Blockchain in Service Management and Service Research – Developing a Research Agenda and Managerial Implications

By Marion Büttgen*, Julia Dicenta, Kai Spohrer*, Viswanath Venkatesh, Raji Raman, Hartmut Hoehle, Arne De Keyser*, Cédric Verbeeck, Thijs J. Zwienenberg, Kim Peiter Jørgensen, Roman Beck*, Olivier Rikken*, Marijn Janssen, Zenlin Kwee, and Fabian Schär*

Marion Büttgen is Professor of Corporate Management at University of Hohenheim, Institute of Marketing & Management (570B), Schwerzstraße 42, 70599 Stuttgart, Germany, E-Mail: buettgen@uni-hohenheim.de
* Corresponding Author

Julia Dicenta is doctoral student at University of Hohenheim, Institute of Marketing & Management (570B), Schwerzstraße 42, 70599 Stuttgart, Germany, E-Mail: j.dicenta@uni-hohenheim.de

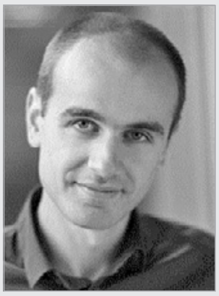
Kai Spohrer is Assistant Professor at the Department of General Management and Information Systems at the University of Mannheim, Schloss, 68131 Mannheim, Germany E-Mail: spohrer@uni-mannheim.de
* Corresponding Author

Viswanath Venkatesh is Eminent Scholar and Verizon Chair in Business Information Technology at the Pamplin College of Business, Virginia Tech, Blacksburg, VA 24061, USA E-Mail: vvenkatesh@vvenkatesh.us

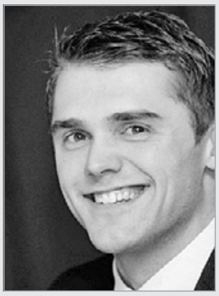
Raji Raman is Assistant Professor of Practice in the Business Information Technology Department at the Pamplin College of Business, Virginia Tech, Blacksburg, VA 24061, USA. E-Mail: rajiraman@vt.edu

Hartmut Hoehle is Professor and Chair of Enterprise Systems at the University of Mannheim, Schloss, 68131 Mannheim, Germany E-Mail: hoehle@uni-mannheim.de

*Arne De Keyser** is Associate Professor of Marketing at EDHEC Business School, 24 Avenue Gustave Delory, CS 50411, 59057 Roubaix Cedex 1, France, E-Mail: arne.dekeyser@edhec.edu
* Corresponding author



Cédric Verbeeck is Assistant Professor of Operations Management at EDHEC Business School, 24 Avenue Gustave Delory, CS 5041, 59057 Roubaix Cedex 1, France, E-Mail: cedric.verbeeck@edhec.edu



Thijs Johannes Zwienenberg is doctoral student at KU Leuven, Warmoesberg 26, 1000 Brussel, Belgium, E-Mail: thijs.zwienenberg@kuleuven.be

Kim Jørgensen is PhD fellow doing research on universal wallets at IT University Copenhagen, Rued Langgaards Vej 7 DK-2300 Copenhagen, Denmark, E-Mail: kjrg@itu.dk

Roman Beck is Full Professor at IT University Copenhagen, Rued Langgaards Vej 7 DK-2300 Copenhagen, Denmark, E-Mail: romb@itu.dk
* Corresponding Author

Olivier Rikken is CEO at Ledger Leopard and PhD candidate at Delft University of Technology, Jaffalaan 5, 2628 BX Delft, The Netherlands. E-Mail: O.K.Rikken@tudelft.nl
* Corresponding Author.

Marijn Janssen is full Professor in ICT & Governance of the Technology, Policy and Management Faculty at Delft University of Technology, Jaffalaan 5, 2628 BX Delft, The Netherlands. E-Mail: M.F.W.H.A.Janssen@tudelft.nl

Zenlin Kwee is Assistant Professor of Strategy and Innovation at Delft University of Technology, Jaffalaan 5, 2628 BX Delft, The Netherlands. E-Mail: Z.Roosenboom-Kwee@tudelft.nl

Fabian Schär is Professor of DLT (Blockchain) and Fintech at University of Basel, Faculty of Business and Economics, Peter Merian-Weg 6, CH-4002 Basel, Switzerland. E-Mail: f.schaer@unibas.ch
* Corresponding Author

As blockchain technology is maturing to be confidently used in practice, its applications are becoming evident and, correspondingly, more blockchain research is being published, also extending to more domains than before. To date, scientific research in the field has predominantly focused on subject areas such as finance, computer science, and engineering, while the area of service management has largely neglected this topic. Therefore, we invited a group of renowned scholars from different academic fields to share their views on emerging topics regarding blockchain in service management and service research. Their individual commentaries and conceptual contributions refer to different theoretical and domain perspectives, including managerial implications for service companies as well as forward-looking suggestions for further research.

Introduction

Service researchers and practitioners are equally interested in novel technologies and their impact on industries, society, service companies and customers. One of the most discussed and purportedly disruptive innovations is the distributed transaction and data management technology blockchain (White 2017). Blockchain technology can be defined as "a distributed ledger technology in the form of a distributed transactional database, secured by cryptography, and governed by a consensus mechanism" (Beck et al. 2017). This implies that the particular technology is not administered by a central server, but describes a peer-to-peer (P2P) network in which decentralized nodes keep copies of all the transactions within a network (Önder & Treiblmaier 2018). In this kind of network, blockchain technology enforces transparency and ensures a system-wide consensus on the validity of every transaction (Risius & Spohrer 2017). Also, new transactions can be added, while previous information cannot be removed. This enables all nodes to track the history (Beck et al. 2017).

Primarily known as the technology behind bitcoin and other cryptocurrencies, blockchain (BC) has emerged from its use as a verification mechanism and is expected to revolutionize a broad field of industries and applications, such as peer-to-peer energy trading (Basden & Cottrell 2017; Esmat et al. 2020; Hua et al. 2020), patients' electronic health record storing and sharing (Patel 2019; Xia et al. 2017; Zhang et al. 2018), and blockchain supported identity management (Elsden et al. 2018; Lim et al. 2018), to name just a few. While the number of blockchain start-ups and major companies implementing blockchain applications is increasing (Ante et al. 2018; Popov 2020), scientific research focuses predominantly on subject areas of computer science and engineering, while there is still minimal managerial guidance (Centobelli et al. 2021; De Keyser et al. 2019). Such a lack of research has already been identified in numerous publications (Risius & Spohrer 2017; Rossi et al. 2019). Also, only about four percent of all blockchain publications can be assigned to the research areas of business and management (Centobelli et al. 2021). We therefore strongly believe that this topic requires more thorough and multidisciplinary attention in management research, particularly in service management research since blockchain applications predominantly apply to service industries such as financial services, healthcare, energy trading, and e-governance. These applications are expected to have a strong impact on service companies and customers (Casino et al. 2019; Centobelli et al. 2021). In order to address this research gap, this special research paper identifies several open research questions, as well as management opportunities and challenges regarding blockchain technology. The contributing authors work in the fields of service management, information systems or financial management.

