Blockchain for Business Applications: A Systematic Literature Review

Ioannis Konstantinidis[1(✉)], Georgios Siaminos[1], Christos Timplalexis[1], Panagiotis Zervas[1], Vassilios Peristeras[1], and Stefan Decker[2]

[1] International Hellenic University, Thessaloniki, Greece
{i.konstantinidis,g.siaminos,c.timplalexis, p.zervas,v.peristeras}@ihu.edu.gr

[2] Fraunhofer Institute for Applied Information Technology FIT, 53754 Sankt Augustin, Germany
stefan.decker@fit.fraunhofer.de

Abstract. Blockchain technology is widely known as the technological basis on which bitcoin is built. This technology has created high expectations, as transactions of every kind are executed in a decentralized way, without the need of a trusted third-party. Blockchain real business applications are currently limited mostly to financial services but many R&D projects in companies and corporations try to amplify the areas of blockchain implementation. In this paper, we conduct a systematic survey with the aim of pointing out the areas in which blockchain technology applications and services are being developed both in the public and private sector. In the results, we discuss the disruptive effect that this technology could bring to various business sectors as well as the concerns regarding the development of the blockchain technology.

Keywords: Blockchain · Literature review · Business · Applications

1 Introduction

Blockchain is a digitized, decentralized public ledger intended to keep a record of every data transaction happening in its network. Every different user constitutes a network node and maintains a copy of the ledger. Each transaction on the blockchain database is verified by the users participating in the system, so a trusted third-party verification is not required.

In 2008, an unknown author, Nakamoto, wrote a paper about accomplishing non-reversible and cash-like transactions without the involvement of any third-party. This was blockchain's first use, the technology behind bitcoin cryptocurrency. The concept was quite simple [1, 2]. Suppose that user A wants to transfer money or data to user B. When this transaction happens, it is represented as a block which is transmitted to every node/user of the network. Then, the users have to verify if this transaction is valid. The users have to solve a puzzle in order to be the first to validate the transaction [3]. This puzzle demands the use of certain computational power. The puzzle solving procedure is called "mining" and the first miner who will find the solution gets a bitcoin reward, so miners are competing to be the fastest to solve the puzzle. The transaction is completed

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when 51% of the users approve the provided solution. Then, the block of the transaction is added to the blockchain. The blockchain is a list of blocks that includes every single transaction that has ever been made [4, 5]. The blocks are visible to all users, but they cannot be edited.

Blockchain is becoming increasingly popular and use cases are showing up at a large variety of industries. The European Commission presented a report in April 2016 [6], supporting that blockchain technology has the potential to radically overhaul existing business models. At the same report, it was estimated that smart contracts, based on blockchain technology, could reduce infrastructure costs of banks from 13.8 to 18.4 billion euros annually by 2022. On October 2017, Bloomberg published an article which stated that Goldman Sachs and Google are among the most active blockchain investors [7]. Moreover, 10 of the largest U.S.A. banks have invested $267 million in six blockchain companies and one consortium.

In this paper, we conduct a systematic literature review aiming to explore the business areas that blockchain technology is applied. We discuss existing or future use cases found in the literature and we analyze the impact that blockchain could have on multiple industries. We also take into consideration possible concerns that may arise from the expansion of blockchain applications to various sectors.

The remainder of the paper is structured as follows. In Sect. 2, we describe the research method, we formulate our research questions and we analyze the procedure that led us to our final set of primary studies. In Sect. 3, we report the results of the literature review and discussion follows at Sect. 4. Finally, in Sect. 5, we provide our concluding remarks.

2 Research Method

2.1 Goal and Research Questions

The goal of our research is to point out industries in which blockchain technology use cases are met. Almost ten years after it was first introduced, blockchain has expanded its use at a large variety of services beyond cryptocurrencies. This relevant experience gives us the chance to discuss issues emerged over the last years. For this, we formulated research questions, (RQ1) What are the business sectors in which blockchain applications are being used or developed? (RQ2) What are the obstacles and challenges of blockchain technology? The first question aims at discovering in the literature, applications of blockchain technology that are currently used as well as research results for other potential uses. The second question tries to showcase issues and challenges related to the expansion of blockchain application areas.

