On the Impact of Blockchain Technology on Business Models and Supply Chain Management

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Abstract: Digitalization is changing the way companies create value. It is an umbrella term for diverse applications of digital technologies to processes inside companies and along the value chain. This research aims at understanding how literature has addressed the impact of blockchain technology on business models (BM) and supply chains. The study is based on a simple framework assuming that blockchain technology can affect BM directly, but also indirectly via supply chain management (SCM). Thus, three types of relationships are studied: *i)* the impact of blockchain on BMs, *ii)* the impact of blockchain on SCM, and *iii)* the impact of blockchain on BMs via SCM. To this aim, a systematic literature review is conducted using the Web of Science and Scopus databases. The selected 78 relevant articles are analyzed both by descriptive and content analysis. Results show that blockchain technology can affect BMs either generically or in specific industries, while it affects SCM on the dimensions of *1) efficiency and process improvement, 2) transparency and traceability, 3) sustainable SCM,* and *4) supply chain collaboration*. The indirectly impact of blockchain on BMs via SCM act on the dimensions of *1) supply chain transparency, 2) supply chain restructuring* and *3) supply chain collaboration*. This paper concludes with a research agenda discussing the open research questions before blockchain can achieve wide adoption in practice.

Keywords: Blockchain, supply chain management, business model, literature review

1. Introduction

Blockchain technology was invented and introduced in 2008 by Nakamoto (2008). Since then, this distributed ledger technology that enables decentralised peer-to-peer transmission has received increasing attention by both practitioners and scholars. Much emphasis was put on the financial application of this technology, given the success of the cryptocurrency *bitcoin* developed on the basis of blockchain. The industry has started to envision its use in supply chains (SC) as a solution to various challenges upfront (Casey and Wong, 2017).

Big companies have placed themselves in the race to improve SC performances with blockchain technology. A massive effort in collaboration is apparent to improve SC traceability in sectors where provenance is a crucial factor. Walmart, IBM and several leading food companies explored the use of blockchain for food traceability, by testing it in authenticating records on pork transactions between China and the US (Alicke et al., 2017; Hackett, 2017; Marr, 2018). Nestle applied blockchain technology to achieve full transparency in their dairy SC (Pirus, 2019). Start-ups also play an important role in this field. At Provenance (https://www.provenance.org), the blockchain technology has been resorted to providing artisanal products a digital history, while Everledger (https://www.everledger.io) empowers authenticity proofing in diamond SCs (Catalini, 2017).

There is little doubt that blockchain, as a recent technological innovation, holds multi-facet implications on the future of supply chain management (SCM), while innovation in SCs can generate changes in business models (Abdelkafi and Pero, 2018). In other words, blockchain, if introduced to support SCM, might impact how companies make money, and consequently their business models (BMs). It will not only give rise to new value propositions in established companies – e.g. customer can gain access on the SC-related data of a product, but also new business opportunities with new service offering – e.g. companies provide blockchain as services or platforms.

To the best of our knowledge, despite the potential of blockchain technology to change BMs, research has not yet been synthesized in relation to supply chains. Thus, the objective of this paper is to clarify how *literature has addressed the impact of blockchain on business models, either directly, or indirectly via SCs* by means of a systematic survey to literature. The research model distinguishes three types of impact: *i)* the impact of blockchain on BMs, *ii)* the impact of blockchain on SCM, and *iii)* the impact of blockchain on BMs via SCM.

The remainder of the paper is organized as follows: section 2 presents the research background and model, section 3 presents the methodology and first preliminary descriptive analysis of the selected literature. Section 4 discusses the findings, which are the basis for developing research

avenues presented in section 5, along with concluding remarks.

2. Research background

2.1 The blockchain technology

Blockchain is a distributed ledger system, in which information details on transactions are shared by Peer-to-Peer (P2P) network computers (Nakamoto, 2008; Zhao et al., 2016). The consensus mechanism in the network verifies the transaction details. After verification, the transaction is added to existing blocks and cannot be modified. Since all transactions are validated and recorded through the support of the consensus mechanism between the network computers, a trusted central entity that acts as an intermediary to verify and confirm transaction data is not required (Rennock et al., 2018).

