If Blockchain is the answer what is the question?

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Abstract

The purpose of the paper is to identify the issues and challenges to employing blockchain technology for different operations context. The paper analyses five cases to identify drivers and barriers to adopting the technology. Our findings suggest that interoperability and platform dependency can limit the wide-scale deployment of the technology. Additionally, trust in rule-based software automation and consensus among supply chain actors can inhibit effective adoption. In summary, the paper finds that care should be taken when applying blockchain, since there are many situations where its implementation is not feasible or not beneficial.

Keywords: Blockchain, Challenges, Limitations

Introduction

Blockchain has emerged as a technology that can provide visibility, traceability and transparency in business operations, which will lead to better accountability. The potential usefulness of the technology has been reported in many sectors such as: energy (Adoni et al., 2019); health-care (McGhin et al., 2019); digital supply-chain (Min, 2019); retail (Morkunas et al., 2019); financial services (Tapscott and Tapscott, 2017); and transportation (Lei et al., 2019). The key properties of this technology that makes it a valuable proposition to handle heterogenous transactions in different sectors are discussed below and these have been reported in the pilot studies undertaken by technology providers such as IBM (2017), Capgemini (2017) and in academic research.

- ***Immutability****:* The transactions recorded in a blockchain cannot be tampered, deleted and revised, i.e. the process and information stored in each block is irreversible, thus providing an accurate view of the activities. However, the

authenticity and quality of the information will depend upon the author and source.

- *Distributed:* The blocks and corresponding chain is stored among all the entities in the network participating in the transactions, which increases visibility of the information. However, access restrictions may apply depending on the nature of the information and the rules associated with the creation of blocks.
- *Decentralised:* The transactions occur based on automated rules set in the network (mainly through a process of consensus), which eliminates the need of a central authority, i.e. this potentially will lead to faster transactions, and eliminates the risk of the data being held centrally in a server (as in contemporary information systems). However, as the size of the chain increases the processing time to create or retrieve a block will increase.
- *Automation*: Most processes in the network, i.e. creating a record, processing transactions, are executed automatically by the software codes deployed in the network. The cryptographic verification process ensures authenticity of the transactions and makes the process incorruptible, i.e. devoid of errors (if the software codes do what they are meant to or agreed upon in a suitable manner). It is worth highlighting that the process of rule creation and revisions is a grey area and will depend on the context and purpose of using the technology.
- *Single Unified Ledger:* This helps in aggregating all the records in a single network, i.e. provides the actors with high-level as well as low-level view of all the transactions, linked-information efficiently, thus reducing the information and cognitive overload to some extent. Employing blockchain analytics to provide such a view can be complex and inefficient, due to size of the chain and automated access rights imposed by automated rules.

The existing literature has focussed mainly on the advantages offered by the technology in different business sectors. Though, the merits offered by the technology are demonstrated through pilot projects undertaken by technology providers, it is necessary to understand the challenges to large-scale adoption of the blockchain and readiness of businesses to deploy the technology.

Issues and challenges identified from the literature.

The literature gathered from various business disciplines, information systems and computing science was systematically reviewed to identify the potential challenges associated with the adoption of the technology from a business perspective. Though, the emerging technology has been tipped to transform businesses in a 'positive way', the key issues associated with the technology (usage, implementation and deployment) and organisation needs (value of using the technology, skills and expertise) are yet to be understood and discussed comprehensively. *Table 1* will present the key challenges that can be potential barriers towards the wide-scale adoption of the technology in business domain (in-particular global supply-chains which are increasingly becoming complex). A quick review of the table highlights: the need to understand that will aid in managing and implementing the technology (skills and expertise); agreement between various businesses adopting the technology on the automated rules (process and author), and operational software platform; assessing the long-term benefits of the technology (i.e. consider its efficiency to process multiple transactions and viable integration with the existing operations and processes).