2.2 Search Process

In this paper, a systematic literature review approach was followed according to the guidelines proposed by Kitchenham [8]. In order to cover a large spectrum of relevant publications, we decided to search the following widely recognized and extensively used electronic libraries: ACM Digital Library, IEEE Xplore Digital Library, Science Direct, and Springer Link. The keyword strings that were used are: "BLOCKCHAIN AND APPLICATIONS", "BLOCKCHAIN AND USE CASES". At the next step, we decided in which fields of the papers we would apply the search terms. In order to get a reasonable number of results, we searched for the keyword strings in the paper title, abstract, and keywords. We confined our search to publications written in the English language and selected as a content type only journals and conference papers, rejecting book chapters or webpages. No restrictions regarding the paper release date were used. The procedure for selecting the literature was conducted in November 2017, so it contains papers that were published or indexed up to that date. The final number of papers that we gathered after removing duplicates is 385. Then, we manually excluded papers that their title seemed irrelevant to our research, reducing the papers to 125. The above procedure was repeated by scanning the papers' abstracts, reaching 70 papers. We read the whole text of these papers, culminating in 44 of them in order to extract information and answer our research questions (Fig. 1).

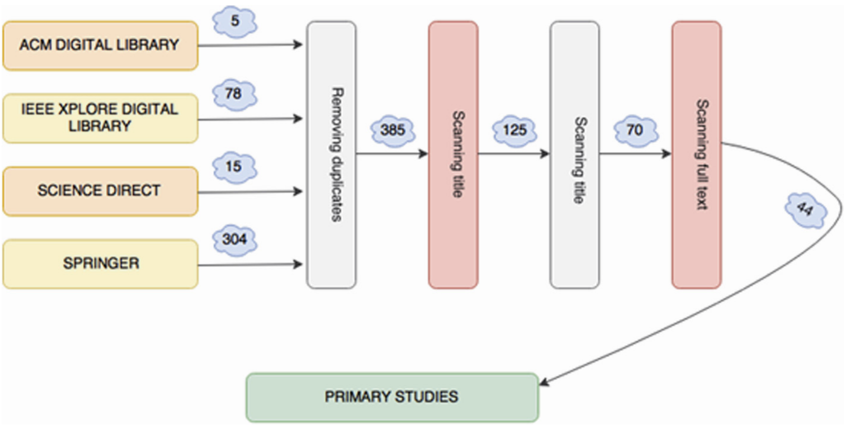

Fig. 1. Procedure for identifying primary studies

3 Results

In this section, we present the results of our literature review. The results are organized by research question and each attribute of the concept matrix is examined separately (Table 1).

Table 1. Concept matrix RQ1: business sectors in which blockchain applications are being used or developed and number of papers referring to them

	Cryptocurrencies	E-government	Healthcare	Supply chain	Energy	Banking
Total # Papers	8	14	10	7	8	5

3.1 Business Sectors in Which Blockchain Applications Are Being Used or Developed

According to our literature, we focused on six specific domains where blockchain use cases were found i.e.cryptocurrencies, e-Government, healthcare, supply chain, energy, banking, which we extensively describe below.

Cryptocurrencies. Cryptocurrencies constitute a major application area for the blockchain technology. Here, we mainly focused on the use of cryptocurrencies as a payment solution. In [2], the authors analyze the way that some of the most famous cryptocurrencies such us Bitcoin, Ethereum, Litecoin work. It is also presented a comparison among these digital currencies, regarding their coin limit, algorithm, mean block time, initial and current block rewards. In [5], the parameter of computational cost (gas) is examined and a method for reducing the gas cost while executing business processes in the Ethereum blockchain is proposed. Cryptocurrencies, could also be used as an incentive mechanism for proposing ideas in cross-functional group projects. The whole procedure is achieved via smart contract technology, which will automatically reward the group that managed to find the best idea with a predefined amount of digital coins [9]. In [19], the authors demonstrate OpenBazaar, a bitcoin-based multi-signature-protected decentralized marketplace, which enables free e-commerce transactions without any platform fees required. In [20, 32], the potential of a blockchain-assisted information distribution system for the IoT is introduced. The Internet of Things is anticipated to include sensors connected to the Internet. These devices are awaited to have access and produce a huge amount of information. Towards this, every Thing that generates an information item, may create a smart contract which will accept as an input an amount of virtual, digital coins and will output a payment receipt. The authors of [41] highlight the uses of the bitcoin blockchain protocol for payments and also use linear regression to predict attitudes towards bitcoin and the likelihood of bitcoin ownership. The implementation of a bitcoin-based community cryptocurrency is described in [42]. The suggested model includes community fund and the members may take loans that are approved by the vote of the community members.

