Blockchain and the United Nations Sustainable Development Goals: Towards an Agenda for IS Research

Completed Research Paper

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Abstract

The United Nations Sustainable Development Goals have gained strong traction in the renewed global discourse on sustainability, and attribute a key role to digital technologies. Blockchain technology is now transitioning beyond the realm of cryptocurrencies applications, to embrace a wider array of applications, including the sustainability of supply chains and traceability of responsibly sourced goods. Despite the rise in the global agenda, and emerging research in other academic fields, Information Systems (IS) research on blockchain and sustainability is still scarce. Based on a review of empirical studies, we use the perspective of the 17 United Nations SDGs to map research on blockchain and sustainable development, and lay the ground for a research agenda in the IS field. Based on this agenda, we showcase the exploration of some of the proposed research questions in an ongoing research project on the use of blockchain in the lifestyle and design industry in Denmark.

Keywords: Blockchain; sustainable development goals; SDG; literature review; research agenda.

Introduction

On September 25, 2015, the 193 Member States of the United Nations unanimously adopted 17 Sustainable Development Goals (SDG), detailed in 169 targets, with a vision of linking separate goals of sustainable development across different areas, into a unitary vision. The main consequence of this new vision has been to move the focus beyond the individual instances of e.g., environmental impacts of human activities, or economic inequalities, and to link them in a coherent system (United Nations 2015a). Digitalization is widely acknowledged as an integral part of achieving sustainable development goals. Digital technologies are in fact seen as both enablers or obstacles to sustainability, equity and social inclusion (Zheng and Walsham 2008).

Blockchain technology is a decentralized, transactional database technology that facilitates validated, tamper-resistant transactions consistent across a large number of heterogeneous network participants, called nodes (Beck et al. 2018). Given its decentralized and tamper-resistant nature, blockchain technology comes with promises of tackling issues of trust, decentralization, and transparency among a wide variety of individuals, organizations, and institutions across society (Kewell et al. 2017). Initially developed and only focused on in relation to the phenomenon of cryptocurrencies, research on blockchain is now gradually starting to include a wider range of potentials, including supply chain

management, certification, and smart cities initiatives (Rossi et al. 2019). Due to its characteristics, blockchain in relation to sustainable development has started to be situated at the center of research agendas in a wide range of disciplinary areas (Lindman et al. 2017; Rossi et al. 2019). Many of the applications of blockchain technology, in fact, would naturally fall within the scope of sustainable development initiatives. Blockchain technology, for example, has the potential to enhance supply chain transparency, support circular economies, and reduce information asymmetry in resource management, (PricewaterhouseCoopers 2018). This emerging focus on sustainability is evidenced by the increasing number of empirical studies in areas as diverse as gender studies (Thylin and Duarte 2019), supply chain management (Queiroz et al. 2019), and public administration (Ølnes et al. 2017). Quite surprisingly, though, little to no empirical research in the Information Systems (IS) field investigates the potential and challenges of blockchain against sustainable development goals. Risks of the IS community not adopting a systematic approach to understanding the phenomenon of blockchain against the principles of sustainable development include, on the one hand, missing the opportunities to inform the practice of a technology that is now recognized to be of immense potential impacts; and, on the other hand, to being unable to conceptualize its capabilities and uses in an adequate and responsible manner.

With the goal of avoiding these risks, in this paper we aim at providing an agenda for IS research on blockchain in explicit connection with the UN SDGs. After this introduction, we discuss the relevance of the SDG agenda for IS research in general, and for the emerging area of IS blockchain research in particular. We then identify illustrative cases of application of blockchain in relation to SDGs and, drawing on a systematic literature review of major outlets in the IS field, we discuss gaps in the existing body of empirical studies on blockchain in IS research against each of the 17 SDGs. Last, we showcase an application of our proposed research agenda by illustrating it with ongoing empirical research that we are conducting in a project on blockchain adoption in the lifestyle and design industry in Denmark.

Background

SDGs and Information Systems

The concept of sustainable development is not new. Frequently referred to as "development that meets the needs of current generation without compromising the ability of future generation to meet their own needs" as defined in a milestone report published in 1987 (Goodland and Daly 1996), the current conceptualization of sustainable development has extended its original focus on the nature of economic growth only, to more widely encompass the wider discourse on how solutions to needs of society can be not only economically viable, but also environmentally bearable, and socially equitable at the same time (Mensah 2019).