Furlonger and Uzureau (2019) identify five elements/properties of blockchain: distribution, encryption, immutability, tokenization, and decentralization. Decentralization may be the most critical and difficult-to-realize characteristic of blockchains, since it ensures that no single entity controls all the computers or dictates the rules. Therefore, the blockchain is said to follow a democratic governance model (Vyas et al., 2019). Similar to democracies in the real world, blockchain is susceptible to the 51 percent attack, when one or a group of miners have control over at least 51 percent of the networks' computers. This problem, the high energy consumption induced by blockchains to solve the cryptographic puzzles, and the fact that transaction data are not centralized, but distributed among many nodes, make companies doubt the successful diffusion of blockchain technology in the future. Because of this, industry has created so-called permissioned blockchains beside permissionless blockchains. Whereas permissionless blockchains can be accessed to by anyone, permissioned blockchains are only accessed by authorized users such as companies that are members of a specific supply chain.

2.2 Supply chain

Chopra and Meindl (2016, p. 13) define supply chain as follows: *"a supply chain consists of all parties involved, directly, or indirectly, in fulfilling a customer request. The supply chain includes not only the manufacturer and suppliers, but also transporters, warehouses, retailers, and even customers themselves."* In general, supply chain management and planning deal with three key areas: supply chain configuration, supply chain collaboration, and supply chain coordination (Heiber, 2002).

The advancement in technology has pushed supply chains in constantly evolution. Transportation management systems (TMS), warehouse management systems (WMS), or recently Internet of Things, drones and 3D Printing are all examples of technologies that have changed or are currently inducing an ongoing change in SCs. Among them, blockchain is currently revealing high change potential.

2.3 Business models

As compared to the term *supply chain*, BM is a relatively new concept. In simple terms, it denotes the logic of the business, or the way companies are making money. A BM refers to how a company communicates, creates, delivers, and captures value out of a value proposition – be it a product or a service – offered to the customer (Abdelkafi, 2013).

The importance of BM research and practice has increased with the emergence of the Internet. Advancement in technology can call for changes in BMs. In particular, when new technologies emerge, established companies that have based their BMs on mainstream technologies can see their businesses and their profit formula degrade. For instance, leading researchers and practitioners has considered electric mobility as a disruptive technology that is inducing big transformations in the business in the automotive industry.

2.4 Research model

As an emerging technological innovation, blockchain seems to introduce changes on SCs directly. Some impacts derive directly from the specific characteristics of the technology itself. For instance, since (permissioned) blockchain is a system that can maintain a record of all transactions conducted, it is natural that blockchain can contribute to an increased transparency and traceability in the SCs, especially in industries where the documentation of provenance constitute a necessary trade requirement (Ganerwalla et al., 2018). Blockchain also seems to influence BMs directly. As this technology enables transactions to be conducted directly between peers, it reveals serious potential in eliminating intermediary BMs.

At the same time, some changes in BM are not expected to result directly from blockchain implementation, but rather indirectly via the mediation of SCM. Blockchain affects SCs on the first place, leading to a change in the BMs. Such effect can be explained by the SC innovation-driven BMs (Abdelkafi and Pero, 2018). Consequently, three types of impacts are captured in our research model: *i)* the impact of blockchain on BMs, *ii)* the impact of blockchain on SCM, and *iii)* the impact of blockchain on BMs via SCM.

3. Methodology

3.1 Material collection and selection

This paper analyses how extant research has addressed the impact of blockchains on BM and SC. We adopt the methodology of systematic literature review, defined as the replicable, scientific and transparent way to provide comprehensive and unbiased result based on existing knowledge (Denyer and Tranfield, 2009; Tranfield et al., 2003). In line with established methodologies on systematic literature reviews (e.g. Cronin et al., 2008; Tranfield et al., 2003) and extant reviews papers in peer-reviewed journals, our literature review follows a three-step process: (1) Identification and collection of literature according to the review protocol, (2) selection of relevant publications, and (3) critical analysis and reporting the result of the review process.

To search for the relevant publications, we use possible keyword combinations: (*blockchain* OR "*block chain*") and ("*supply chain*" OR "*supply network*" OR "*business model*") in the field of title, abstract and keywords. The search terms were set broad to capture all possible implications of blockchain on BM or SC, while the relevance is assured by the subsequent selection process. Based on the review protocol, we only look for articles, reviews and editorials from peer-reviewed journals in English. Our literature search was performed in two databases respectively: *Web of Science* returned a list of 160 qualified articles, while *Scopus* resulted in 299 articles.

