOUT BLOCKCHAIN LITERATURE

Provided the above, we were able to structure the reviewed literature into a total of three debates, that concern the findings verified in the application of Blockchain technology to Supply Chain. In doing so, these 3 clusters based on the unit of analysis of each candidate presented several points of view on the technology's applicability.

4.1. Real case applications of blockchain technology and observed benefits

Overall, the technology is perceived as beneficial in the three contexts introduced. Although each focused on different features of Blockchain: **[A]** Acceptance **[B]** Trust **[C]** Smart Contracts **[D]** Adoption. Every single one of them seem to agree on the elements to point out of the application, as presented on the previous Figure. Naturally, the acceptance of the technology in an environment where several parties interact and depend on the behaviour of each player, highlights the network effects of the technology (Catalini & Gans, 2016), which in turn make evident the care for trust, that once verified generates adoption trends and the necessity to create the so called smart contracts, that make the interactions between transacting parties on a network to be set up and automated (Christidis & Devetsikiotis, 2016), making it a more secure way for transactions to be processed.

For the automotive industry [A], the success of blockchain applications relies on the non-mediated power, meaning the removal of third-parties translates directly into trust among organizations, given the inter-organizational trust that comes from this direct linkage. This is what is highlighted as a critical factor of acceptance of Blockchain technology application in the supply chain process. The diamond industry [B], that relates to the transaction of high value physical goods, demands higher caution in transactions. Also, from a social perspective, it attributes the value of the technology to the transparent proof of ownership based on traceability of all related actions in the blockchain, avoiding fraud and illegal measures. This statement goes hand-in-hand with what is observed in [A], where trust becomes the distinctive factor of the technology. Also, for this sensitive industry, the consensus mechanism of the technology avoids recording fraudulent transactions in the ledger, which is of utmost importance, given the risks involved in luxury goods transactions.

Although the shipping industry [C] highlights the tamper-proof storage of information as a determinant benefit of the solutions, as it is an essentially decentralized environment, where accessibility is crucial, given that systems need to be shared within a network of participants, where transactions need to be traced back to certain users, whilst preserving privacy. The importance of smart contracts in this segment is given as a more secure and trustworthy way of information management in international trade, that nowadays is centred around the Bill of Lading, which is the physical document that goes across the different stakeholders in the supply chain. The position that Blockchain can have for this purpose is evidenced in the text, when it states that: *“According to Maersk, the largest container shipping company in the world, managing the trade documentation can be more costly than the actual transport of the container.”* (Lehmacher, W., 2017). Lastly, for the transport industry the greatest concern pertains to the immaturity of the technology and lack of successful implementations, as it questions the adoption of the technology and how disruptive it actually is, when applied to supply chain. As observed in the previous industries, trust is a highly debated aspect of the technology, but it also regards the importance of the adoption of other players for that to be verified. The reasoning behind such debate is verified in the paper and by the industry, that integration of logistics activities and adoption of supply chain technology may not be straightforward, which cause the need for clear incentives for the implementation of the blockchain. Whilst for this industry the incentives are verified on a firm level, [B] determines that the incentives may come from consumers, that may be willing to pay 'higher' prices if they 'trust' the originality and quality of the goods.

4.2. Interrelations verified in a Supply Chain Network, B2B and B2C

Distrust between parties is one of the most common issues within supply chains that blockchain tries to address and come as solution (Fawcett, Jones, & Fawcett, 2012). Therefore, new ways for consumers to gain insights regarding how their products are produced and having detailed

information of all the steps that a given product took up until the point it reaches them, is considered beneficial. The same applies if a solution of this kind could provide the necessary trust within the intermediaries [E]. Another dimension of trust pointed out by one of the authors is related to payments between the supply chain involved parties using blockchain. If the overall process is considered effective and transparent with the added benefit of having an overall reduction of financial transactions costs, considering payments, blockchain adoption is considered very positive [F].

Product and service tracking are one of the most emphasized advantages that could be achieved through the implementation of a blockchain solution by the studied authors. By tracking and tracing the products from their origin up to the consumer certain quality standards and overall transparency can be achieved [E][F].

The usage of the ledger, and the ability that it has, to store information and to allow further analysis of all transactions done throughout the supply nodes is one of the features that has been highlighted by one of the authors. This characteristic allows all intervenient parties to have access in real time to all transactions that have been done ensuring a transparent flow of goods and/or services. In addition to this, the enhanced functionalities brought by the smart contracts usage could allow blockchain to make automated actions once a certain threshold is attained, exempting from the whole process an intervention of an additional third party [F].

Commercial transactions have been mediated for some years until now by the usage of IS solutions. Currently companies execute transactions relying mainly on third parties, and from an overall process optimization this could eventually be done with the usage of a blockchain solution that will remove unnecessary intermediaries [F].

4.3. Focus on constraints and challenges within the Supply Chain

Despite the broad usage of blockchain technology in the financial sector, including the wide adoption mainly with cryptocurrencies, there are a reasonable number of authors that state that there are more usages rather than these aforementioned [G]. Other authors state that business networks are structural templates and architectures where a blockchain solution could take an important role [H]. Finally, one specific publication is dedicated to the implementation of a blockchain solution within the logistics area, that corroborates the feasibility of this deployment [J].