The United Nations have formulated 17 SDGs with a vision of mapping the main global challenges in a coherent system that goes beyond seeing each challenge in isolation. These goals are: 1. No Poverty; 2. Zero Hunger; 3. Good Health and Well-Being; 4. Quality Education; 5. Gender Equality; 6. Clean Water and Sanitation; 7. Affordable and Clean Energy; 8. Decent Work and Economic Growth; 9. Industry, Innovation, and Infrastructure; 10. Reduced Inequalities; 11. Sustainable Cities and Communities; 12. Responsible Consumption and Production; 13. Climate Action; 14. Life Below Water; 15. Life on Land; 16. Peace, Justice, and Strong Institutions; 17. Partnerships (United Nations 2015b).

Information Systems research has previously focused on environmental impacts of technology using the lens of the principle of sustainability. Such efforts have been mostly channelled towards looking at sustainability in terms of impacts of information technology on the natural environment, as evidenced in the emergence and consolidation of a stream of studies in Green IS (e.g., El Idrissi and Corbett 2016; Elliot 2011; Jenkin et al. 2011; vom Brocke et al. 2013; Wang et al. 2015; Watson et al. 2012), including special issues in the main journals in the field (e.g., Elliot and Webster 2017; Gholami et al. 2016), and dedicated tracks at the IS field's main conferences.

However, as of today very few IS contributions have materialized extending the focus of environmental footprint of Green IS to the wider perspective of sustainable development. In fact, a simple search of

the expression "sustainable development" in either title or abstract of the IS Senior Scholar's Basket of Eight journal, results in only two studies (Corbett and Mellouli 2017; Watson et al. 2010). Such research gap also results in overlooking the specific potential of blockchain technology to tackle traditional sustainability challenges in particular, and the wider challenges of UN SDGs, in general.

Blockchain and SDGs

Research on blockchain is rapidly emerging and maturing. Conceptual framings of blockchain, and initial empirical studies in IS, have started to move beyond the original narrow consideration of blockchain in terms of its applications in the financial sector exclusively, and have started to envision its potentials in a much wider array of areas (Lindman et al. 2017; Rossi et al. 2019). These areas can potentially include the focus on blockchain and sustainability.

Blockchain is seen as enabling sustainability in a number of ways: for example, by enhancing transparency of supply chains, incentivizing circular economies, reducing information asymmetry in resource management, facilitating access to finance, improving monitoring, improving disaster preparedness, and enabling geospatial platforms (PricewaterhouseCoopers 2018). Nevertheless, existing literature reviews of empirical research on blockchain hardly mention sustainable development (Grover et al. 2018; Hawlitschek et al. 2018; Notheisen et al. 2017; Risius and Spohrer 2017), with just a handful of exceptions (e.g., Kshetri 2018). When mentioned in the context of blockchain research, sustainability is mostly referred to only in relation to the ecological footprint of blockchain technology itself – i.e., the high energy consumption required by the computing-intensive processes, such as the blockchain proof-of-work consensus mechanism, that characterize blockchain (Becker et al. 2013; Delliere and Grange 2018).

Given the mushrooming of blockchain applications in the areas of SDG, such as humanitarian aid (Coppi and Fast 2019), gender equality (Kamath 2018), or clean energy (van Rijmenam & Ryan 2019), the current lack of empirical studies focusing on blockchain for sustainable development signals an urgent need to encourage and channel research energies towards this area (Hughes et al. 2019).

Mapping Research on Blockchain and SDGs

In order to profile and tackle this need, we reviewed empirical studies in the IS field focusing on blockchain to identify the possible presence and map the types of foci on issues related to sustainable development, using the 17 UN SDGs as a classification tool.

To this end, we conducted a review of empirical research in the IS field consisting of a two-step approach. In the first step, we analysed the pools of articles from previous literature reviews of blockchain research. We identified existing reviews using a snowball approach. We excluded from our search predominantly technical reviews on the blockchain protocol (e.g., Morisse 2015; Tschorsch and Scheuermann 2016; Yli-Huumo et al. 2016), seeking instead literature reviews that adopt a socio-technical approach, which underpins the principle of sustainable development. This resulted in analysing articles from five reviews: Grover et al. (2018) (N=40); Hawlitschek et al. (2018) (N=17); Hughes et al. (2019) (N=51); Notheisen et al. (2017) (N=26); and Risius and Spohrer (2017) (N=69). We scanned all the publications included in these five literature reviews, and searched for studies mentioning sustainability or sustainable development in either title, abstract, keywords, or main text[1]. Tellingly, we found only four blockchain empirical studies (Gomber et al. 2018; Kshetri 2018; Larios-Hernández 2017; Sullivan and Burger 2017), and an editorial (Kewell et al. 2017) mentioning sustainability as part of their research design.

