

A REVIEW ON BLOCKCHAIN TECHNOLOGIES FOR CORPORATE SOCIAL RESPONSIBILITY AND SUSTAINABLE SUPPLY CHAIN MANAGEMENT

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Abstract

The rise of Industry 4.0 and paradigms like Internet of Things (IoT) are increasingly dependent on trusted partnerships. In this scenario, blockchain technology has been recently introduced and is already revolutionizing the digital world, bringing a new perspective to business operations. It removes the need for a trusted authority, offering a reliable, secure and transparent way to exchange any kind of service, good or transaction, enabling more agile value chains. This paper reviews its potential in the field of Corporate Social Responsibility (CSR) and Sustainable Supply Chain Management (SSCM), where organizations must take responsibility for their impact on society, integrating social, environmental, and economic concerns into their business processes. Blockchain can positively impact the safety, traceability, accountability, sustainability, and transparency of the supply chain, therefore ensuring the ultimate goals of all the stakeholders involved.

Resumen

El auge de la Industria 4.0 y paradigmas como Internet of Things (IoT) dependen cada vez más de asociaciones confiables. En este escenario, la tecnología blockchain introducida recientemente está revolucionando el mundo digital, brindando una nueva perspectiva a las operaciones comerciales. Elimina la necesidad de una autoridad confiable, ofreciendo una forma fiable, segura y transparente de intercambiar cualquier tipo de servicio, bien o transacción, lo que permite cadenas de valor más ágiles. Este trabajo revisa su potencial en el campo de la Responsabilidad Social Corporativa (RSC) y la sostenibilidad de la cadena de suministro, donde las organizaciones deben asumir la responsabilidad de su impacto en la sociedad, integrando las preocupaciones sociales, ambientales y económicas en sus procesos comerciales. Blockchain puede tener un impacto positivo en la seguridad, la trazabilidad, la responsabilidad, la sostenibilidad y la transparencia de la cadena de suministro, garantizando así los objetivos finales de todos los agentes involucrados.

1. Introduction

Industry 4.0 refers to the fourth industrial revolution and is expected to represent the next phase in the digitalization of all the sectors in the economy. This revolution takes advantage of several enabling technologies in industrial processes: the massive use of sensors (Fraga-Lamas et al., 2017), modern computation technologies, and ubiquitous connectivity; the use of machine learning, artificial intelligence and business-intelligence capabilities; new forms of human-machine interaction such as augmented-reality and virtual systems; and advances in transferring digital instructions to the physical world, such as Cyber-Physical Systems (CPS), Internet of Things (IoT), robotics, and 3-D printing. Most of these technologies are now at a position where their maturity, reliability and cost-effectiveness are starting to be appealing for massive use in industrial applications.

Specifically, Internet of Things (IoT) is transforming the way organizations communicate, organize everyday businesses procedures, and transform information into knowledge through big data analysis for better decision-making (Zamora, 2016). The number of interconnected devices will increase in the next years: IoT is estimated to reach 50 billion of connected devices by 2020 and the potential economic impact will be from \$3.9 trillion to \$11.1 trillion per year by 2025 (Manyika et al., 2015). Overall, IoT would allow for the automation of everything around us in sectors like precision agriculture (Pérez-Expósito et al., 2017), public safety (Fraga-Lamas et al., 2016), home automation (Suárez-Albela et al., 2016), energy efficiency (Blanco-Novoa et al., 2017) or retailing, including physical stores (Rey-Garcia et al., 2017).

In this scenario, blockchain –understood as a distributed and decentralized ledger composed by connected blocks of transactions- has emerged as a revolutionary technology in distributed computing. Originally designed and popularized by Bitcoin and other cryptocurrencies like Ethereum, it is currently making feasible for businesses to address inefficiencies and unethical practices along their supply chains, in order to comply with their Corporate Social Responsibility (CSR) requirements and to achieve Sustainable Supply Chain Management (SSCM). The aim is to reduce the social and environmental impacts in global supply chains (Pagell & Wu, 2009). Furthermore, blockchain and IoT can cause together significant transformations when using blockchain to control and configure IoT devices (Christidis et al., 2016).

Traditionally, traceability in the supply chain has been managed by using technologies like RFID (Fernández-Caramés, et al., 2017). However, blockchain technology goes one-step further, enabling a new era of end-to-end transparency in the global supply chain system where stakeholders are able to share information rapidly and with confidence across a strong trusted network. Furthermore, it enables smart contracts, thus providing a lower cost of transaction with a trusted contract monitored without the intervention of third parties.