Table1: Summary of key challenges reported in academic literature and business (Y means that the challenge has been briefly discussed/mentioned in the literature)

Challenges	Min (2019)	Morkunas et al., (2019)	Atlam and Wills (2019)	Casino et al., (2019)	Kamble et al., (2018)	Kshetri (2018)	Deliotte (2018)	Capgemini (2017)
Access control/ authorisation						Y	Y	Y
Compliance: legal and regulatory	Y	Y		Y		Y	Y	Y
Computing power	Y			Y		Y	Y	
Data Management			Y	Y				
Efficiency and performance			Y	Y		Y	Y	Y
Skills and expertise	Y				Y		Y	
Platform standardisation		Y	Y					Y
Operational Costs		Y					Y	Y
Organisational Resistance [within firm]	Y	Y				Y	Y	
Organisational Resistance [between firm]	Y					Y	Y	
Privacy	Y		Y	Y			Y	Y
Scalability	Y		Y	Y			Y	Y
Security								
Strategy to			Y	Y				Y
Suitability				Y	Y			
Trust in automated software	Y	Y		Y				Y

Review of industry pilot cases

Blockchain is considered as a valuable solution in different areas because it can record transactions in a secure, transparent, decentralised, efficient, and low-cost way (Schatsky & Muraskin, 2015). It can simplify the transmission of information to eliminate the commonly conflicting layers found in supply chains, making information more reliable,

timely, highly visible and incorruptible. The purpose of this section is to present different instances in which blockchain has been implemented to investigate the themes identified in the literature review and to understand the requirements to leverage the potential of this technology. The five cases selected are looking at the food industry, energy, disaster relief, housing and banking. The findings stemming from the review of the pilot cases is summarised in Table 2.

- ***Food Supply Chain.*** The food supply chain is an excellent example of the potential value of blockchain. Freshness of food, especially meat, is a significant health concern. That was the motivation behind Provenance (Provenance, 2019), a company that has implemented blockchain to provide more certainty and transparency in the food supply chain. The purpose is to allow users/companies to know more about the origin, travel and destination of food. Talking about meat that can allow users to trust the "kill" dates in their meat products, thereby ensuring freshness. In fact, the company implemented a similar idea in Indonesia, in which they used blockchain to track tuna from the moment it was caught until it reached the consumer (Safaryan, 2017). That way, it was possible to add traceability to the supply chain and ensure consumers about the journey of their product. The potential of blockchain in this setting is not only to increase traceability though. It can allow to support commodity management to reduce duplication of certificates and paperwork, allow marketplace creation by connecting suppliers and customers, increase data sharing among different members of the supply chain through collection of information from different sensors at different stages, increasing access to capital investments, and enhancing payments (Noel, 2018).
- ***Energy.*** Introducing a fully decentralised energy system is another potential venue for blockchain. The technology available nowadays allows people to be not only consumers of electricity, but also producers. Blockchain has the potential to support transactions among customers with different roles. Elektrify is a good example of the use of blockchain to allow these interactions (Electrify, 2019). In fact, a project between Busan City, Nuri Telecom, Pusan National University, Busan City Gas, and Korea Industrial Complex Corporation tries to exploit this possibility, to improve power generation and distribution in the region (Marley, 2019). This would also facilitate the creation of a micro-grid in regions of the country, which is a project currently pursued by Korea Electric Power Corporation (KEPCO). Beyond that, also in Korea, Swytch, is partnering with Chuncheon to use smart meter and blockchain technology to incentivise and provide benefits for companies and people looking to reduce carbon emissions (SmartCitiesWorld, 2018). On top of that, blockchain can also be used to allow metering, billing and clearing processes (PwC, 2016), which shows the reason this technology is very promising for other countries as well.
- ***Relief and disasters.*** Collaboration and cooperation are very complicated in situations in which a disaster has affected a region because of the multiple number of organisations involved. Governmental organisations, non-governmental organisations, charities and civil organisations try to provide support for the affected people, but it is complicated to provide a honed response because of the duplication of efforts and the centralised systems used by these organisations. The U.S. government realised that blockchain could be effectively used to enhance collaboration. Blockchain can be used to create a decentralised system through improved information sharing exploiting its traceability, transparency and immutability (Akilo, 2018). In that way, organisations could have more clarity about

the activities of the other stakeholders, helping guide their activities. Moreover, this would allow to pool resources and introduce a coordinated response. This benefit, however, would not be only for the organisations. Transparency and traceability would allow donors to increase trust in NGOs and charities and ensure a more efficient response to the victims. From that perspective, blockchain can allow to provide support for donations and financial transaction in disaster settings (Phil, 2018).