In the second step, to extend the depth and time coverage of our review to the end of November 2019, we have performed a keyword search ("blockchain" and "block chain" in title or abstract) on all journal articles from the AIS Senior Scholars' Basket-of-Eight journals and all conference proceedings from the four AIS main conferences (ICIS – International Conference on Information Systems, ECIS–

[1] We excluded studies focusing on sustainability only in economic terms - e.g., blockchain and the economic sustainability of the music record industry (O'Dair and Beaven 2017).

European Conference on Information Systems, AMCIS – Americas Conference on Information Systems, PACIS – Pacific Asia Conference on Information Systems), again looking for empirical studies that mention sustainability as part of their research design. The search resulted in a total of 13 contributions: 11 from the ICIS conference (Diniz et al. 2018; Jahanbin et al. 2019; Labazova 2019; Loebbecke et al. 2018; Lopes et al. 2019; Nagel et al. 2019; Ning et al. 2019; Rupasinghe et al. 2019; Schweizer et al. 2017; Sun et al. 2019; Wörner et al. 2019), and two in the AIS Senior Scholars' basket of eight journals (European Journal of Information Systems, Information Systems Journal, Information Systems Research, Journal of the Association for Information Systems, Journal of Management Information Systems, Management Information Systems Quarterly, Journal of Strategic Information Systems, Journal of Information Technology) (Chanson et al. 2019; Gomber et al. 2018). For each of the empirical studies, the authors discussed the relevance against each of the 17 UN SDGs. In case of conflicting classifications, each study was further discussed until consensus was reached.

Table 1 illustrates which of the 17 SDGs are covered by at least one empirical study, used as an example. In addition, we included an example of practical application of blockchain for each of the SDGs (from sources also outside our article review base), and in the right column we have formulated corresponding possible future research questions, to be part of an agenda for IS research. We present these in the next section.

Table 1. Examples of practical applications, empirical studies in IS research, and possible research questions on blockchain for UN Sustainable Development Goals (SDG)

Sustainable Development Goal	*Example of blockchain application*	*Example of IS empirical study*	*Possible research questions*
1. No Poverty	Proof ownership of capital, which, combined with a self-sovereign identity, can be used to obtain loans (Rijmenam et al. 2018)	Agency and surveillance in blockchain use for poverty relief funding allocation (Ning et al. 2019)	How is transparency enacted in the implementation of blockchain to counter corruption in the allocation of financial aid?
2. Zero Hunger	The UN World Food Program "Building blocks" pilot is using blockchain at refugee camps in Jordan to distribute food (UN World Food Programme 2017)	Design principles for a blockchain-based loyalty program system to hybridize business and charity (Sun et al. 2019)	What are the impacts of ledger decentralization in the distribution and supply of food?
3. Good Health and Well-Being	Blockchain for biomedical and health care applications (Kuo et al. 2017)	Privacy and consent management in healthcare services (Rupasinghe et al. 2019)	What are impacts of blockchain-enabled shared access to health data on patient-doctor interactions?
4. Quality Education	A global higher education credit platform (Turkanović et al. 2018)		How are learning routines established in blockchain-enabled remote education?
5. Gender Equality	Blockchain use in UN Women's cash-for-work programme in Jordan (Thylin and Duarte 2019)		How is gender bias affected by the anonymity of blockchain-mediated interactions?