Marion Büttgen and *Julia Dicenta* provide a systematic literature review on blockchain in service research, aiming to identify the most relevant service themes and deducing research questions that can serve as a preliminary research agenda for blockchain-related service research. *Kai Spohrer*, *Viswanath Venkatesh*, *Raji Raman* and *Hartmut Hoehle* explain how service management and information systems research can make a difference by elaborating blockchain systems' consequences for behavioural and organizational research areas and offering insightful research questions. *Arne De Keyser, Cédric Verbeeck* and *Thijs Johannes Zwienenberg* reflect on blockchain's implications for customers and service organizations. In so doing, they consider four major changes that can occur in service industries that implement blockchain technology. *Kim Peiter Jørgensen* and *Roman Beck* introduce the service potential of universal wallets in blockchain systems and thereby investigate the central role of managing identity through wallets to interact with blockchain-based services. *Olivier Rikken, Marijn Janssen* and *Zenlin Kwee* evaluate the application of blockchain technology in interorganizational information sharing. Using two cases of interorganizational information sharing, they identify and conceptualize the triple value of trust, transparency, and cost savings in blockchain applications. Finally, *Fabian Schär* addresses flash loans and decentralized finance in the context of smart contract-based lending platforms.

Blockchain in Service Research – A Systematic Literature Review

By Marion Büttgen and Julia Dicenta

Technological innovations like smart technologies and connected objects have rapidly changed the service landscape in how services are created and delivered (Furrer et al. 2020; Ostrom et al. 2015). Thus, not surprisingly the number of publications in service research on new technologies has continuously been increasing in recent years (Furrer et al. 2020). While academic service research has already paid significant attention to some technologies such as service robots (e.g., Van Doorn et al. 2017; Wirtz et al. 2018), artificial intelligence (e.g., Huang & Rust 2018; Larivière et al. 2017), and self-service technologies (e.g., Meuter et al. 2000), other technologies such as quantum computing and commercial unmanned aerial vehicles (UAV) have been largely neglected (Kunz et al. 2019). One of these underrepresented technologies is blockchain technology. Despite its promising potential for business practice, very little service research has addressed the implications of blockchain technology (De Keyser et al. 2019). This is surprising, since the majority of blockchain applications and use cases belong to service industries or, respectively, are services themselves. Examples include blockchain-enabled applications such as voting services, ticketing services or payment services, to name only a few (Elsden et al. 2018). Further, the implementation of smart contracts executed on a blockchain also holds significant opportunities for services and new business models (De Keyser et al. 2019). The emergence of potentially disruptive technologies is creating new opportunities for companies, while incorporating those technologies relies more on experimentation than on managerial guidance delivered by academic research (Ostrom et al. 2015).

Therefore, this short paper aims to capture the state of research on blockchain technology in service management. Further, we aim to identify and classify relevant service themes and research streams in the blockchain context and to develop research questions that can serve as a preliminary agenda for future research projects. In doing so, we pave the way for insightful managerial implications.

Research Methodology

This study adopts a systematic literature review approach to retrieve relevant articles in the scope of service research. Based on the goal and scope of our review, we developed a twofold search strategy to build a comprehensive literature sample.

First, we conducted a keyword search in "titles, abstracts, and keywords" of the top three service research journals and additionally in the top seven general marketing journals Furrer and Sollberger (2007) identified as especially relevant to service research. These are the *Journal of Service Research (JSR), Journal of Service Management (JoSM), Journal of Services Marketing (JSM), Journal of Marketing (JM), Journal of Marketing Research (JMR), Journal of Consumer Research (JCR), Journal of Retailing (JR), Journal of the Academy of Marketing Science (JAMS), Marketing Science (MS), and International Journal of Research in Marketing (IJRM)*. Additionally, we included the *Journal of Service Management Research (SMR)*. The search string was based on the following combination of keywords: "blockchain" or "block chain" or "distributed ledger" or "decentralized consensus" or "smart contracts". This process resulted in a sample of 31 articles. Next, we read titles, abstracts and keywords to exclude papers that did not examine blockchain as a primary matter of investigation. Using this exclusion criterion eliminated 28 articles. After a full reading of the three remaining articles, one was excluded because the share of attention to blockchain was not substantial, which gave us a total sample of two articles for the first search.

Second, we expanded our search because research conducted in service contexts might not be published in service journals. We conducted the additional search using academic databases, namely ProQuest, Scopus and Ebsco to retrieve peer-reviewed research articles. We used the same search string as in the first step with the addition of: AND "service" or "services" or "service research" to focus the results on the service context. This search returned a total of 15,583 articles. To position the review on high-quality evidence, we adapted exclusion and inclusion criteria from Alkhudary et al. (2020). Since blockchain technology was first introduced in 2008 (Nakamoto 2008), we set our search timeline from 2009 to 2021. Also, we selected only articles written in English, and we refined the research area to business, management, and customer behaviour. Next, we examined the titles and abstracts of the remaining 668 articles to ascertain their relevance to our study. For inclusion, blockchain had to be given a significant share of attention; consequently, articles that were not sufficiently focused on blockchain were removed from the sample. In addition, the article needed to be either conducted in a service field or include a service application according to the typology Elsden et al. (2018) developed. This resulted in the further exclusion of 131 articles. We read the remaining articles in full to confirm that they fitted in the parameters of our study. Further, we excluded articles that dealt mainly with technological attributes, took a computing science perspective or a mathematical approach. This process resulted in a list of 25 publications added to the first search stream's two articles.

Results

Examining and coding the 27 relevant articles revealed that service research on blockchain technology to date has

Major service theme	Subthemes	Source
Organizational adoption and implementation decision	Organizational technology adoption	Clohessy et al. (2020); van Hoek (2019); Verhoeven et al. (2018)
	Managerial decision making	Clohessy et al. (2020); Dozier & Montgomery (2019); Karamchandani et al. (2020); van Hoek (2019); Verhoeven et al. (2018); Walsh et al. (2020)
Consumer attitude and behavior	Consumer attitude	Dam et al. (2020); Ingold & Langer (2021); Lian et al. (2020); Nam (2018); Shin & Hwang (2020)
	Consumer behaviour	Bolici et al. (2020); Fell et al. (2019); Schuetz & Venkatesh (2020); Treiblmaier et al. (2020)
	Individual technology adoption	Schuetz & Venkatesh (2020); Treiblmaier et al. (2020)
BC influence on business models and service industries	Influence on business models	Babich & Hilary (2018); Biswas & Gupta (2019); Morkunas et al. (2019); Trabucchi et al. (2020)
	Influence on service industries	Erceg et al. (2020); Kizildag et al. (2019); Osmani et al. (2020)
	Benefits and barriers	Biswas & Gupta (2019); Osmani et al. (2020)
BC architecture in services	Architectures for service interactions	Chang et al. (2020); Choi et al. (2020); Geneiatakis et al. (2020) Li et al. (2018)
	Background architectures	Fukawa (2020)

Tab. 1: Major themes in service-related blockchain technology research

focused on four major themes: (1) organizational adoption and implementation decision, (2) consumer attitude and behaviour, (3) BC influence on business models and service industries, and (4) BC architecture in service applications (see *Tab. 1*). We describe each of these major themes in the following sections, aiming to identify relevant research questions. The proposed themes are a non-exhaustive list of topics, which can be expanded in future research to include further relevant service topics, such as service ecosystems, service quality or customer experience in blockchain services or applications.