- ***Housing.*** The housing industry represents an area with huge potential for the implementation of blockchain. A very interesting example comes from the intersection of housing and public policy. The Kenyan National Housing Fund provides government-funded housing for families in need. However, the scheme has been criticised because of fraudulent activities and corruption (Aki, 2018). The use of blockchain would allow to ensure the transparent distribution of houses because blocks cannot be altered once these have been added to the chain. The notoriously porous land registry database would be recorded using blockchain to ensure that houses go to the people who need them. Additionally, funds would be more difficult to embezzle, and bribes would be reduced considerably (Sharma, 2018).
- ***Banking.*** The most notorious application of blockchain is related to cryptocurrency. Looking at financial services, blockchain has an incredible potential to improve transactions. The We.Trade platform from HSBC in collaboration with another 9 banks is a clear example (Finextra, 2018). HSBC has been at the spear point of the use of blockchain to improve financial transactions. In 2018, the bank was able to perform the first trade finance transaction using R3's Corda scalable blockchain platform, in the situation of a Cargill shipment of soybeans going to Malaysia from Argentina (HSBC, 2018). The purpose of this test was to use a shared application instead of applications in multiple systems, which reduced the transaction time from days to less than 24 hours. This outcome showed the feasibility of trade digitisation and emphasised the potential to reduce fraud risks in letters of credit, and introducing more efficient procedures (Ganesh, Olsen, Kroeker, & P, 2018).

Research Agenda

An important contribution of this research is to convert the themes identified in the literature and illustrated through analysis of cases, into possible directions for future research. We identify four research questions that demand attention, if blockchain is to be seen as a valuable technology for operations management.

- ***Interoperability.*** Research on blockchain focuses on the benefits and the characteristics, but often overlooks the technical requirements and implications. For example, each actor in the system must possess the required expertise and equipment to effectively share data. Therefore, research should investigate the minimum technical requirements and how big a challenge it may be to bring organisations to the required standard. Additionally, when discussing cases in which individuals also read or write data, this becomes even more complex.

Table 2: Summary of the business cases

Cases	Technical		Social	
	Interoperability	Platform	Rule-based software automation	Consensus among actors
Food SC	Different levels of IT expertise and equipment among different links from supply chain (from fisherman to retailer).	Data recording methods and technology might be inconsistent. Different stakeholders can have multiple platforms.	Rules development and agreement can have a significant effect on the different links in the SC	Permissions for data editing/access need to be properly agreed. Acceptance to technological innovation can be challenging.
Energy	The decentralised system requires similar technology for users/producers and organisations to record/update.	Highly complex system with multiple nodes in which a single platform across all users/producers would be required.	Data protection can be problematic because of GDPR. Data sharing rules would need to be clearly defined.	The level of access to producers/users should be well-established and agreed upon. There is a need to ensure consistency in practice.
Disasters	There is a varying level of technological proficiency and resources among actors, particularly donors.	Multiple platforms should be integrated, and databases consistently prepared.	The different type of participants would need to define who would be making the rules, how/if these can be modified and how are all the stakeholders integrated.	The combination of private and public funding could affect the interests of different stakeholders. Decisions on how much information is shared and what information can be taken should be agreed.
Housing	Technological requirements for data collection and recording need to be defined. The expertise to implement blockchain would be essential.	Different branches of government need to interact through the integration of different systems.	GDPR requirements can be complicated. The level of personal data shared, its use and level of access would need to be carefully stated.	It requires involvement of contractors/suppliers and governmental officials to identify the kind of data shared and who would be the main participants.
Banking	Technological proficiency would need to be consistent across actors.	Multiple platforms should be integrated into a single platform.	Decisions should be made about to what extent should data be shared, who will be defining the rules and how/if these can be modified.	Banks and authorities would need to agree on what data can be taken from the transaction and what access level is required from the different parties.