Sustainable Development Goal	*Example of blockchain application*	*Example of IS empirical study*	*Possible research questions*
6. Clean Water and Sanitation	Blockchain to improve the solid waste management in small municipalities (França et al. 2020)		How does decentralization impact actors' behaviour in a context of scarce natural resources?
7. Affordable and Clean Energy	Exchange of renewable energy in a reliable and trustworthy manner (Rijmenam et al. 2018)	User preference in peer-to-peer blockchain-enabled energy trading (Wörner et al. 2019)	How does blockchain use in trading affect user preferences?
8. Decent Work and Economic Growth	Transparency in workforce payroll to ensure fairness and decent working conditions (Rijmenam et al. 2018)		How do smart employment contracts affect perceived and effective working conditions?
9. Industry, Innovation, and Infrastructure	Opening the architecture of commercial and banking infrastructures (Chong et al. 2019)	Business model innovation in commercial and financial transactions (Chong et al. 2019)	How do blockchain-enabled organizing (DAOs) affect governance innovation?
10. Reduced Inequalities	The ID2020 Alliance is using blockchain for those with no access to identification authorities (Digital Identity Alliance 2019)	Governance and architecture of social cryptocurrencies for financial inclusion (Diniz et al. 2018)	How does blockchain affect the emergence of a global workforce?
11. Sustainable Cities and Communities	Blockchain technology for smart devices to provide a secure communication platform in a smart city (Biswas and Muthukkumarasamy 2016)	Blockchain and startup business models in smart city applications (Nagel et al. 2019)	How does blockchain transform the allocation of scarce resources in an urban environment?
12. Responsible Consumption and Production	Blockchain to ensure that consumers can be guaranteed the origins and quality of products (Rijmenam et al. 2018)		How does blockchain facilitate practices of circular economy by opening up product life cycles?
13. Climate Action	Blockchain to enable the creation, usage, and exchange of renewable energy in a trustworthy and reliable manner (Rijmenam et al. 2018)		How does blockchain affect the production and distribution of renewable energy?

Sustainable Development Goal	*Example of blockchain application*	*Example of IS empirical study*	*Possible research questions*
14. Life Below Water	Tracking responsibly-caught fish from catch to consumer in Indonesia (Provenance 2016)	Incorporation of blockchain into Internet of Things architecture (Kshetri 2018)	How does blockchain affect conflict management in the trading of rival goods?
15. Life on Land	Blockchain to combat illegal international timber trading (Vilkov and Tian 2019)		What are the impacts of blockchain-mediated transactions on natural resource externalities?
16. Peace, Justice, and Strong Institutions	Certification and tracking in diamond trade to avoid sales of "conflict stones" by warlords (Jollans 2016)	Design principles of blockchain application in the voting process (Lopes et al. 2019)	How do the perceived features of blockchain affect the trust of citizens towards the democratic voting process?
17. Partnerships	Partnering universities, trade and industry association and innovation clusters with the aim of addressing several of the SDGs with blockchain technology in the Danish design industry (Industriens Fond 2019)		How does blockchain affect the strategies for trust-building in the establishment of global partnerships?

Blockchain and SDG: Towards a Research Agenda

As Table 1 illustrates, initiatives in the use of blockchain for sustainable development exhaust all aspects of the SDGs, including poverty relief, education, institution building, and responsible consumption. For example, the startup firm Everledger certifies and tracks trade in diamonds, to reduce sales of the so-called "conflict stones" from warlords, and thus potentially reduce the likelihood of armed conflicts that plague areas of the world in need of peace, justice, and strong institutions (SDG 16. Peace, Justice, and Strong Institutions) (Jollans 2016).

What our analysis shows, however, is that besides the scarcity of IS studies in sustainability in general, among the little empirical research that there is, a number of the areas of the 17 goals are still altogether ignored. This is the case, for instance, of climate action, which is arguably the most present item in the global news and current political agenda, includes a variety of initiatives of use of blockchain, and yet does not feature any visible attention from the IS research community.

The need to study sustainability goals in their entirety should not however stem from a mere wish to follow a popular agenda, however attractive or hyped. Quite the opposite: the SDGs should lend themselves to function as a catalyst for formulating research questions that are of wider theoretical interest for the IS discipline. This is, in fact, well evidenced by the research questions in some of the areas that are already covered by empirical research in our article base. For example, Loebbecke, Lueneborg, & Niederle (2018), by investigating the use of blockchain in the trading of diamonds, conceptualize the role of trust in technology-mediated trading of high value physical goods. Chong, Lim, Hua, Zheng, & Tan, (2019) by comparing a number of companies using blockchain in different

areas, including FinTech and agriculture, are able to unpack novel innovation phenomena in technology-enabled business models.