Adoption of new technologies is not a straightforward process, that is why several authors invested a lot of research effort into this topic (Oliveira & Martins, 2011). This is why the same challenges are also valid for blockchain adoption and it is where some of the reviewed articles also focus on. One of the authors states that *“to drive research efforts and the overall adoption of blockchain technology, we contribute to the establishment of a common understanding of the interactions and*

structure in blockchain business networks” [H]. Another paper points out that since there are different interactions between business networks, a common understanding could be beneficial to adoption of blockchain solutions, which means that there could exist different approaches for the same problem and eventually a lack of uniformization could poise blockchain adoption [I]. Finally, the last author focuses his studies in the blockchain adoption cost, where he concludes that “industries with low adoption cost (e.g. cryptocurrency, digital contents, and video games) and high (cost of) uncertainty (e.g. food, pharmaceutical, and luxury good industry)” which could indicate that there are industries more prone to adopt blockchain rather than others due to cost related decisions [J].

According to one of the authors, one major challenge that blockchain adoption is facing is caused by the focus on research published in the last 5 years, that instead of dealing with several other possible applications, focuses mainly on the financial/cryptocurrency area. This same author also suggests that there isn't yet available a standardized approach for each industry or specific use cases based on the type of blockchain solutions available, permission wise and according to the available consensus mechanism. This void could create a barrier that can increase the difficulty of blockchain adoption per industry [G]. The last authors point out that there are several challenges regarding the level of privacy, transparency and trust that a blockchain can provide or ensure. In the study it is stated that using a blockchain solution can simultaneously, contrary to what would be expected, provide privacy and the necessary transparency. Regarding trust, this study contradicts what most of the authors ensure, that is that blockchain establishes trust between the involved parties, but in the specific logistics sector and according to them it doesn't, being currently the trust in third parties the preferred way to work [J].

5. LIMITATIONS AND AVENUES FOR FUTURE RESEARCH

Although it is verified a growth on the available literature regarding the emergent technology, that is blockchain, one can say that the application of it to specific areas, other than cryptocurrencies and financial markets is fairly low (Yli-Huumo, Ko, Choi, Park, & Smolander, 2016). One evident limitation of the current research is the scarce literature on the application of it to areas, such as Supply Chain.

Even though the results focusing on supply chain are not as abundant as initially expected, it can be concluded that some of the authors do not reserve the use of blockchain technologies to financial/cryptocurrency related scenarios (Tapscott & Tapscott, 2016). This is notorious when Constantinides, states that one of the future research questions could be “How can blockchain-based digital platforms transform existing value-creating interactions?”

Despite most of the articles that are part of the study sample are not blockchain and supply chain relevant simultaneously, a large number of them, proved to be very useful by providing general blockchain considerations regarding challenges surrounding IT value and adoption within firm level (Holotiuk & Moormann, 2018).

By the end of the research phase of this paper, additional limitations arose, ones concerning the number of candidates accounted for, this limitation was due to the mislabelling of the source of some articles on the search engine sites. Only one element was detected, by the end of the process and therefore was not included in the analysis, even though it presented high potential to be part of the final candidates: “Industrial Case: Blockchain on Aircraft' s Parts Supply Chain Management” (Madhwal & Panfilov, 2017). This limitation leads us to believe that perhaps expanding the literature sources could present broader results, nonetheless the reliability and quality of the objects of analysis in those cases may not be as acclaimed.

Several studies point out that strategic value, derived from blockchain adoption, is mainly coming from cost reduction resulting from operational and process improved efficiency. The removal of intermediaries will lower the overall inefficiencies thus creating value, and in the long term, via the creation of new business models, additional value could come from revenue generation and capital relief (“The strategic business value of the blockchain market | McKinsey,” n.d.).

Keeping the above in mind it can be concluded that studying existing value-creating interactions at firm level, considering the framework proposed by (Lacity, 2018) “The Relative Advantage of Blockchain Applications”, could be one interesting avenue of research.

In order to guarantee that the aspects of blockchain verified in each debate are to be conjugated, when applied to a supply chain management solution, that can be replicated to several businesses and not only adapted to the conditions predefined by each unit of analysis, one may explore the evaluation and ranking of each attribute by experts on the topic, from which the benefits all together can be exploited to a more significant contribution to current literature and organizational frameworks, therefore being generalized to the whole business process (Hsu & Sandford, 2007). The need to reach consensus on both areas, blockchain and supply chain, prompts incremental adoption incentives for the technology's implementation (Premkumar & Ramamurthy, 1995). Additionally, and on a more quantitative approach, the extrapolated outcomes of this paper may serve as a base to create key performance indicators for how the technology behaves in a real case application, and comparisons to what has been observed so far, can serve as a way to understand how the verified benefits apply to a more general context, measuring technological innovation capabilities and firm performance (Camisón & Villar-López, 2014). Given the low maturity of the technology applications, this approach may take more resources, as we must account for the implementation and performing phases altogether.

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