1. Organizational Adoption and Implementation Decision

Increased digitalization has substantially influenced business processes in service organizations. This necessarily brings challenging situations for managers, as manifold new technological opportunities that drive digital transformation in the company, arise (Rachinger et al. 2019; Zeike et al. 2019). Blockchain technology is still perceived as a rather immature technology, therefore implementing it comes with certain risks (Lacity 2018). Our literature review disclosed that organizational technology adoption is an emerging topic, therefore managers' perspectives concerning blockchain are highly important to ensure its adoption in service organizations (Dozier & Montgomery 2019; Karamchandani et al. 2020; Walsh et al. 2020).

Walsh et al. (2020) studied how managers evaluate blockchain-based systems' value in financial service organizations and developed a model to explain many managers' resistance to blockchain implementation. Contrary to the authors' expectations, perceived costs of switching did not appear to explain their resistance. Their key finding is that blockchain technology's perceived benefits can reduce managers' resistance. Hence, the paucity of blockchain knowledge managers have, could currently be an important barrier to adoption (Walsh et al. 2020).

Dozier and Montgomery (2019) evaluated the decision-making process in financial service organizations which plan to adopt blockchain technology. They claim that decision making is a series of three processes (understand, organize, and test) that help determine blockchain's value. This is foundational to their Proof-of-Value (POV) model. One major finding of their qualitative study is that financial service organizations' managers do not prioritize blockchain implementation because they cannot see a clear path to value creation (Dozier & Montgomery 2019).

Karamchandani et al. (2020) studied service industry managers in India's perception of enterprise blockchain in the context of supply chain management. One of their key findings is that service industry professionals perceive the potential practical usefulness of enterprise blockchains in terms of information quality, mass customization, service quality, delivery reliability, and customer relationship. Additionally, service practitioners do believe that implementing enterprise blockchains can result in growth of firm profitability (Karamchandani et al. 2020). These results contrast with those of Dozier and Montgomery (2019). While managers in the latter study do not yet see a clear path to create value through blockchain, managers in Karamchandani et al.'s (2020) study seem to be relatively optimistic in this respect. Possible reasons for the divergent results are the different research contexts (financial services vs. supply chain management) or cultural differences in the surveyed countries (USA vs. India) regarding their technology adoption propensity.

Due to the significant impact IT innovations have on service organizations, managers are careful when they have to decide on adopting such innovations. Therefore, Verhoeven et al. (2018) propose a framework for mindful adoption of blockchain technology, based on five mindful technology adoption principles, namely engagement with the technology, technological novelty seeking, awareness of local context, cognizance of alternative technologies, and anticipation of technology alteration. Van Hoeck (2019) adopted and slightly expanded this framework based on case study findings analysing three different kinds of companies that had been early adopters of blockchain technology. Also, motivated by blockchain's promised potential, Clohessy et al. (2020) developed a comprehensive framework in which they claim that organizations' adoption of blockchain is dependent on technological, organizational, environmental, individual and task-related considerations. As these are recently developed frameworks, empirical research testing these conceptual frameworks and developing insightful managerial implications is hardly available. We therefore propose the following research question.

RQ1: How do BC adoption and implementation in service organizations proceed, who is involved, and which antecedents are most influential?

2. Consumer Attitude and Behaviour

To successfully implement blockchain in service transactions, companies need to consider consumers' attitudes towards this technology and understand the reasons for these attitudes. Therefore, recent studies have started to address this research topic (e.g. Dam et al. 2020; Nam 2018; Shin & Hwang 2020) and to shed light on different aspects of consumer attitudes, such as the intention to use certain blockchain applications (Dam et al. 2020; Lian et al. 2020), the willingness to pay for blockchain services (Nam 2018), the perceived attractiveness of an organization that uses blockchain (Ingold & Langer 2021), and the impact of different blockchain affordances on consumers' perception of a service (Shin & Hwang 2020).

One of the main drivers of consumers' attitude towards and intention to use a blockchain service or application is trust in the technology (Shin & Hwang 2020). Although increased trust or trustworthiness is often cited as a strength of blockchain technology (Ølnes et al. 2017; Osmani et al. (2020); Tapscott & Tapscott 2016), consumers seem to have more trust in traditional technologies than in the blockchain (e.g., Ingold & Langer 2021). Then, it remains unclear how trust can be gained and how it ultimately influences consumers' interaction with blockchain-based applications (Shin 2019). For this reason, we propose the following research question.

RQ2: How can service organizations enhance consumers' trust in blockchain applications and how does this influence their usage behaviour?

Our literature review further revealed several dimensions of blockchain-related consumer behaviour that have already been investigated, such as individuals' technology adoption (Schuetz & Venkatesh 2020; Treiblmaier et al. 2020), consumers' blockchain-related information sharing (Bolici et al. 2020), and – perhaps most importantly – consumer participation (Fell et al. 2019).

Basically, service provision and consumption is characterized by customer participation and, not least due to infusion of technology, consumers increasingly represent active contributors, rather than passive recipients during the service delivery process (De Keyser et al. 2019; Kim & Tang 2020). This shift could be significantly amplified by the use of blockchain technology, since it is considered a network of peers in a structure that eliminates the third party. In such a network, consumers could act not only as users of a service, but also as service providers, so-called prosumers. One prominent use case is peer-to-peer (P2P) electricity trading where prosumers consume, produce, store, and share energy with other participants in the network (Espe et al. 2018), ideally leading to a more flexible and sustainable process of energy sharing. According to Fell et al.'s (2019) survey-based study, more than half of the respondents in the UK would like to participate in a P2P electricity network.

However, eliminating the third party to make transactions more efficient and flexible also increases consumer responsibility. Consumers are directly accountable for their actions in a blockchain network. Once transactions are stored on the blockchain, they cannot be reversed (Beck et al. 2017). As extant research has already revealed (e.g., Berry et al. 2015; Blut et al. 2020), consumers might feel stressed, participating in the service delivering process. Additionally, there could be uncertainty on whether consumers understand what they are agreeing to when they conclude a transaction on the blockchain. Since these aspects are essential to whether blockchain technology will be adopted and whether a wide range of consumers will actively use the underlying services, we recommend addressing the following research question.

RQ3: Do consumers perceive increased responsibility and uncertainty when they use blockchain services, and if so, how does this influence their participation behaviour?

3. BC Influence on Business Models and Service Industries

After the hype over blockchain technology in 2017 a great deal of capital was invested in the development of new business concepts (Gatteschi et al. 2018); however, the outcomes did not meet practitioners' expectations, as many initiatives did not even survive the concept phase (Lacity 2018). To gain a realistic view of blockchain's potential for building new or transforming existing business models and achieving realistic expectations of blockchain technology, numerous publications have addressed the benefits and barriers to blockchain implementation from different research perspectives and in different business contexts.