- ***Platform dependency.*** As with information technology, the extent to which blockchain delivers benefits is affected by the data in the system. This means the platforms used, the way in which they are used by actors and the level of expertise of these actors are all important. In particular, the way that data are captured and communicated could be crucial. For example, if objective data are captured using a standardised approach, the data will be more trusted than data input manually, with implications throughout the lifetime of these data. Research should seek to understand data management, platforms and readiness for blockchain implementation.
- ***Trust in rule-based automation software.*** Rule-based systems, whether electronic, economic or otherwise, are important in enabling business. Trust in such systems, however, is greatly affected by the source of the rules. Whether blockchain rules are set by regulatory bodies or by individual companies and whether they can be modified by individuals or not can affect the trust and hence the adoption or success of blockchain. Research should investigate the behavioural aspects in particular, to understand how and when blockchain can command sufficient trust to be adopted.
- ***Consensus among supply chain actors.*** The adoption of the technology will require an understanding and agreement between all the actors (for example, supply-chain entities) participating in the blockchain network. This will require have an agreement on the rules set-up within the network, using a platform provided by a technology provider, which will require integration with the existing processes, and participating in the transactions (i.e. willingness and mindset to use the technology). The consensus between the firms will be driven by the potential benefits offered by the technology to the individual firms and the awareness/ expertise of the managers about this new and complex technology. The consensus within firm will be driven by the organisation culture to take risks i.e. adoption a technology whose benefits are yet to be validated through long-term usage and technical complexities involved to integrate with existing process in the firm, which will require persuading the management and updating the skill-set of the relevant employees throughout the processes involving technology adoption, deployment and maintenance. Research should understand and investigate various consensus factors within and between firms that will lead to wide-spread adoption of blockchain and eventually make it scalable.

Managerial Implications

Operations Managers in a variety of business contexts may find blockchain being offered as the silver bullet that will solve all problems. Examples, including the cases discussed in this research, demonstrate the breadth of applications, from supply chains for consumer products, to government contracts and from energy to banking. Blockchain can be applied in almost every business context. Before leaping into the unknown, however, managers should question whether it should be used in their specific context. This research outlines four key questions that should be considered before deciding that blockchain offers the appropriate solution.

- ***What kind of expertise is required?*** Implementing a blockchain based solution requires both strategic and technical expertise. The former is to evaluate and

decide on the most appropriate implementation of technological possibilities. The latter must be updated as the technology will evolve, and its complexity increases. This complexity is particularly clear in cases such as the energy one, in which the number of actors contributing energy (and data) is enormous. Ensuring that all of these actors are appropriately connected and that the sources of data are integrated, as well as being certain that the system will remain suitable over time, represents a considerable technical challenge.

- ***Who has the right to input data?*** Assuming the required technical expertise and strategic decision making are in place, one of the key challenges is platform governance. Consider, for example, the case of the food supply chain, in which traceability depends on the information in the system, how it is input and how it is communicated. If false data are input, these will be stored and transmitted through the whole system. While using blockchain should give confidence that fish have been caught legally or food safety standards have been maintained, this confidence would be unfounded if an actor in the supply chain has deliberately or inadvertently supplied inaccurate data. It is essential, to be sure that the right people have the right access and use it appropriately for blockchain to be useful.
- ***Who will decide the rules, and can they be modified?*** Access rights are among the aspects that should be defined in the rules of a blockchain system. For example, in a smart contract, it is important that access is restricted to those affected by the contract and that decisions are made when rule-based conditions are met, e.g. once payment is made by one party, the ownership of a property is transferred to that party. Managers should be aware of which actors can decide the rules, for example, in a supply chain, will suppliers have any say and, should the members of the supply chain make changes, will there be ongoing implications? Moreover, should the situation change, the original rules may no longer be relevant, but if they cannot be changed, blockchain may not be appropriate. For example, if a buyer and seller change their agreement, so that a higher amount is payable at an earlier date (or vice-versa) it is possible that blockchain would limit flexibility and prevent changes.
- ***What level of transparency is good for business?*** Blockchain provides potential benefits in terms of transparency and traceability. An important consideration, however, is whether this is always desirable. In most business contexts, holding back some operational details can be very important. For example, knowing which sources of supply are used or how efficient equipment is can affecting negotiating positions between buyers and suppliers. The transparency offered by blockchain can be of benefit between partners in a supply chain, but managers must consider whether too much transparency may be involved. Consider, for example, a situation where a supplier also supplies competitors, who therefore have access to information. Or an alternative situation in which the agreement with a supplier ends and their access to their own data is restricted. Neither of these situations suggest that the benefits of blockchain should always outweigh the costs.