E-government. In recent years, there is a massive expansion of e-government services to citizens, businesses and public bodies. Blockchain technology can serve as a platform capable to foster innovative applications and handle the information transactions where digitization of assets (e.g money, stocks, land properties rights) and decentralized exchange (peer to peer exchange) are involved or, could be involved. In [3, 12, 30, 31] blockchain based electronic voting systems are proposed, making votes transparent and securing that governments cannot manipulate an election because everyone is capable to read and verify the votes. The authors of [24] analyze a blockchain system that verifies the origin and genuineness of data during transmission in the e-government and public services, implemented in China. Blockchain utilizes a secure data structure that enables identifying and tracking transactions digitally and sharing the information across computer networks. In [4], the use of blockchain technology as a service support infrastructure in public sector procedures such as Digital ID management and secure document handling is discussed. The authors of [38, 40] also suggest the development of an identity management system built on top of the Bitcoin and Ethereum blockchain respectively. The authors of [29, 33] propose innovative blockchain platforms in order to overcome the issue of tax fraud by increasing transparency. In particular, a new blockchain protocol, Pajakoin, is created as a simple, transparent and secure Value-Added Tax system [29], while in [33] a potential blockchain database is introduced, towards managing dividend flows, aiming to diminish as much as possible the double spending problem in the public taxation sector. The digitalization of the core governmental activities is likely to happen through using the blockchain platforms. A use case where academic certificates are stored in a secure way is analyzed in [26], an approach that might be very useful in the public sector. In [27], a system where private data can be shared with many organizations by the order of the user is proposed. The users of this system have full control of their data and new information is automatically updated in every organization that has access to those data. In [28], the authors suggest a novel distributed online lottery protocol that applies techniques developed for voting applications for the purpose of reducing security risks while avoiding the trusted third party. Finally, an application of blockchain is mentioned in [43] where the technology is used to track politicians' activities and serve as a transparency tool to citizens' hands.

Healthcare. Healthcare is another sector where blockchain technology could be effective. Leveraging blockchain technology, healthcare organizations could accomplish high-data volume and high-throughput transaction processing. In [3] the authors showcase the example of Estonia where blockchain technology is used for sharing medical records. Blockchain can be used as a way of storing and accessing medical products during the logistics process in the pharmaceutical supply chain [12]. In addition to that, blockchain can be used in sharing and managing health data securely and privately, ensuring anonymity and integrity across providers during the lifetime of a patient [13, 15, 18, 19]. The authors of [25, 39] provide a solution via blockchain to manage Electronic Medical Records in such a way that data handling of the patients becomes more secure, private and simple. More specifically, in [25], MedRec (the first and only functioning prototype where patients grant access of their personal medical information to doctors and healthcare providers), ARIA (a platform that combines radiation, medical and surgical oncology information and can assist clinicians to manage different kinds of medical data, develop oncology-specific care plans, and monitor radiation dose received by patients) and a new prototype created by the authors are presented as applications of blockchain in Healthcare. In [34], a lightweight backup and efficient recovery scheme for keys of health blockchain is suggested, whereas, in [43] a demonstration of a monitoring system is introduced where the collection of personal medical data and the notification of the patient (in case of an emergency) happen in real-time.

Energy. In [17, 20–22] blockchain technology is used in order to conduct transparent transactions in the energy market between consumers and prosumers(active consumers that both produce and consume electricity) at local energy grids consisting of renewable energy resources. In particular, the authors of [22] propose a token-based decentralized energy trading system where peers anonymously negotiate energy prices and are able to securely perform transactions. In [37] they present a local energy market scenario with 100 residential households with artificial agents, implemented on a private blockchain, while in [3] it is highlighted that blockchain technology at local power grids allows the distribution, metering and billing of the electricity to be administered by the community itself without a reliant third-party intervention. In [11, 23] blockchain-based, intelligent, trusted measurement and monitoring of energy-related assets in a Smart Grid or a microgrid is suggested.