Our literature review reveals that a number of articles have addressed the impact of blockchain on business models, in general (e.g., Babich & Hilary 2018; Morkunas et al. 2019) as well as on specific types of business models (e.g., Trabucchi et al. 2020), and on different kinds of service industries (e.g., Erceg et al. 2020; Kizildag et al. 2019; Osmani et al. (2020).

The articles addressing the general impact of blockchain on business models highlighted the strengths (e.g., validation, automation, and resilience) and weaknesses (e.g., garbage in, garbage out, black box effect, and inefficiency) of blockchain (Babich & Hilary 2018), and they explore how two different types of blockchain technologies (private and public BC) offer opportunities to add value to a company's business model (Morkunas et al. 2019). One article focuses on blockchain technology's impact on business models in the specific context of two-sided platforms (Trabucchi et al. 2020). The authors suggest decoupling the traditional platform provider into a blockchain provider (operating as a Platform-as-a-Service provider) and a service provider (offering valuable services to buyers and sellers). In blockchain-enabled platforms end users could take a more central role (e.g., buyers, sellers, arbiters, token holders and validators), while the service provider reduces to a mere intermediary, using the Platform-as-a-Service the blockchain provider offers (Trabucchi et al. 2020). This shift towards a decentralized platform ecosystem could lead to a plethora of novel business models in various business sectors, as the role of end users could be more central in creating and capturing value.

Two articles in our scope examine the technology's potential for the tourism industry (Erceg et al. 2020; Kizildag et al. 2019). They found that the most promising applications for blockchain relate to online reservation systems, direct bookings (Erceg et al. 2020; Kizildag et al. 2019), and storing and validating guests' data without requiring them to disclose their personal information (Kizildag et al. 2019). The main benefits of blockchain technology for financial services that Osmani et al. (2020) identified are privacy, transparency, cost saving, enhanced security, immutability, trust, and faster transactions. These benefits can provide sustainable competitive advantages and might in the future help banks offer new services (Osmani et al. 2020).

Whereas the benefits of blockchain technology make its use seem attractive, Biswas and Gupta (2019) drew attention to the barriers to implementing it in the service sector. They developed a framework of ten different barriers which could negatively impact blockchain's diffusion in and transformation of service business models, such as challenges in scalability, market-based risk, technology risk, high sustainability cost, privacy risk and regulatory uncertainty.

To summarize, regarding service business models, our literature review reveals partially inconsistent assessments of the blockchain technology. While some authors argue that costs can be reduced using blockchain technology that eliminates the need for intermediaries (Osmani et al. 2020), others claim that increased electricity consumption and delay costs in transmission raise the blockchain technology costs (Biswas & Gupta 2019; Yli-Huumo et al. 2016). Further examples of scholars' divergent evaluations refer to transaction speed (e.g., Osmani et al. 2020; Croman et al. 2016) and increased privacy (e.g., Tapscott & Tapscott 2016; Androulaki et al. 2013). Which of these perspectives hold true might depend on factors like the specific use case (e.g., intraorganizational, interorganizational, number of participants, complexity of the task running on the blockchain), the underlying BC architecture (e.g., public blockchain, private blockchain), and the type of verification (e.g., proof-of-work, proof-of-share, proof-of-concept) used in the respective case. However, since both empirical research and practical insights on blockchain's impact on service business models are still scarce and inconsistent, we suggest addressing the following research question.

RQ4: To what extent do new blockchain-enabled decentralized business models replace or change traditional service business models? What are the major success factors of such business models?

4. BC Architecture in Services

Although our literature review excluded most articles that addressed technical aspects or blockchain architectures, some were considered since they contributed to service research. The selected articles proposed BC architectures and frameworks in various service domains, for instance home care services (Chang et al. 2020), cross-border e-government services (Geneiatakis et al. 2020), background technology for robotic services (Fukuwa 2020), knowledge and service sharing in manufacturing ecosystems (Li et al. 2018), and for individualized pricing in on-demand service platform operations (Choi et al. 2020).

After developing the architectures, a few were tested under realistic conditions (e.g., Chang et al. 2020; Geneiatakis et al. 2020; Li et al. 2018), showing that blockchain-supported architectures are more traceable (Chang et al. 2020), efficient (Chang et al. 2020; Li et al. 2018), effective, less expensive, more flexible, and of generally better quality than traditional systems and approaches (Li et al. 2018). Further, Chang et al. (2020) conducted a quantitative study with home care service users which indicated that participants benefit from increased efficiency, better transparency, and a higher level of process automation (Chang et al. 2020). Studies like these provide great value to service organizations because they offer insight not only on how well the technology is working, but also on how users perceive the respective services. However, they predominantly follow a technology-focused perspective in that they take the new technology as a starting point and search for appropriate problems that the new technology can solve in a better way. From a service research perspective, it could be fruitful to follow a design-thinking approach, starting with customer problems and needs, then identifying technological requirements or characteristics that are beneficial in solving the problem. Finally, if the problem characteristics fit the technology characteristics, designing a BC-based solution and architecture that is similarly functional or effective, efficient, and customer-centric (Brown 2008; Wang et al. 2019) could assist in problem solving. We therefore propose the following research question.

RQ5: In what way can design-thinking based service research contribute to the development and design of customer-centric blockchain architectures and solutions?

Conclusion

This literature review aimed to provide an overview of blockchain in service research. Although only a few articles have been published in service related target journals to date, we were able to identify 27 articles that contribute to service research. We analysed these articles, the relevant literature on the theme, to synthesize the findings and contribute to current service research by presenting a categorization of four major themes that the service context has already addressed (Table 1), and we provided corresponding research questions that can serve as a starting point for further research. We further aim to contribute to a growing interdisciplinary research stream that will provide service managers with valuable guidance on mindful blockchain-related decisions and successful technology implementation.

While we identified some topics that have already been covered in the extant literature, there are many more service areas especially related to consumer behaviour or service ecosystems that have not yet been addressed in academic literature. In terms of consumer behaviour for example, it could be interesting to study whether customer loyalty towards certain blockchain platforms develops, or how customers behave in cases of a bad experience with transactions on a blockchain and how a corresponding service recovery might take place. Additionally, it would be fruitful to take a closer look at the complex changes that arise if the third party is eliminated from a service ecosystem perspective. Thus, the actions and interactions of multiple actors that contribute to co-creating value can be studied and could provide new insights. For this reason, we would like to encourage service and management researchers to address these areas.

Blockchain Technology: How Research on Information Systems and Service Management Can Make a Difference

By Kai Spohrer, Viswanath Venkatesh, Raji Raman, and Hartmut Hoehle

1. Introduction

Blockchain technology is still one of the most trending technologies in Gartner's hype cycle and has aroused tremendous expectations in industry and academia alike. As such, blockchain proponents are promising that this technology will disrupt various industries and challenge the business models of intermediary service providers (Beck et al. 2018). Notwithstanding the global economic crisis that was brought about by the COVID-19 pandemic, more than $1 billion in venture capital were raised through blockchain-based initial coin offerings in the first half of 2020 (ICO Data 2020). During the same time, a surge in popularity and market capitalization of decentralized finance applications has led analysts to conclude that blockchain-based digital assets outperformed gold as an investment during the 2020 economic crisis (Bloomberg 2020).