A blockchain acts as a distributed database whose strength lies in its trustworthiness: the difficulty of reversing or changing what has been recorded. The blockchain database can also hold much more data than what single stakeholders get today, providing tools for more detailed decision-making (i.e., the use of analytics). All the stakeholders can view the global supply chain traceability as a collaborative issue and are willing to work together to improve the system for everyone's benefit.

The contribution of this article focuses on providing a holistic approach to blockchain applied to CSR and SSCM with a deeper study of the most relevant requirements, as well as an overview of the key challenges. Besides, the aim of this article is to help the industry to exploit the opportunities created by the use of blockchain for CSR and SSCM.

The remainder of this paper is organized as follows. Next section summarizes the main principles of CSR and SSCM, and reviews the basics of blockchain technologies. In addition, it presents some promising scenarios for blockchain-based applications enabling CSR and SSCM. Section 3 presents some questions for discussion and summarizes the main effects on services, business, and regulation. Finally, section 4 is devoted to conclusions

2. Case development

Basics: Corporate Social Responsibility and the Blockchain

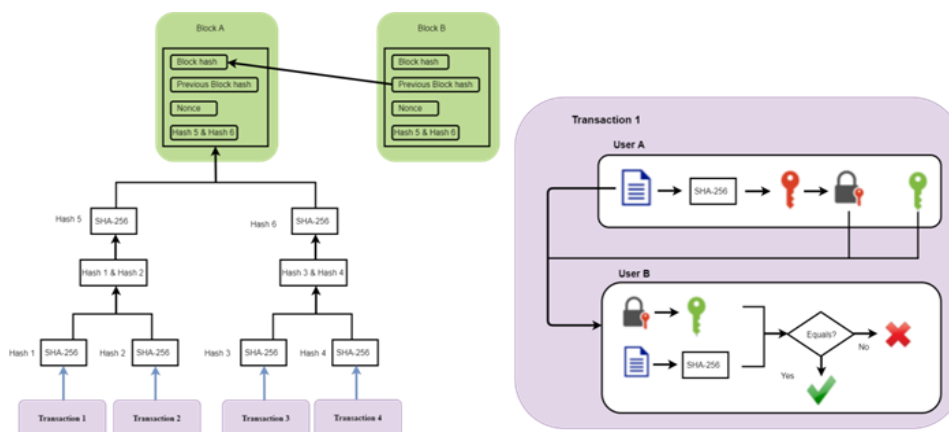
The definition of CSR is related with ethical behaviors in business organizations, and particularly with the relationship between a corporation and its stakeholders within a societal context, integrating social, environmental, and economic concerns into its business processes (European Commission, 2001 and 2011). There are three basic principles, which together comprise all CSR activities: sustainability, accountability and transparency. These three principles can be achieved by answering the questions who, what, when, where and why relating all the business processes. In order to answer them, it is necessary to have in place a traceability system, which must support both internal and external tracking and tracing.

Traceability is defined as the ability to retrace steps and verify processes, events and data throughout the value chain by following the processing of raw materials from their origins, through suppliers, to production, distribution and location after delivery and, ultimately, until the end of the life-cycle (ISO, 2015). Internal traceability seeks to track and trace unique products or components within a company. External traceability is the ability to track and trace unique units in the information flow linked to the physical movement of the goods between organizations. It requires that the partners have effective information connectivity and sharing between the different information systems, and it also depends on the collaboration and coordination of the logistics processes within the supply chain. The importance of external traceability has been enhanced by the global expansion of complex supply chain structures, combining networks of actors from multiple sectors (business, public, non-profit and informal) in multiple locations. Therefore, in the field of CSR and SSCM, traceability is specifically defined as “the ability to identify and trace the history, distribution, location and application of products, parts and materials, to ensure the reliability of sustainability claims, in the areas of human rights, labor (including health and safety), the environment and anti-corruption” (UN Global Compact, 2014: 6). Traceability is therefore a key organizational capability to foster corporate social responsibility and sustainability.

Regarding the blockchain, it is a distributed and decentralized ledger composed by connected blocks of transactions. It can be adapted to store any kind of digital information, which implies that it could be the future of all secured transactions. Each transaction request is received by all the computers on the peer-to-peer network. As shown in Figure 1, a verified transaction is stored in the form of a block (lists of transactions) linked to the previous one.

There are four types of ledgers: traditional (centralized), permissioned private, permissioned public and non-permissioned public. Except for centralized ledgers, the rest are often denoted as blockchains.