The result of the two databases is merged by removing duplications. Then we used a filtering process by applying the VHB-JOURQUAL ranking – a valid, comprehensive ranking of academic journals in the field of business administration widely adopted in German institutions (Schrader and Hennig-Thurau, 2009) – to assure the quality of selected materials. 134 articles are identified for further selection, which is conducted in two steps.

The first step consists of a careful reading of the abstracts and keywords, and sometimes the introduction, to ensure that we only keep the publications that are relevant to our research question. During this step, a rough classification was performed to divide articles upon the three macro-clusters as in the research framework: *i) blockchain impact on BM*, *ii) blockchain impact on SCM* and *iii) blockchain impact on BM via SCM*. Articles removed at this stage mainly include *i)* papers that suggested blockchain only in future research direction, *ii)* papers that cited blockchain only as a minor component among other digital technologies, and *iii)* papers with limited implication on the impact, for instance, survey on the current adoption rate of blockchain in industry. All three authors participated in the selection process, and any misalignment was resolved through discussions. This process yielded 78 papers for consequent in-depth reading and analysis (i.e. the second step).

The process of literature analysis started by coding the content of the articles according to focal issue, research methodology, unit of analysis, industry, theoretical perspective and the implication regarding the three types of impact. The coding process was tracked in a database containing all the papers.

3.2 Descriptive analysis

To get an overview of the selected literature, we start by analysing the distribution of articles with respect to the year of publication and journals, as well as the type of impact studied in the article (Table 1[1]).

Our analysis shows that literature is still at its infancy. The first relevant articles were published in 2017. Nevertheless, a steady growth in the number of publications can be observed along all the years: 3 papers in 2017, 11 papers in 2018, and 62 papers in 2019. As the paper database was consolidated in late January 2020, only two papers are captured in this year. Most of the identified papers deals with the impact of blockchain on SCs (57 papers), less papers have addressed the impact of blockchain on BMs, while the smallest number of papers are dedicated to the impact of blockchain on BMs through SCs (6 papers).

In terms of research dissemination, *International Journal of Information Management*, *International Journal of Production Research* and *Sustainability* hold the leading role with more than six relevant papers selected (Table 2[2]).

4. Findings

4.1 The impact of blockchain on BM

Although the literature argues that blockchain technology will have an impact on BMs, it is still unclear how blockchains will change BMs. In particular, we do not know the types of new BMs that will be created based on the new technology.

General impact of blockchains on business models

Morkunas et al. (2019, p. 296) mention, "*blockchain is predicted to challenge existing BMs and offer opportunities for new value creation*." Because literature provides little guidance how blockchain technologies may affect BMs, the authors use the business model canvas by Osterwalder and Pigneur (2010) to examine conceptually, while drawing on case examples from secondary literature, how blockchain can change the BM elements: customer segments, value proposition, channels, customer relationships, revenue streams, key resources and activities, key partnerships, and cost structure.

Lee (2019) argues that blockchains and cryptocurrencies are creating a token economy through different BMs. As Blockchain technology decentralizes not only currencies, but also other business assets, it can be disruptive by leading to entirely new ways of doing business. For instance, the US startup SyncFab supports buyers in finding manufacturers that have the required capabilities of producing the products developed by the buyers themselves. Buyers no longer care about proving their ownership for Intellectual property (IP) related to the product idea or manufacturing process, as IP is protected through blockchain and real-time updates. SyncFab also issued a cryptocurrency, which is used as a utility token to enable transactions on the platform.

Kollmann et al. (2019) show that blockchains can foster a renaissance of cooperative principles on electronic marketplaces. They notice the misbalance of power on current platforms. Although users on platforms like YouTube create the contents, the platforms themselves capture most of the money. D.Tube (Decentralized Tube), a video streaming service like YouTube but based on blockchain technology, however, ensures balanced value creation and takes no revenue from advertising, while also offering a fair and transparent platform. Kollmann et al. (2019) introduce so-called BEEM (Blockchain-Enabled Electronic Markets) as new types of marketplaces that work with the cooperative principles.