Yet, there are many voices that call for caution, as blockchain systems and especially their implications for business domains and markets are not well understood (Risius and Spohrer 2017, Rossi et al. 2019). Governmental agencies and regulatory institutions worldwide are struggling to find sustainable positions that balance the openness to this innovative technology and the management of the uncertainty that is associated with its consequences. As many information systems (IS) scholars suggest that blockchain technology may constitute the foundational pillar of new economic systems that could differ tremendously from extant ones (Beck et al. 2018, Schuetz and Venkatesh 2020), the IS field has focused heavily on elaborating application scenarios and use cases (Hinz et al. 2019). We have not yet achieved a necessary level of generalization that allows us to make a strong impact beyond the boundaries of specific use cases and business domains. A core reason may be that behavioral and organizational IS researchers currently lack guidance on how to study theoretically relevant effects of blockchain technology in traditional IS research domains that go beyond technical development.

This paper calls for stepping outside the boundaries of the traditional technical and use case-oriented focus of blockchain research by highlighting consequences of blockchain systems for behavioral and organizational research areas in the broader IS literature and in service management in particular. This paper provides a key, though non-exhaustive, list of IS research domains that are influenced by blockchain technology, asks emergent questions that challenge current thought, and shows a need for new or modified theory that together can generate broader and more generalizable insights.

2. Blockchain Systems and Traditional IS Research

In its generic form, a blockchain refers to a distributed system for capturing, validating, and storing a consistent and immutable linear event log of transactions by cryptographic means (Risius and Spohrer 2017). Blockchain systems intrinsically provide economic incentives for the networked actors to participate in storing and validating transactions and maintaining the consistency of the shared database with an agreed-upon history of transactions. In a wider sense, blockchains constitute digital infrastructures that can be used as both interorganizational IS and public platforms. Interorganizational blockchains typically consist of permissioned blockchain instances that are used to connect the IS and business processes of a bounded network of organizations. In contrast, public blockchains, such as Ethereum and Bitcoin, constitute distributed digital infrastructures that distribute control by means of transaction verification, are open to the manipulation of infrastructure capabilities, and generative with regard to organizing objectives (Andersen and Ingram Bogusz 2019).

A number of prior studies have raised important research questions related to blockchain technology. Scholars have outlined questions regarding the design and impact of blockchain systems (Risius and Spohrer 2017, Rossi et al. 2019), governance and management of blockchain infrastructures (Andersen and Ingram Bogusz 2019, Beck et al.2018), and specific blockchain use cases such as supply chains (Kumar et al. 2020, Queiroz and Fosso-Wamba 2019), sensor data protection (Chanson et al. 2019), and financial inclusion in developing countries (Schuetz and Venkatesh 2020). We build on and extend these prior works in order to delineate promising directions related to blockchain technology for behavioral and organizational researchers in IS and service management.

Organizational and behavioral research constitute two major IS research strands and have been widely accepted as part of the discipline's intellectual core (Goes 2013, Sidorova et al. 2008). Scholars of both strands have long advocated openness and integrative perspectives on theory and methodology to embrace new phenomena holistically in theory building and testing (Venkatesh et al. 2013). To make blockchain research projects interesting for organizational and behavioral researchers, we outline areas where blockchain properties challenge current thought in research domains that are relevant to service management research. We highlight emergent questions that warrant attention and provide ground for theoretical contributions.

3. Individual Blockchain Service Adoption

Research on individual technology acceptance and use is one of the most mature streams of IS research (Hoehle et al. 2012, Venkatesh et al. 2003, Venkatesh et al. 2012, Venkatesh et al. 2016). Although this maturity implies practical limits in further explaining technology adoption in traditional organizational contexts, novel contexts provide room for fruitful theoretical extensions. For example, Venkatesh et al. (2016) outline a number of opportunities to contextualize extant theory of individual IS adoption and use by examining different technological, organizational, and environmental contexts. They recommend taking more multilevel perspectives and accounting for more detailed patterns and effects of feature use. Following a similar line of thought, Thong et al. (2011) suggest placing more emphasis on differences between generic types of services that will influence technology adoption and use.

Arguably, blockchain systems and blockchain-based services provide a novel context of technology adoption that exhibits some fundamental differences from traditional organizational contexts (Queiroz and Fosso-Wamba 2019, Schuetz and Venkatesh 2020). For example, the current surge in popularity of decentralized finance applications suggests that blockchain services may indeed provide a basis for large-scale peer-to-peer finance and pave the way for more financial inclusion. This opens a number of theoretical questions on the adoption of such services (see Schuetz and Venkatesh 2020).

Moreover, new forms of distributed organizational participation are currently being established on public blockchains and differ tremendously from established organization structures (Andersen and Ingram Bogusz 2019, Risius and Spohrer 2017). This is important for adoption theory because social influence of workplace referents, such as managers and colleagues, is an important factor in adoption models (Venkatesh et al. 2016). Whereas classical perspectives on IS adoption assume that individual users work in hierarchical organizations and multiteam systems (Bick et al. 2018, Venkatesh et al. 2016), blockchain-based forms of organizational participation may require new multilevel perspectives. For example, new perspectives need to account for decentralization and organizational participation beyond clear and linear hierarchy (e.g., in decentralized autonomous organizations, see Risius and Spohrer 2017), for membership in multiple virtual organizations, and for more community-like organizational structures. New, blockchain-based forms of organizing may actually alter the meaning of social influence and provide rich ground for contextualizing extant adoption theory. Thus, we propose:

RQ1 How do environmental and organizational context factors influence individual blockchain service adoption?

4. Interorganizational Blockchains and IS Strategy

Prior work on IS strategy suggests that the implementation of interorganizational IS often targets efficiency gains such as faster resource acquisition, lower procurement costs, quicker change of business partners, and reduced cycle times (e.g., Chatterjee and Ravichandran 2012, Rai and Tang 2010, Venkatesh and Bala 2012). Given that blockchains are highly effective in securing and storing transaction histories with many transaction partners but often lack efficiency in doing so (Kumar et al. 2020), interorganizational blockchains likely rely on different value creation mechanisms than traditional, centralized systems.

There are a number of reasonable candidate variables that may drive the value of blockchain systems in interorganizational settings. As such, traditional interorganizational IS have been found most effective when there is high operational integration between partner organizations (Chatterjee and Ravichandran 2012, Rai and Tang 2010) and little difference in their norms, values, and business environments (Dong et al. 2017). Similar to the example of reliable cryptocurrency transactions between nearly anonymous users, blockchains may allow for reliably connecting business partners that are less tightly integrated and differ more in their backgrounds, norms, and business environments (Kumar et al. 2020, Subramaniam 2018). Leveraging the capabilities of blockchain technology, organizations may be able to reduce the uncertainty and risk of transactions with distant and potentially opportunistic business partners (Beck et al. 2018). Blockchains may thereby create new business opportunities, making interorganizational exchange more effective rather than more efficient. In addition, interorganizational blockchains may increase the visibility along supply chains and facilitate exception and error handling as they inherently enforce all business partners to agree on the correctness of transactions. Thus, we propose:

RQ2 How do interorganizational blockchains create value for companies?