Figure 1. Blockchain internal structure.



Source: Author's own elaboration

The non-permissioned public ledger is used by the digital currency of Bitcoin. In a non-permission public blockchain, computers and their owners (a group of anonymous strangers called miners), collect the request into a block. Miners make use of the new block and the previous one, and process them through a mathematical function called hash. All miners race to solve a complex cryptographic puzzle; the more computing power used, the more likely it is they solve it first. Once solved, a new block is formed. Any changes to a previous block would result in a different hash function and thus, it would be immediately visible to all the miners in the blockchain. Since blockchains are replicated across a peer-to-peer network, the information they contain is very difficult to corrupt or alter.

3. Blockchain-based applications enabling CSR and SSCM

Blockchain came into the scene in 2009 and it has already been tested by companies in all the sectors in order to manage their business more efficiently. According to a recent study by Juniper Research (July 2017) (Juniperresearch, 2017), 57% of the world's largest companies are now researching blockchain technologies through pilots and proof-of-concepts with the goal of integrating them into their products by the end of 2018. The following paragraphs illustrate blockchain-based applications for balancing economic efficiency with responsible behaviors towards people and planet by organizations and, ultimately, achieving a sustainable supply chain management.

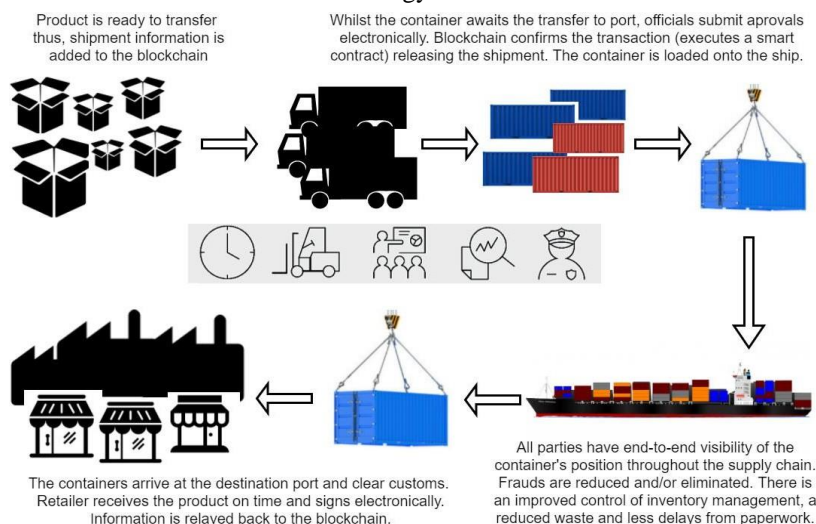
Traceability

Walmart, together with IBM, is developing an enhanced blockchain-based traceability system (Forbes, 2017). In October 2016, they started tracking two items that involved thousands of packages shipped to multiple stores. For example, they complained that when a customer became ill, it could take days to identify the product, shipment and vendor. Through blockchain, it is possible to obtain crucial data from a single receipt, including suppliers, details on how, where and when the food was grown and who inspected it. The database is able to extend information from the pallet to the individual package. This functionality enables Walmart today to find immediately where a product came from in minutes (instead of days).

Following this approach, in August 2017 IBM announced a consortium with the food sector that includes Walmart, Driscoll's, Dole, McCormick, Nestlé, Kroger, Tyson Foods and Unilever. This consortium will further explore the potential of blockchain technology to boost traceability and transparency along the global food supply chain.

The shipping industry can also benefit from a blockchain. Ocean freight accounts for 90% of the goods shipped globally, but their transport is highly dependent on documents that are usually not digitized. For example, one shipment can require sign-off from 30 organizations and up to 200 communications. One missing form or late approval can leave a container stuck in port for a long time. This process can be digitized using blockchain technologies to trace the container's path. The process is represented in Figure 3.

Figure 3. Shipping value chain with blockchain technology.



Source: Author's own elaboration

For example, Maersk and IBM are creating a solution for global logistics based on the open-source Hyperledger Fabric. The solution is expected to be widely available in 2017 to support multiple parties across the ocean shipping industry ecosystem.