Supply Chain. Blockchain technology ensures identification of product provenance [14, 19] and facilitates tracking of processes [10, 36]. Furthermore, in [14], a product ownership management system is demonstrated to prevent counterfeits once the products reach the end in the supply chain. In this way, tracking of origin can be implemented after purchasing and acquiring a product. In [19] it is argued that blockchain technology provides security of supply chain. It can pinpoint the source of problematic parts and can ensure the trustworthiness between supply chain partners. Another blockchain use case in the supply chain is Everledger [26]. Everledger uses blockchain technology, which constitutes a worldwide ledger of diamonds in the luxury goods market and ensures their ownership. The authors in [43] mention that blockchain can improve the food supply chain. More specifically, they demonstrate Eaterra, which is a decentralized market that connects producers with consumers by ensuring food traceability.

Banking. A number of financial institutions are currently testing transactions on blockchain platforms. Goldman Sachs, J.P Morgan, and other banking giants, have all established their own blockchain laboratories collaborating with blockchain platforms. Standard Chartered uses "Ripple", an enterprise level blockchain platform to operate its first cross-border transactions [35, 43]. It took 10 s for the platform to complete a process that currently takes the banking system 2 days to complete. [35] also gives a thorough analysis on how blockchain can achieve asset digitization, point-to-point value transfer, thus rebuilding the financial infrastructure. This clearly increases the efficiency of clearing and settlement of financial assets after transactions. There have been estimations, that the cost of each transaction in cross-border businesses, can be extremely reduced owing to the application of blockchain. More specifically, in [10], a blockchain-based cross-border payment system is indicated, implemented in a banking blockchain platform. In addition to that, blockchain application could help banks facilitate foreign exchanges and real-time payments by gathering nodes in a blockchain, rather than having a central bank to deal with payments [3, 16]. Blockchain's disruption in the banking sector is highlighted by IBM's prediction that, "in 4 years, 66% of banks, will have commercial blockchain scale" [35].

Other Business Sectors. Apart from these results, blockchain can play a major role in other business sectors that are not so extensively analyzed in our literature. It can be a solution for a pay-as-you-go car insurance application. More specifically, all the data streamed from the vehicle monitoring engine are stored in the blockchain database, which guarantees that the data are tamper-proof and traceable providing a quicker and better customer experience and less operating cost as well as avoiding frauds [44]. Moreover, with the exploitation of smart contracts, blockchain can be used in farming insurance by gathering weather data, where farmers need insurance protection against the consequences of bad weather. Smart contract could also be used, in combination with smart sensors, for home insurance with automatic reimbursements for damages [43]. Blockchain technology has also potentials for construction management. It can provide a reliable infrastructure for building information management, legal arguments and secure storage of sensor data during all life-cycle stages without using a centralized building information model avoiding the need of the trusted third party [45]. There are a lot of expectations that blockchain technology will be incredible disruptive to automotive industry as well. The future connected vehicles that will be part of IoT will need a comprehensive security architecture to protect the transferred data. In [46] the authors introduce us to an automotive security platform utilizing blockchain to tackle the implicated security and privacy challenges of future connected vehicles. Education will also be potentially benefited by the blockchain implementation. Academic credentials must be universally recognized and verifiable. Blockchain solutions in education could streamline verification procedures – thus reducing fraudulent claims of un-earned educational credits. The University of Nicosia [26] where the academic certificates of the students were stored in blockchain, is the first example moving towards this direction.

3.2 Results for RQ2 (Table 2)

Focusing on RQ2, Security, Privacy, Latency and Computational Cost are identified as the main technical challenges in the current blockchain systems found in our research.