[1] See at: https://bit.ly/2NjOtKX

[2] See at: https://bit.ly/2NjOtKX

Impact of blockchains on business models in specific industries and new business model patterns

In addition to the articles that deal with blockchain effect on BMs in general, some articles are related to specific industries. Dutra et al. (2018) focus on the media and entertainment industry. Especially in this industry, where monetization continues to be a challenge, blockchain seems to lead to the emergence of new BMs. The authors found that two patterns of BMs could be disruptive: (1) Monetizing content for both creators and curators, and (2) Building a one-stop content shop. The first new BM involves creating a social network, in which users can earn financial rewards (in the form of micropayments or payments of digital currency) by posting their own content or curating and promoting others' posts. The second simplifies the value chain by decreasing or eliminating the need for intermediaries between content creators and content consumers.

In the energy sector, Bürer et al. (2019) found many blockchain-supported BMs. Smaller firms or new entrants to the energy sector are entering markets with business models based on peer-to-peer trading of energy. Therefore, established utilities are starting to feel the pressure to learn more about the new technology and to come up with more competitive BMs for certain types of customers. It seems that, in the energy sector, especially in the area of renewable energies, blockchain technology will facilitate peer-to-peer transactions through tokenization. Many startups are currently leveraging blockchains and smart contracts to enable private energy producers (e.g. households) to be paid by consumers of electricity for the energy they dispatch into the grid.

In general, disintermediation has been recognized as the most significant BM change that industries will experience when the level of diffusion of blockchain technologies increases.

4.2 The impact of blockchain on SCM

There is a general agreement among authors that blockchain technology will generate new opportunities for SCM, leading to new SC strategies and changes at the operations' level. In the following, we address specific areas where blockchain can impact SCM.

Supply chain efficiency and process improvement

Blockchain technology exhibits high potential in improving efficiency. Due to the immutability, of blockchains, companies can eliminate errors, streamline processes, and improve processes of order fulfillment (Hastig and Sodhi, 2019). Blockchain also integrates fragmented production data and information on production system breakdowns, while enhancing automation and standardization in order fulfillment and quality management (Roeck et al., 2019; Wang et al., 2019). Blockchain ensures an increased speed of data and financial transactions and facilitates digitalization of assets based on the connectivity and capacity related to IoT (Pournader et al., 2019). In addition, improvements in efficiency are due to the reduction of transaction costs because of better and more structured processes and reduced reliance on intermediaries (Cole et al., 2019). Based on the transaction cost economic theory, Roeck et al. (2019)(2019) reveals supply chain transparency enabled by the distributed ledger can stimulate the disclosure effect, based on analysis on the historical record documented in the blockchain system. In this way, SC structural complexity decreases, while enhancing coordination among SC members (Hald and Kinra, 2019; Schmidt and Wagner, 2019). Activation of the event-triggered automated payments procedure accelerates the SC execution processes. This can lead to higher efficiency during the design and new product development where multiple parties are involved (Cole et al., 2019). Block chain-enabled smart contracts, software programs that facilitate negotiation, support interaction within networks, while automating and verifying the processes and products within the SCs (Saberi et al., 2019).

Supply chain transparency and traceability

Blockchains make the tracking of items and transactions in the SC radically faster and simpler (Gurtu and Johny, 2019). Owing to its record-keeping nature, blockchain can improve SC visibility and transparency (Kamble et al., 2019; van Hoek, 2019). In general, blockchains facilitate sharing of documents instantaneously and securely among all SC participants. Therefore, information on inventory along the entire SC can be instantly shared free from risks and frauds (Gurtu and Johny, 2019). This practice of SC traceability and trackability is prominent in the shipment industry (Philipp et al., 2019), while similar implications could be extended to other sectors such as the pharmaceutical and mining sectors (Hastig and Sodhi, 2019; Montecchi et al., 2019). Blockchain is bringing radical change to SC transparency, not only because it enables tracking products or components along the distribution process, but also because of its ability to trace whole histories of production processes and even individual products (Bai and Sarkis, 2020). In the pharmaceutical industry, RFId enables tracing at the pallet level, whereas blockchain technology makes this possible for a single pill (Hastig and Sodhi, 2019). However, other research justifies that the blockchain technology is not going to substitute past technologies for supply chain track and tracing (e.g. RFId), while the maximum value would remain in the combination of multiple technologies (Hoek, 2019).