Another example is represented by public health applications. For example, healthcare could use blockchain for managing data more efficiently during a health crisis. Success in this sector depends on the ability of peer organizations - centers of disease control, state and local agencies, government, hospitals and clinics- to collaborate effectively and efficiently. Moving that data from one peer to another in a secure, compliant and transparent manner, as quickly as possible, is a key part of the business model. Questions such as whose computers should maintain the ledger and who should have permission to read

or modify data, or how should identities, not only patient IDs but also the IDs of public health organizations, be managed on the blockchain, are still open issues under research and discussion.

Several blockchain startups are innovating in the traceability sector. For instance, Provenance (Provenance, 2017) has created a system for materials and products, enabling businesses to engage consumers at the point of sale with information gathered collaboratively from suppliers all along the supply chain. A distributed global factory is Genesis of Things (Genesis, 2017), which is working to combine 3D printing, blockchain, and IoT-sensor technologies to create more advanced manufacturing processes and efficiently deliver products where and when they are needed, while protecting the rights of all their stakeholders.

Transparent transactions

Blockchain could be used to create a more direct payment flow that connects payers and payees across borders or domestically without intermediaries, at ultra-low fees and almost instant speed. The benefits of using blockchain for smart contracts and verifiable transactions can also be applied toward making business accounting more transparent. Besides, cybersecurity risk is decreased by removing the need for human intermediaries, thus lessening the threat of hacking, corruption, or human error.

The experience of leasing, buying, or selling is a notoriously fragmented process for stakeholders on all sides of a transaction, but the blockchain could change that. For instance, in 2015 the DocuSign's Digital Transaction Management (DTM) platform and eSignature solution together with Visa's secure payment technology developed a proof-of-concept project that used blockchain to enhance the car leasing process transforming it into a "click, sign, and drive" process (DocuSign, 2015).

Accurate transaction records enable the use of analytics tools for forecasting. For instance, Augur (Augur, 2017) is a decentralized prediction-market platform built on the Ethereum blockchain that rewards the user for correctly predicting future real-world events. Prediction markets have allowed users to purchase and sell shares in the outcome of an event, and have proven to be a powerful forecasting tool.

Storj.io (Storj.io, 2017) is a blockchain-enabled cloud storage network to improve security and lower the transaction costs of storing information in the cloud. Users can rent their unused digital storage space in a peer-to-peer manner, potentially creating a new market for crowdsourced cloud storage capacity.

Startups like OpenBazaar are developing decentralized blockchain utilities to connect buyers and sellers, without an intermediary. OpenBazaar (OpenBazaar, 2017) operates as an open-source, peer-to-peer network offering merchants no fees and no restrictions on what can be sold. Customers purchase goods using any of 50+ cryptocurrencies, and sellers are paid in Bitcoin with all associated data distributed across the global network. Bitcoin-based charities like the BitGive Foundation (BitGive, 2017) use blockchain's secure and transparent distributed ledger to give donors greater visibility into fund use. The company has launched GiveTrack, a platform that provides the ability to transfer, track, and provide a permanent record of charitable financial transactions across the globe.

Integrity

Deploying blockchain solutions could ease verification procedures reducing fraudulent claims. For instance, Sony Global Education (Sony, 2017) has developed a new educational platform in partnership with IBM that uses blockchain to secure and share student records. Users can take educational records, create a digital transcript, and safely provide it to a different educational institution. Additionally, this also makes it possible for evaluating organizations to analyze this data and use it to provide suggested improvements to educational institutions' curriculums and management.

Learning Machine (Learning Machine, 2017) has collaborated with MIT Media Lab to provide an open infrastructure allowing academic credentials to be shared peer-to-peer and verified as authentic. Blockchain removes single points of failure, such as a vendor service or issuing institution, ensuring that records can be verified without any institutional dependencies and without a costly and time-consuming process.

Good societal and corporate governance

The management of public services is yet another area where blockchain can help lessen paper-based processes, minimize fraud, and increase accountability between authorities and those they serve. For instance, the Delaware Blockchain Initiative (Forbes, 2017) aims to create an appropriate legal

infrastructure for distributed ledger shares, to increase efficiency and speed of incorporation services.

Regarding online voting, leveraging blockchain can be used to create an infrastructure for tracking and counting votes, potentially eliminating the need for recounts by taking voter fraud. By capturing votes as transactions through blockchain, governments and voters would have a verifiable audit trail, ensuring no votes are changed or removed and no illegitimate votes are added. An example of a start-up working in this issue is Follow My Vote (FollowMyVote, 2017).