Table 2. Concept matrix for RQ2: obstacles and challenges of blockchain technology

Papers	Privacy	Security	Latency	Computational cost
Total	6	6	3	4

Security. Even though blockchain is used in many sectors, there are still some security concerns that need to be addressed. In [2], the “Transaction Malleability” attack is described. This type of attack occurs when someone changes the unique transaction ID before the transaction is confirmed. As a result, the transaction is modified and cryptocurrencies are being transferred to the attacker’s account. The authors of [3] support that there are challenges at the blockchain’s individual nodes, whose keys may be stolen, leading to malicious transactions. In [10], it becomes clear that the most crucial issue proof of work mechanism faces is, when miners try to control more than 50% of the network’s computing power in order to prevent transactions from gaining confirmations, which is known as the 51% attack. It is summarized that further research needs to be done towards this direction, in order to find solutions that will increase blockchain’s confidence. A solution for the 51% attack is suggested at [29], where a VAT system is developed on a centralized blockchain. In [16] the authors express their concern about the fact that all nodes participating in a blockchain are connected to a P2P network but generally security leaks have been reported about P2P networks. In [14] a product ownership management system has been developed on the Ethereum blockchain but since Ethereum is still under development its security is not fully verified.

Privacy. Privacy is a main issue that is still under research. In [13], it is mentioned that even though blockchain technology can provide transparency in the clinical trial and precision medicine, this could lead to privacy concerns. The anonymity of the blockchain users' identity cannot be fully accomplished using cryptographic keys. It is also stated that in the traditional blockchain about 60% of the users' identities had been compromised via big data analytics of data sets across the Internet. Furthermore, in [16] the authors mention that financial systems, such as the banking systems, must provide high privacy in contrast to the current blockchain technology, which has a low privacy level. In [19] the authors claim that the obstacles of blockchain's deployment in the healthcare sector are also psychological, as there are data sharing concerns among medical organizations. Moreover, in some applications, privacy issues could lead to trust problems. In [31] it is claimed that in a smart grid infrastructure (energy sector) privacy is a facet of trust in the sharing economy. In addition, Bitcoin users can send digital coins to a specific address that belongs to themselves. In [49] it is mentioned that these addresses of the same person can be linked.

Latency. One of the biggest limitation all blockchain consensus protocols have in common, is that every fully participating node in the network must process every transaction. Decentralization is a core and innovative characteristic of blockchain technology but, unfortunately, drives to latency challenges. In [26], it is referred that Bitcoin blockchain theoretical transaction power is seven transactions per second. As a result, in a financial system where speed and executions in high rates are obligatory, the P2P network that blockchain provides is clearly far from being applicable [16]. The e-commerce sector is also beyond the usage of blockchain technology. The time needed for a transaction to be verified in bitcoin blockchain, which is the dominant and "traditional" blockchain protocol, is almost ten minutes something opposite to the real-time transactions that the retail businesses require. However, many platforms based on alternative blockchain protocols are developed to overcome this latency obstacle and speed up the confirmation process [50].

Computational Cost. One of the hardest issues in blockchain-based applications is the specialist hardware that is usually required, to implement a transaction via a blockchain platform [2]. Special hardware, means higher energy consumption, hence more computational costs. Due to this concentration and consolidation of mining power blockchain technologies depend upon, every potential application based on a blockchain development is imminent to further research. More precisely, in [37], a local energy market with artificial agents, implemented on a private blockchain is presented. However, the suitability of blockchain technology as mainstream ICT remains to be investigated owing to the energy consumption that incurs. Focusing in the IoT domain, authors in [44], propose the reinvention of a consensus protocol that uses tweets to encode transactions for IoT applications, to substitute the massive power that miners require towards validating the transaction. Additionally, the computational cost of blockchain technologies is highlighted in [47], where a comparison between blockchain and cloud services for software applications takes place, resulting in the fact that Ethereum's blockchain cost per process, can be a hundred times higher than on Amazon SWF.

4 Discussion

After thoroughly gathering information from our literature, in this last section we present blockchain's hype, applications grouped by use cases, and concerns, as topics that caught our attention during conducting our review and made an impression upon us.

4.1 Blockchain's Hype

During our research, we realized that blockchain technology is increasingly gaining in popularity and gathers huge research interest. This becomes obvious by the pie chart of the annual distribution of our primary studies (Fig. 2). About 70% of the papers that we included in our review were published in 2017.