There are also open questions regarding the investment of companies in interorganizational blockchains and their adoption. For example, control and ownership play traditionally important roles in the development and success of interorganizational IS (Bakos and Nault 1997, Cho et al. 2017, Choudhury 1997). Theory holds that firms strive to exert power in interorganizational IS by financing the systems and controlling the transactional rights of connected organizations (Chatterjee and Ravichandran 2012). Although there are some technical variations[1], blockchains are typically much more distributed than traditional interorganizational systems. They therefore provide less possibilities for centralized control by single business partners (Beck et al. 2018). Understanding how this influences organizations' willingness to finance the creation and maintenance of interorganizational blockchain systems will be important for IS research. Moreover, the current lack of blockchain standards may create uncertainty, which is known to reduce the propensity of interorganizational IS adoption (Venkatesh and Bala 2012). However, early investments in interorganizational blockchains may provide the opportunity to create network effects that are hard to achieve with later investments (Subramaniam 2018). Thus, we propose:

RQ3 Why do organizations invest in interorganizational blockchains?

In addition, firms may need to build new IT capabilities for managing such distributed systems. Whereas traditional interorganizational systems can be leveraged by firms that possess capabilities for extending and recombining the IT elements of their interorganizational systems (Rai and Tang 2010), effective use of blockchains may require different capabilities. For example, distributed systems like blockchains cannot easily be changed and updated. Major changes require consensus of the involved actors (Andersen and Ingram Bogusz 2019). The capability to achieve such system-wide consensus with all business partners may therefore be critical for the long-term use of blockchains in interorganizational settings. Thus, we propose:

RQ4 Which IT capabilities are necessary for organizations to leverage interorganizational blockchains for their purpose?

In spite of first standardization endeavors[2], there is currently a lack of established technological standards regarding blockchains, their constituent parts, and their business functionality. Comparing this situation to the establishment of interorganizational business process standards (Bala and Venkatesh 2007, Venkatesh and Bala

[1] Some blockchain projects focus on providing means for more centralized control, e.g. https://www.hyperledger.org/

[2] e.g., https://www.iso.org/committee/6266604.html accessed 20 June 2020

2012), which only emerged based on technical standards for interorganizational systems (Malhotra et al. 2007), we must expect that establishing blockchain business process standards will take significant time. On the one hand, the research stream on business process standards, their adoption, and their effects (Bala and Venkatesh 2007, Venkatesh and Bala 2012) may provide valuable guidance in how to successfully establish blockchain business process standards. This may constitute a particularly rich ground for design science and action research studies. On the other hand, blockchains may require a re-evaluation of parts of prior research in this area. For example, the role of trust has been emphasized as critically important for business alliances before establishing shared process standards (Krishnan et al. 2006, Venkatesh and Bala 2012). Given that blockchain technology is frequently argued to dramatically reduce the need for trust in business partners (Beck et al. 2018, Cusumano 2014, Subramaniam 2018), research may need to evaluate prior assertions and investigate if other drivers than trust become indeed more important when blockchains are involved in adopting and managing interorganizational business process standards. Inspiration may be drawn from extant theory on the role of contractual control and how it complements other forms of control in business alliances and IS sourcing relationships (e.g., Huber et al. 2013, Kotlarsky et al. 2018, Schilke and Cook 2015). Thus, we propose:

RQ5 How do blockchains influence the adoption, application, and enforcement of interorganizational business process standards?

5. Platform Ecosystems

Contemporary public blockchain systems, like Bitcoin or Ethereum, were recognized early as platforms that critically depend on the size and quality of their ecosystems of developers, complementary service providers, users, and validating actors in the network (Cusumano 2014). At the same time, however, there are also characteristic differences between blockchain platforms and traditional platforms (Andersen and Ingram Bogusz 2019, Risius and Spohrer 2017). For example, blockchain platforms may contain e-marketplaces for trading similar goods and services as traditional platforms, but blockchain marketplaces tend to be strongly or completely decentralized (Beck et al. 2018). Whereas development and operations of traditional platforms are tied to the resources and decisions of a platform owner (e.g., Apple developing, operating, and governing its app store for smartphones), many blockchain platforms are operated as distributed systems without (extensive) centralized infrastructures and are often developed in open source projects (Andersen and Ingram Bogusz 2019). Consequently, novel development methods can become necessary, which often entails a strong shift in necessary developer skills as well (Venkatesh et al. 2020). Theory on platform ecosystems generally holds that the actions of a platform owner who governs the ecosystem with rules, norms, and technical design elements are crucial for the value created on the platform, its attractiveness to complementary service providers, and the long-term retention of such service providers (Constantinides et al. 2018, Huber et al. 2017, Tiwana 2015). It is largely unclear, however, how the absence of a platform owner in decentralized blockchains influences value creation and platform success. First investigations into blockchain governance suggest that platform governance in blockchains relies predominantly on mechanistic transaction verification (Beck et al. 2018) but is inherently open to altered governance models and different forms of self-organization (Andersen and Ingram Bogusz 2019). Future research on platform ecosystems should engage in theory building based on revised assumptions and should critically re-examine extant knowledge on distributed digital infrastructures. Thus, we propose:

RQ6 How do successful development, governance, and (self-) organization occur in blockchain platforms?

Moreover, the absence of a central decision maker and the distributed nature of blockchains also lead to phenomena intrinsic to this type of IS. As such, changes to the blockchain protocol or other core parts of the system can only become effective if the distributed instances that operate the blockchain accept them (Risius and Spohrer 2017). Otherwise, a running blockchain may fork, resulting in two blockchains. In such cases, the resulting blockchains share a common history of transactions but diverge at a certain point in time, as they accept distinct new transactions based on either altered or unaltered system properties (Andersen and Ingram Bogusz 2019). This means, however, that assets stored on the common historical part of the blockchain can be accessed and used in both resulting blockchains. For example, the Bitcoin blockchain has forked in the past, allowing users who previously held one Bitcoin to spend this Bitcoin twice, i.e., once on each resulting blockchain. In spite of first investigations, the consequences of such forks for the value created on a public blockchain and for its attractiveness to developers and users are not yet clear (Andersen and Ingram Bogusz 2019). Future research may build on and extend theory on source code forks in open source projects. For example, one strand of theory suggests that some open source projects disincentivize forks in their projects as forks can fragment community resources (Stewart and Gosain 2006) and prevent cross-project learning (Faraj et al. 2011). Nonetheless, forks can constitute an important generative mechanism (Andersen and Ingram Bogusz 2019). Unlike forks in open source software development, blockchain forks entail not only a fork of source code, but also a fork of the operational blockchain that encompasses assets and blockchain-based services. The characteristics of block-