Supply chain sustainability

Strictly linked to transparency and traceability, blockchain technology will have implications on sustainability (Bai and Sarkis, 2020). This empowerment of tracing and understanding the origin of the products can be considered as new value propositions to the market (Hald and Kinra, 2019). Due to its immutability characteristic, blockchain can help companies verify and govern sustainable practice in SCs (Gurtu and Johny, 2019). One the one hand, it serves as the basis for the development of sustainable measures by tracking product sustainability information (Bai and Sarkis, 2020), exerting a positive impact on the management of food quality, safety and sustainability (Kamble, 2019). On the other hand, it facilitates the adoption and diffusion of sustainable practices in organizations and SCs (Hastig and Sodhi, 2019).

Blockchain addresses SC sustainability on the economic, social and environmental levels of the firm (Saberi et al., 2019). The reduction of SC tiers via disintermediation, minimisation of human errors, and transaction times, while avoiding deliberate alteration in SC data via data authentication are all factors that support economic sustainability (Saberi et al., 2019). The environmental sustainability can be achieved by avoiding product recalls, ensuring that "green" products are actually environmentally friendly, and by providing support to incentive recycling as well as fraud avoidance by using reputation-based systems (Saberi et al., 2019). On the social dimension, the case of MoyeeCoffee analysed in Wang, et al. (2019) deploys blockchain technology to create social impact by establishing a fair and honest SC. Most cases, however, analyse big global corporations such as Walmart and Unilever (Cole et al., 2019).

Supply chain collaboration

Blockchain technology is believed to "potentially remove certain tiers of actors from SCs that have the power to manipulate product prices and supplies" (Wang, Singgih, et al., 2019), and the result might lead to more intense financial collaboration across the multiple tiers along the SC. The so-called digital trust established by the blockchain technology could potentially stimulate and safeguard SC-wide collaborative projects (Wang et al., 2019a), having the collaborations extended to actors who are beyond historical trust-based relationship (Schmidt and Wagner, 2019). In contrast, others view collaboration itself as a critical challenge for blockchain introduction to the SC (Hastig and Sodhi, 2019). Collaboration is antecedent prerequisite for technology deployment with the same importance as capability and technology readiness. As a result, the implication of blockchain on SC collaboration is not as straightforward.

4.3 The impact of blockchain on BM via SCs

The papers that consider blockchain, BMs and SCs at the same time are relatively few. All papers but one report the results of systematic or comprehensive literature reviews. These reviews generally applied unstructured analysis of scientific literature discussing cases from secondary sources (Fosso Wamba et al., 2020; Queiroz et al., 2019; Tönnissen and Teuteberg, 2019). The characteristics of the blockchain that are mainly reported and discussed due to their implications on the BM are SC transparency, SC restructuring and SC collaboration.

Impact on BM via SC transparency

Varghese et al. (2019) argue that blockchain is faster than other tools, making it powerful for a company to offer new services to customers, thus affecting the value proposition. As firms are continuously looking for innovations and novel BMs to be coupled with the rapid technological and product development, blockchain-based traceability promotes various opportunities as new value propositions through changes in SC transparency. Among the examples, an Irish craft beers producer (https://www.down-stream.io/) uses blockchain to enable customers to retrieve all information regarding the beer by scanning a QR code as a customer attractant (Fosso Wamba et al., 2020).

Impact on BM by restructuring the SC

Blockchain can offer new ways of value capture through SC restructuring and innovations (Hald and Kinra, 2019). Mainstream research assumes that blockchain-enabled SC restructuring is substantially related to disintermediation (Wang, Singgih, et al., 2019). Some of the activities currently performed by 3rd-parties are expected to be eliminated with the introduction of blockchain technology (Hughes et al., 2019). Therefore, as the adoption of blockchain combined with smart-contracts will continue to increase in the coming years (Queiroz et al., 2019), and the resulted disintermediation will lead to a reduction of structural complexity within SCs (Schmidt and Wagner, 2019). Contrastingly, by comparing case studies from secondary sources, Tönnissen and Teuteberg (2019) observed the phenomenon of intermediation or re-intermediation rather than disintermediation as expected. As a result, the number of SC actors has increased. However, regardless of the addition or elimination of intermediaries, this discussion on SC restructuring is intimately intertwined with the implications for the BMs of the actors in the SC. The application of blockchain will result in changes in the SC configuration, e.g. 3PL will no longer be required to verify the transfer of objects, new companies offering new services will emerge, or actors already present in the SC will offer new services by relying on blockchain service providers (Hughes et al., 2019; Tönnissen and Teuteberg, 2019).