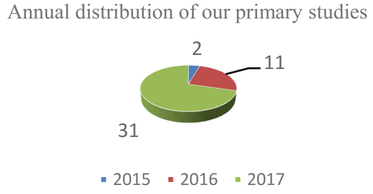

Fig. 2. Primary studies pie chart distribution per year

According to Gartner Hype cycle of emerging technologies that was published in July 2017, blockchain technology is currently close to the borders of Peak of inflated expectations sliding slowly into the Trough of Disillusionment. In other words, the technology receives negative press for the first time. Challenges and obstacles reach the surface and implementations of the technology fail to deliver. The prediction of the firm is that the platform will be mainstream in 5 to 10 years.

Besides the fact that, introductions to cryptocurrencies have already been included in university curricula all over the world, another verification of our claim about blockchain's disruption, is that in 2017 we had the first pedagogical attempt to teach a smart contract programming course at the University of Maryland [51]. Smart contracts can be viewed as distributed protocols executed between a number of parties. The execution of the smart contracts is automatic and it is guaranteed by the rules of the underlying cryptocurrency. The students of the course developed smart contract applications atop Ethereum blockchain using Serpent programming language.

4.2 Prospective Use Cases

Through the research we have conducted, we noticed that blockchain could undoubtedly be the foundational technology for the birth of new applications. Nevertheless, in this section, we categorize three specific areas that we believe blockchain can make a huge impact on.

Transactions/Payments. It is evident that blockchain technology is capable of creating an immutable digital ledger for transactions which can be incorporated into business processes today. Blockchain technology grants a high level of privacy by providing that transaction details are shared only amongst users involved in those transactions, thus removing the need for a central authority to administer them. As depicted above, in papers [9, 19] we highlight some specific applications based on a blockchain platform, where cryptocurrencies are used as a payment solution. Moreover, in the E-government sector, increasing transparency in the transactions, which is a blockchain's platform advantage, could help overcome issues of tax fraud, as indicated in [29, 33]. Finally, considering the ability of clearing and the agreement of the financial assets after transactions that blockchain platforms provide, we point out the foundational disruption of blockchain technology in the banking industry, illustrating certain banking blockchain platforms, found in papers [10, 35, 43].

Data Storage. Blockchain technology and its special features could bring big advantages to data storage systems, as it will provide cheaper, faster, more secure and decentralized storage than the existing cloud storage platforms. Decentralized storage works by distributing the data across a network of nodes, in a similar way to the distributed ledger technology characteristic of blockchain. Blockchain applications that already encompass decentralized storage are Storj, Maidsafe and IPFS [43]. The use of blockchain as a database applies to different economic sectors. E-government, healthcare, banking and supply chain sectors try to implement various blockchain projects to optimize their operational procedures. MedRec, ARIA [3], University of Nicosia certificate storage, Bitnation, E-resident and Everledger [26] are only some of those projects that their usage could bring enormous profits. On the contrary, having a great potential is not the same as having great success. There are still some insurmountable obstacles that prevent the adoption of the technology with its current structure. New protocols and platforms are created every single day to correct the previous ones. There is no doubt that blockchain in the near future will make interaction between people and organizations faster and cheaper.

ID Management. Blockchain technology can become a powerful tool for identity management. As we are continuously being asked to share personal information to access places or information or to do business with other companies, we are at risk for identity theft. Blockchain constitutes the underlying technology for identity management through decentralized networks. As shown in [24], in e-government applications, identity management with blockchain can provide each citizen with a verifiable digital immutable identity, simplifying processes and improving the speed and authority in government approval. Furthermore, it is found that blockchain can facilitate patients' health identity management by giving pharmacists and doctors access to patients' electronic medical records [15, 18]. This would allow care providers, pharmacists and patients to track dosages, receive automatic alerts for missed or incorrect dosages, monitor possible adverse drug interactions and even help prevent addiction.

4.3 Usage Concerns

Trying to elaborate on blockchain's issues and challenges, we mainly focused on the vulnerabilities that came up with blockchain's expansion to new areas of implementation. Each application have extra requirements the existing blockchains fail to meet. Research recognizes those inconsistencies and suggests customized blockchain solutions. A great example of how current blockchains are inadequately effective is the time that it takes for a transaction to be completed. When bitcoin first started, money transactions that would probably take days to complete, were carried out in a few minutes and that was a revolution. But, as we see in [16, 50] stock markets or e-commerce applications have transactions that have to be completed almost instantly.