General IS Research Question	Exemplary Service Management Research Questions	Possible Theories
RQ1 - How do environmental and organizational context factors influence individual blockchain service adoption?	• Which factors drive the adoption of different blockchain service types? • How does blockchain service adoption differ between developing and developed countries? • How does social influence on IT service adoption unfold in blockchain-based forms of organizations?	Technology Acceptance Model, Unified Theory of Acceptance and Use of Technology, Innovation Diffusion Theory
RQ2 - How do interorganizational blockchains create value for companies?	• What are the value creation mechanisms of interorganizational blockchains? • How do blockchain service characteristics influence the effectiveness of interorganizational blockchains? • How do blockchains moderate the effects of trust in interorganizational alliances of service firms? • How do blockchains alter the effects of organizational integration and institutional similarity on joint performance in interorganizational relationships?	
RQ3 - Why do organizations invest in interorganizational blockchains?	• How do blockchains influence and moderate the effects of information transparency, process alignment, and process flexibility in interorganizational service networks? • How does decentralization influence service firms' willingness to sponsor interorganizational blockchains?	Agency Theory, Control Theory, Competitive Dynamics, Institutional Theory, Resource Dependence Theory
RQ4 - Which IT capabilities are necessary for organizations to leverage interorganizational blockchains for their purpose?	• Which structural IT capabilities are necessary for firms to create performance benefits from supply chain blockchains? • How do blockchains alter the effects of IT capabilities for managing external resources in service networks?	
RQ5 - How do blockchains influence the adoption, application, and enforcement of interorganizational business process standards?	• What are the antecedents and consequences of blockchain standard adoption in interorganizational service networks? • How do blockchains moderate the effects of trust on the adoption and enforcement of interorganizational business process standards?	
RQ6 - How do successful development, governance, and (self-) organization occur in blockchain platforms?	• How and why does the dynamic interplay of governance mechanisms on blockchain platforms differ from traditional platform ecosystems? • How and why do specific developer skills and methods drive blockchain service success on public blockchains?	
RQ7 – (a) Which organizational dynamics lead to forks in blockchain platforms? (b) How do blockchain forks affect value creation, governance, and participation in blockchain platform ecosystems?	• What are the antecedents of blockchain platform forks? • How does collective action of stakeholder groups (e.g., miners, developers, service providers) drive forks of blockchain platforms? • Why do some forks result in two sustainable blockchain platforms whereas other forked blockchains quickly disappear? • How do forks of blockchain platforms affect the ecosystem of blockchain service providers and users?	Control Theory, Collective Action Theory, Complexity Theory, Organizational Inertia Theory

Tab. 2: Overview of general IS research questions

chain forks may change the dynamics that lead to or prevent forks and may also affect software developers, their motivation, and their sustained engagement differently than in traditional open source projects. Thus, we propose:

RQ7 *(a) Which organizational dynamics lead to forks in blockchain platforms? (b) How do blockchain forks affect value creation, governance, and participation in blockchain platform ecosystems?*

6. Conclusion

Overall, this article is meant to stimulate behavioral and organizational IS researchers to take on the challenge of investigating issues related to blockchain technology. We have provided a list of traditional behavioral and organizational IS research areas that are ripe for revised or extended theory based on investigations into blockchain systems. We specifically emphasized research on adoption, interorganizational IS, and platform ecosystems. *Tab. 2* provides an overview of the general IS research questions we raised and some exemplary, more specific research questions from the service management domain. Although this list is certainly not exhaustive, it provides a point of departure for further reasoning and contextualization of theoretical concepts. It highlights the need for critical re-examination of established knowledge and shows that there are many areas with good prospect for meaningful theoretical contributions. Thus, we hope this work spurs behavioral and organizational research to go beyond the traditional technology focus in blockchain research and to tackle a broader set of important issues theoretically as well as empirically.

Blockchain: A Reflection on Its Implications for Customers and Service Organizations

By Arne De Keyser, Cédric Verbeeck and Thijs J. Zwienenberg

1. Introduction

Blockchain is considered by many as the next breakthrough technology, having the potential to alter many everyday activities and (digital) business processes (Woodside et al. 2017). In this short viewpoint, we consider several implications of blockchain for customers and service organizations in specific (Note, we do not claim to be exhaustive, but rather focus on some of the key outcomes of blockchain). Based upon common themes identified in academic and practitioner literature, we consider four major changes that blockchain may bring towards service industries and beyond: (1) enhanced transparency, (2) disintermediation & automation, (3) risk reduction and (4) enhanced sustainability (i.e., Saberi et al. 2019; Gaur and Gaiha 2020; Dutta et al. 2020; Deloitte 2017; PwC 2018). For each, we outline some key research questions that need to be addressed.

2. Implication #1: Enhanced Transparency

Today, many service organizations serve at the end of supply chains, often global in nature, that are operating as a black box. Underlying IT systems can typically not guarantee the integrity of information within the supply chain, making it harder for service organizations to monitor their suppliers in real time. When Chipotle, the American chain of fast casual restaurants, faced an E. coli outbreak in 2015 leading to 55 customers becoming ill, it was not able to detect neither contain the contamination in a targeted way due to a lack of supply chain insights (Casey and Wong 2017). In response to this type of scandals, customers now increasingly demand transparency, with service organizations needing to know what is happening upstream in the supply chain and communicating this knowledge both internally and externally (Kraft et al. 2018). Yet, most service organizations can only provide their customers with limited knowledge of the services and accompanying goods they offer, let alone clearly demonstrate their origin (Montecchi et al. 2019). While the use of certifications (e.g., fair trade, organic, vegan) and country-of-origin labels may partially address consumer concerns, they do not ensure full transparency.

Blockchain can offer a powerful solution to enhance the transparency of service organizations' supply chain and provide customers with provenance knowledge (i.e., "information about the creation, chain of custody, modifications and influences pertaining to an artifact" – Cheney et al. 2009, p. 960) through a robust system that keeps a full audit trail of data along the supply chain (Montecchi et al. 2019). The Mediterranean Hospital of Cyprus, for instance, utilizes a blockchain platform to assign a Digital Healthcare Passport to any patient in the hospital. Patients use this passport to check in when arriving at the hospital, and every subsequent step in the process is registered on it (Mediterranean Hospital of Cyprus 2020). This gives patients full transparency into their medical care. Another example is Renault, the French car manufacturer, that is experimenting with blockchain to develop a tool to provide a better service towards their customers. Specifically, Renault is building a tamper-proof car passport where all information is stored about the cars' service-history, connecting historical information from previous dealership, insurance, repair and maintenance services, thereby enabling enhanced transparency when servicing and selling vehicles (Groupe Renault 2020).

While transparency is one of the key drivers to blockchain adoption and development, many challenges remain that require further research. For instance, in what service industries is transparency most prudent? When are its effects stronger/weaker? To what extent does transparency have negative implications? It may, for instance, increase the exposure of organizations to competitors and other organizations, thereby risking disclosing trade secrets, intellectual property rights and company specifications (Montecchi et al. 2019). From a customer perspective, how will transparency impact their behavior? This might be especially important for restaurants, healthcare and financial services where transparency is important. Does blockchain-based transparency have a different and/or stronger impact on consumer behavior compared to established labels and certifications? Are consumers willing to pay a higher price when given full transparency? How consciously will consumers be scanning for information provided by blockchain applications? Will they do so before or after buying? Or does the mere availability of information serve as a trust-inducing factor?