Impact on BM via SC collaboration

Blockchain is expected to increase trust (Khan and Salah, 2018; Yeoh, 2017) within the SC because the transactional record remain immutable within the blockchain (Galvin, 2017). Trust is the basis of partnerships, an important element of business models. By facilitating the sharing of resources and processes, a traditional standalone manufacturer can transform the structure of its supply chain towards a decentralized and connected manufacturing system (Hald and Kinra, 2019). This supports a timely and flexible match between the demand and supply side of two adjacent SC actors, while leading to low switching costs. Therefore, the business model can be geared toward a better cost structure, more flexible partnerships, and higher availability of key resources.

5. Discussion and conclusion

Our literature analysis considers three relationships: the impact of blockchain on BMs, the impact of blockchain on SCs, and the impact of blockchain on BMs mediated through SCs. Although the literature has mainly focused on the implications of blockchains on SCs, blockchain can also affect BMs, directly or via innovations in the SC. The latter topic is far less developed: this might be explained by the fact that all the papers have been published in between 2019 and 2020, while suggesting that the practical applications of blockchain are so far limited.

Based on our review of the literature, we develop, in the following, a research agenda by formulating questions that

have to be addressed in order for blockchain technology to achieve wide diffusion.

The main implications on BM reside in the possibility of disintermediation or re-intermediation in the SC. A shared ledger might lead established companies to renounce to the services provided by traditional external actors or to rely on new service providers, as well as it might lead to new companies with new BMs entering the network. These considerations lead to the following research questions:

- What kind of new BMs will result from leveraging blockchain technology? How can start-ups propose new BMs based on the use of blockchain technology?
- How can established companies adapt their BMs and react to the changes induced by blockchain technology?
- How blockchain technology will impact SC configurations? What are the implications for BMs?

Blockchain is also acting on the relationships between companies, in particular on contracts and data sharing. The technology can support creating a common ledger that is shared among all the actors of the SC (i.e. permissioned blockchain) or anyone that wishes to join the blockchain (i.e. permissionless blockchain). However, the implication is that, on the one hand, it might lead to resistance to the adoption of blockchain technology, if companies are not willing to share all data, and on the other hand, to new ways of collaborative BMs. Indeed, whereas many technological hurdles seem to be already solved, from a managerial perspective it is still a complex task to bring all the companies in the SC to accept a technology that would require full transparency. Therefore, we propose the following research questions:

- What are the barriers and enablers to the adoption of blockchain technology in the SC?
- How blockchain technology will impact trust in SC collaboration? What are the implications on so-called collaborative BMs?
- How blockchain technology will impact power distribution in SC relationships?
- What kind of BMs will emerge to support this change?

Finally, research should continue to support managers in the choice on whether to adopt blockchain technology, instead of other traditional technologies. Therefore, future research might investigate the following research questions:

- What are the pre-requisites for profitable blockchain application (e.g. data quality) and how to ensure them?
- Why should companies choose blockchain instead of traditional technologies (e.g. centralized databases)?
- When is the blockchain really worth the investment?

From a managerial perspective, three issues are extremely important with respect to the adoption of blockchain technology. First, managers need frameworks that enable them to identify, whether the blockchain is the required technology for the problem at hand. Second, companies require methods that improve the level of trust among them. It is true that blockchain increases the level of trust that the records stored on the distributed ledger have not been changed, but it also calls for a high amount of trust between partners that should accept, at the end, that their transaction data is stored on external systems. Third, managers need tools for the assessment of the costs and benefits as well as the risks and opportunities of the blockchain to decide, whether to embark on the technology or not. Although blockchain is very promising, it is still a long way to go until the it achieves a wide level of diffusion.

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