While blockchain has the potential to demolish barriers of entry to a sector or supply chain and to decrease transaction costs between actors involved, intermediaries and third parties such as governments decrease the output of those organizations by imposing restrictions and creating complex regulatory frameworks. Aragon (Aragon, 2017) aims to disintermediate the creation and maintenance of companies and other organizational structures, and to allow any individual or organization to create value, including employees and contractors from developing countries.

4. Questions for discussion

The purpose of this research is to study the impact of blockchain in CSR and SSCM by answering the following research questions:

Q1. What are the requirements for a company to use blockchain technology systems to deal with CSR and SSCM?

Q2. What are the potential advantages and disadvantages for a company to use blockchain technology to deal with sustainability, accountability and transparency?

Q3. The disintermediation enables direct value exchange between peers over the web. Is a peer-to-peer disintermediated market more reliable than a traditional one? Would operators and consumers be more/less protected in such a market? Would a peer-to-peer market be more/less stable during periods of stress?

Q4. How much will collective irrational phenomena such as sentiment and confidence swings affect the capability of these markets to operate? How can we govern and regulate these systems to avoid abuses and protect users?

Q5. Is blockchain technology a collaboration enabler? An asset/service sharing enabler?

Q6. Will blockchain technology lead to a large-scale decentralized collaboration?

Q7. Will blockchain technology be able to establish a mutual credit system?

Q8. Will blockchain technology be able to create a self-organized society?

In order to help to answer the previous questions, the following paragraphs summarize the key main benefits that blockchain will bring to CSR across markets.

Operational efficiency: current information management systems rely on databases in which information is kept isolated. Corporations hold individual digital books of records that frequently require manual audit. Furthermore, the absence of a single version of the truth and audit trails generates arbitrage concerns. Blockchain technology challenges the logic of information silos between supply chain actors and eliminates the need for interfirm agreement. For instance, it provides a unique historical single version of the truth, with immutable and distributed records endorsed by community consensus, lowering disputes over audit trials and promoting operational efficiency in many domains (Aste et al., 2017).

Rebalancing information symmetry: at present, trades, transactions and negotiations are influenced by asymmetric information among supply chain actors, which cause problems such as moral hazards and adverse selections. Those issues have been historically resolved by the introduction of central authorities that act as a single point of control but also as a potential point of failure. Lack of traceability and transparent accounting and accountability foster the demand for regulatory oversight. Blockchain technology defies this paradigm by eliminating the asymmetry of information among actors. Therefore, blockchain becomes a shared data repository for them. It enables the evolution from post-transaction monitoring to on-demand monitoring and improves the ability of regulators to fulfill their mandate of ensuring the markets' legality, stability, and security with a transparent record of auditable data that is verified, timestamped, and immutable (Aste et al., 2017).

Decentralized corporations and governance: blockchain enables innovative organization forms, novel business models, and new production processes in which access prevails over ownership, and sharing prevails over property (Kurka et al., 2017). Decentralized organizations (DOs) and Decentralized Autonomous Organizations (DAOs) will enable new models of non-hierarchical governance, in which decision-making is spread across the network's nodes. DOs and DAOs will be able to run a business autonomously under an incorruptible collection of business rules programmed into smart contracts (Aste et al., 2017).

Better traceability, transparency and trustworthiness than centralized systems: regarding traceability, similar effects can be achieved by using either of the systems. Blockchain systems can be divided into permissioned public and private, and non-permissioned public ledgers (fully accessible for anyone). Thus, transparency can differ between different types of blockchain systems. In centralized systems, only one party is controlling the information. The data on the blockchain is trustworthy. This is due to the advanced mathematical algorithm that makes data stored on the blocks impossible to alter afterwards. Therefore, the same trustworthiness achieved by a blockchain solution cannot be accomplished by a centralized system. Furthermore, in terms of maturity, there are challenges to overcome before a blockchain system can be comparable to a centralized system. Lastly, blockchain technology is said to be superior to the centralized system in terms of the future potential, which is mainly based on the trustworthiness and transparency it brings and the features it enables, such as smart contracts and lack of intermediaries.

5. Conclusions

Blockchain has the potential to radically change many economic and societal sectors and to enhance social responsibility of all types of organizations, sustainability of supply chains, and the enforcement of governance in a completely innovative way. In the context of the current fourth industrial revolution, which is characterized by the fusion of diverse technologies that blurs the borders between physical and cyberspace, blockchain is part of a broader toolbox that together with IoT, can disrupt for better many business sectors and society at large. This article reviews its foundations for developing peer-to-peer platforms for exchanging information and assets without intermediaries and in a trustworthy, sustainable, accountable and transparent way.

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