Applications in different business areas also demand different levels of privacy. Current public blockchains have low privacy but future use cases in banking systems [16] or in medical records in the healthcare sector [19] require high privacy. Security is another domain where increasing concerns are expressed. The computers' increasing computational power along with the rise of mining pools (groups of people mining together as a single unit) could result in an attack on the blockchain if somehow, someone was able to control 51% of the mining power. This scenario is discussed in [10, 16, 29] and even though it does not seem plausible, a potential attack would be fatal for the blockchain's reputation. For example, a 51% attack on the bitcoin could significantly devaluate it. Blockchain's increasing popularity has as a result the boost of miners' number. More and more people are using their computational power to get a cryptocurrency reward. Since only the miner who solves the transaction encryption first gets the reward, all the others just waste resources [37, 47].

The blockchain industry is currently receiving huge attention from everyday startups or tech-people. However, given the fact that the idea of implementing a blockchain is still in the introductory stage of its life cycle and requires a set of skills and knowledge which are not feasible easily, here we present some roadblocks that make its mass adoption truly ambitious, at least at this stage.

As it is known, by disintermediate financial institutions, multiple parties are able to conduct transactions easily without paying a commission. Technically speaking, moving cash to a blockchain infrastructure could lead to a significant increase of the overall transaction cost or, trading on a blockchain system would also be slower than traders would tolerate and mistakes may be inevitable, potentially bringing huge losses. In addition to that, due to its genetically distributed peer-to-peer nature, blockchain transaction can only be completed when all parties update their corresponding ledgers, a process that might take hours. This transaction delay may be a deal-killer. The difficulty of a mass implementation of blockchain technology is visible if we consider that the commitment of blockchain in large part depends upon enough parties using the same implementation of the technology, requiring a universal adoption. Blockchain technology has not yet imbued into many real use cases and besides the technical part, we would like to highlight, that maybe the biggest obstacle of a mass implementation is the education and knowledge that is required even for someone with strong tech-background, in order to fully understand the benefits of this new area of technology. Consider that even the terminology of blockchain is too complex and creates itself some obstacles and doubts, even to CEO's, let alone to everyday consumers. It takes time for a new technology, especially to something as foundational as blockchain, to incorporate itself into the fabric of modern society. In fact, "the more likely blockchain is to disrupt the global financial system, the less likely is to succeed" [48].

Another challenge that has to be tackled about blockchain is establishing standardization and regulatory framework. In April 2016, European Union in one of its reports points out that "The future of blockchain requires the development of a common language with specific rules for interaction, which will be achieved through standardization processes." [8]. In September 2016 ISO accepted Australia's proposal to manage the Secretariat of ISO/TC 307 for new international standards on blockchain and in March 2017 the Roadmap Report was released [52, 53]. Currently, 29 participating member-states and 13 observing member-states are developing 4 standards that are at proposal or preparatory stage.

For the time being, the existing legal framework applies to activities related with the blockchain technology. The regulators are monitoring blockchain-based activities, acquiring knowledge in order to make the law keep up with the evolution of the technology. Regulators are gradually starting to understand the blockchain use cases, while at the same time the innovators are trying to find the regulatory principles that apply to their activity. Current blockchain applications are considered rather immature to guide the legislation towards a specific direction. The development of the existing applications and the creation of new ones are expected to showcase the legal gaps that need to be regulated. In the meantime, existing legal principles can sufficiently face blockchain-related criminal activity whereas experience gained over time will provide guidance and dictate the need for new regulations that cover all the legal scenarios that may arise by the use of blockchain technology.

5 Conclusion

Blockchain technology is challenging the status quo in several areas in a radical way providing a decentralized database of any transaction involving transfer of value i.e. (money, goods, property, assets or even votes). This generic nature is what makes blockchain technology attractive to many business areas today. However, we conclude our review highlighting the risks, effects as well as the unintended consequences of blockchain technology on established markets. The disruption of blockchain technology in business sectors is increasing in pace. Therefore, we believe that further critical research is needed to exploit its capabilities and understand the limitations when applied in a large scale.

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