Based on the value of the SDGs as multipliers of impacts on both the research and the practice of IS, we thus complement the small empirical base of existing research, and tackle the gaps that we evidenced, by proposing a set of research questions for each of the SDGs. In the right column of Table 1 we detail a series of key research questions for each SDG area.

For example, the anonymity of blockchain protocols provides a natural, and relevant, setting for future research to investigate the impacts of anonymity in blockchain use on user bias (SDG 5. Gender Equality). The application of blockchain smart contracts to work employment offers a unique opportunity to enrich our understanding of the impacts of technology on the future of work (SDG 8. Decent Work and Economic Growth). In these research questions, blockchain as a technology phenomenon within the realm of sustainable development goals feeds into the IS research agenda, while the outcome of research feeds back into the wider interrelation between technology and the SDGs.

With these proposals, we have the ambition to lay the ground for a comprehensive research agenda for the IS community on the phenomenon on blockchain in relation to sustainable development. In order to showcase the application of some of these research questions, in the next section we provide details of an ongoing research project on the use of blockchain in the lifestyle and design industry in Denmark.

Showcasing the Agenda: a Research Project on the Danish Design Industry

Drawing on parts of this research agenda, we are undertaking a two-year research project titled "Advancing Block Chain in Danish Design" (ABCD) in collaboration with the Confederation of Danish Industry and the Lifestyle and Design Cluster (Industriens Fond 2019). The Confederation has 11,000 member organizations and the Lifestyle and design cluster has 120 partner companies. The project is funded by the Danish Industry Foundation (Industriens Fond) with € 1 million.

As world-famous Danish design products extend their reach into global and remote markets, such as China, consumers demand increased transparency in their supply chains. This is not only to certify the authenticity of the products but also, for example, to assess that goods come from sustainable sources and not from suppliers that manage labour unethically, or that have a large negative impact on the environment. Tracking information on design products on the blockchain also after the end of their lifecycle enable the recycling of materials, following the principles of the circular economy.

The project addresses these questions and will help design companies realize the potential of blockchain while engaging in global trade in a sustainable manner that enhances their competitiveness. These are in line with three of the UN sustainable development goals (SDG 9:Industry, Innovation and Infrastructure; SDG 12: Responsible Consumption and Production; SDG 13: Climate Action).

The expected outcomes of the project are twofold. On the practice side, the project aims 1) to equip lifestyle and design companies with the competences to make strategic decisions about choosing, implementing, and embedding blockchain technology in their key activities; and 2) to develop a sandbox prototype that allows the companies to couple blockchain with IoT (Internet of Things) technology, in order to improve the transparency, traceability, and authentication in their supply chains, from producers to consumers. Specific attention will be devoted to negative and unintended consequences of blockchain adoption and use, including limits in user-friendliness, hampering innovation, or threats of labour substitution (Manski 2017). Over 100 companies in the lifestyle and design industries are involved, and a goal of minimum of 87 SMEs will be expected to have included blockchain as a value added in marketing their products/ services to their customers by the end of the project in 2021.

From a research point of view, a combination of quantitative and qualitative data collection from the companies has started, with the aim of tackling the following initial questions: what are the company managers' framings of blockchain nature, strategy, and technology-in-use (Orlikowski and Gash 1994; Young et al. 2016)? How do these framings translate into experimental practices with blockchain in a controlled environment? How are organizational and supply chain needs for traceability, transparency, and sustainability translated into expectations from technology strategy and use? These initial research questions will be iteratively refined, following an engagement scholarship approach (Van de Ven 2007).

Conclusion

Sustainable development goals are shaping the global agenda in multiple areas, including public opinion, policy, and research. Blockchain technology has now moved beyond the realm of financial applications, and is expanding its array of applications to include goals of sustainability, transparency, and traceability in supply chains. As we evidenced in our review of the literature, this focus is, however, overlooked in existing IS research.

In this paper we aimed at providing a mapping of existing research and at laying the foundations for a comprehensive research agenda on blockchain and sustainability in IS research. We acknowledge some of the limitations of our review approach. While we draw on comprehensive previous literature reviews, we have only focused on core IS journals and conferences in our search update; moreover, the operationalization of each of the SDG used to classify the studies might be subject to bias from the authors. Last, the use of a limited number of keywords to identify research related to sustainability might have left out relevant research.

Despite the shortcomings of this approach, we trust that the call for more systematic research on blockchain technology against the backdrop of the SDGs will prove of immediate use for the IS community.

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