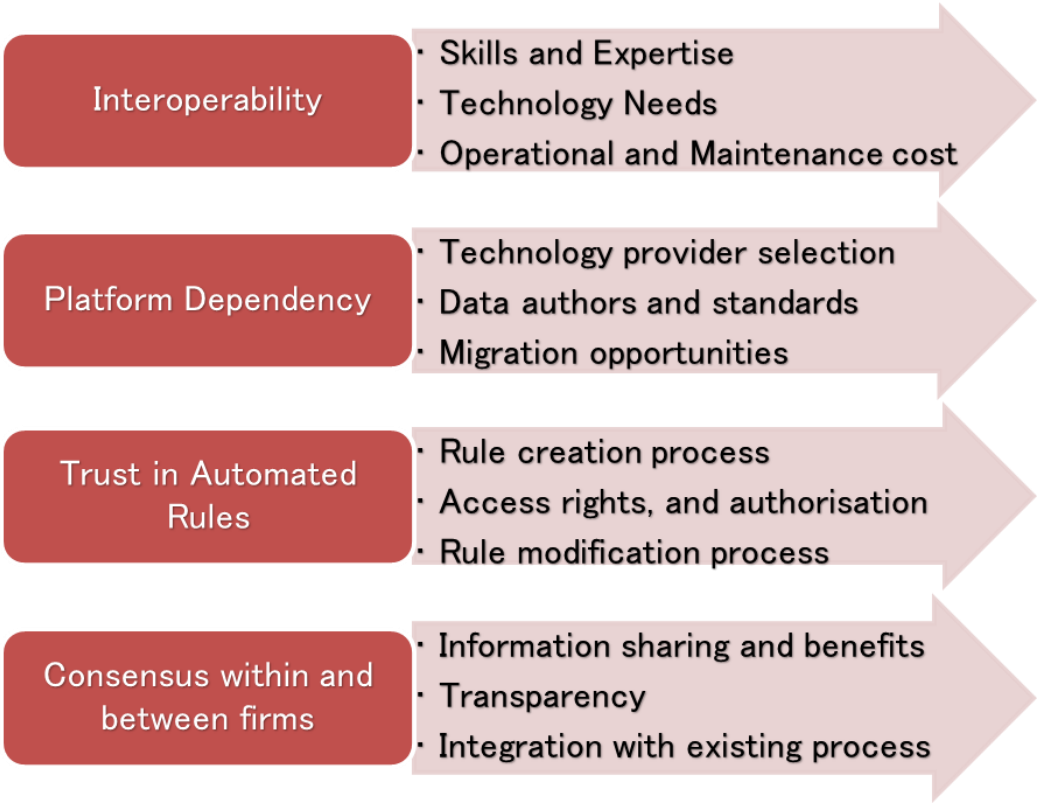

Figure1: Consolidating research agenda and implications for managers

Conclusion

The limitations of the blockchain technology has received less attention, leading to an inaccurate impression that it can address any challenge pertaining to transparency, reliability, effectiveness, efficiency, accuracy, decentralized information storage and distributed information. The paper contributes to theory by developing the understanding of the key challenges of blockchain implementation and proposing a research agenda (Figure 1) that warrants further investigation to understand potential realistic solutions for addressing these challenges. For operations managers, the paper offers a useful starting point to reflect on several key questions that are likely to impact intra-firm relationship, inter-firm relationship and key decisions pertaining to benefits of adopting blockchain (i.e. both short and long-term). However, the key question for the managers *is 'If blockchain is the solution, what is the problem'*.

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