3. Implication #2: Disintermediation & Automation

Today, many service processes are making use of intermediary parties like financial institutions, notaries, brokers and online marketplaces. The advantage of using intermediaries is that they enable mutual trust between transacting parties (Rangaswamy et al. 2020). Moreover, intermediaries often possess specialized expertise, making them an interesting partner to assist service organizations in innovation and networking possibilities (Zhang and Li 2010). The disadvantage, however, is that service organizations have reduced ownership over (sometimes essential) processes and may incur substantial costs for collaborating with intermediaries, as do customers (Morkunas et al. 2019). Service fees on Airbnb, for instance, can reach to almost 15 percent for guests and range from 3 to 20 percent for hosts (Airbnb 2020).

Blockchain allows for the removal of these traditional third-party intermediaries – i.e., **disintermediation** (De Keyser et al. 2019). Given that blockchain is saving records (e.g., property rights) in an immutable manner, it allows to bypass the involvement of a third party (e.g., notary) to enable mutual trust in a specific transaction (e.g., terms of ownership, usage allowance), hence improving efficiency and reducing transaction costs. Given the importance of trusted intermediaries in many service industries today, especially in the financial services industry, blockchain technology may thus significantly impact existing business models (Morkunas et al. 2019). For instance, blockchain is already fueling the further growth of peer-to-peer interactions without intermediary involvement. The blockchain platform Origin Protocol allows users and developers to create their own decentralized peer-to-peer marketplace. On these marketplaces supply and demand of all sorts (e.g., accommodation sharing) can meet in a trusted, decentralized and transparent way. With the help of blockchain technology there is no need for centralized intermediaries, thereby significantly reducing usage and service fees (Origin Protocol, 2020).

One of the fundamental aspects to make sure these peer-to-peer services are trustworthy, reliable and safe to use, is the usage of smart contracts within the platform. It is the introduction of these smart contracts registered on the blockchain that is set to make the real difference through **automation** (Zheng et al. 2020). Smart contracts are "pieces of code stored on a blockchain that are programmed to behave in a given manner when certain conditions are met" (Gatteschi et al. 2018, p. 4). They can be set up in such a way that they allow the automatic execution of contracts or transactions in an "if-then" manner, further eliminating the need of intermediaries (Kumar et al. 2020) and enabling the rise of fully automated service encounters (De Keyser et al. 2019). Smart contracts for car insurances, for instance, can be programmed to transfer money only if customers repair their car at certified mechanics. As soon as the repair operation is added to the blockchain by a certified mechanic, insurance money is automatically transferred to the customer without any further human involvement.

While disintermediation and automation examples are growing, many challenges and unknowns remain. Future research is needed to detect what service industries or processes are affected mostly by disintermediation and what benefits/costs are attached to this. Further, more work is needed to understand how customers react when conflicts or service failures occur in a disintermediated and automated blockchain environment. Research has shown that customers still rely and trust on the involvement of human employees to intervene when transactions go sideways (De Keyser et al. 2015). This leads to interesting research questions: How should service recovery resolutions be automated when it concerns intangible and personalized experiences? How do customers and (peer-)suppliers react when service recovery is handled by the use of smart contracts? To what extent is a human back-up needed? Finally, blockchain and smart contracts allow the further development of Internet-of-Things (IoT)-based services where human involvement will be minimized, and technologies communicate directly with one another (Risius and Spohrer 2017). This evolution raises a new set of questions. What services are prone to automation by means of smart contracts and how far does the potential of smart contracts to replace customers and frontline service employees reach?

4. Implication #3: Risk Reduction

Building on the previous implications – transparency, disintermediation & automation – put forth in this viewpoint, we posit that blockchain may essentially help reduce risks for both the customer and the service organization. Looking at the customer, blockchain may reduce risk in a number of ways. Recent work by Montecchi et al. (2019), for instance, finds that blockchain-induced supply chain transparency leads to lowered financial, psychological, social, performance and physical risks. *Financial risks* may be reduced as services and accompanying goods can be verified in their origin, making sure that premium prices for exclusive materials are warranted (i.e., origin assurance). This may especially be relevant for luxury retailers, often characterized by high-end materials and top-quality service (Wirtz et al. 2020). Further, providing assurance on service/good authenticity may help reduce *psychological and social risk* as customers avoid buying fraudulent services/goods. De Beers, the world's largest diamond producer, has turned to a blockchain application Tracr to provide additional services to their end customers, giving them a tool to track and assure provenance, traceability and authenticity of their diamonds through the value chain (www.tracr.com). Finally, performance and physical risks can be reduced as information on all involved stages and parties from production to consumption of the service or good may be tracked and assessed, assuring these deliver the necessary quality and have been established and maintained in the right circumstances (i.e., custody and integrity assurance). Other work by Efanov and Roschin (2018) discusses how blockchain may help prevent identify theft and fraud. Moreover, it facilitates the possibility to store birth certificates and identity documents in a digital, secure and immutable way. Today, more than 200 million children under the age of 5 are not in the possession of a birth certificate, an essential document to prove one's identity (Unicef 2019). A digital identity enabled by blockchain technology may also be a solution for many of the world's two billion unbanked individuals to gain access to bank accounts, loans and other financial services (Efanov and Roschin 2018).

From an organizational point of view, blockchain may also help reduce risks on multiple fronts. Given the fact that it allows to track information flow as services/good are produced and delivered, it provides organizations with the opportunity to identify potential bottlenecks, uncover double spending touchpoints, and monitor in- and outflow of resources more properly (Martinez et al. 2019). Further, blockchain may be used to recognize and prevent dysfunctional behaviors such as cheating, financial fraud and property abuse partners in the ecosystem, track the origin of service failures and fight counterfeiting (Casey and Wong 2017; Montecchi et al. 2019). A recent PwC survey showed that almost half of the examined organizations experienced fraudulent incidents with existing customers (26 %) or third-party partners (19 %), estimating over 20 billion USD in losses (PwC 2020). With blockchain, the spread and misuse of (false) information becomes harder, helping to reduce risks and costs for the organization. More concretely, by enhancing the transparency of the supply chain, service organizations may lessen the risk of involving faulty services and goods in their own processes and reduce potential liability as errors may be traced back or avoided. From the above discussion, it is also clear that a service organization's financial risks may be downgraded. Parties can determine specific payment conditions in a smart contract that only will be activated when pre-specified conditions are met. To illustrate the above-mentioned lowered risks, consider the example of blockchain food traceability. Restaurants and hotels, for example, can use smart contracts to activate payments only when the ordered food was transported between a certain temperature range, ensuring their own service quality. These temperatures can be captured using IoT sensors that automatically upload the data to the blockchain (IBM 2020). Finally, blockchain may also diminish cybersecurity risks by removing human intermediaries, which in turn lessens the threat of hacking, corruption and human error (CB Insight 2020).

More research is needed to further detail the various ways in which blockchain helps reduce risk, how this should be communicated to and to what extent these risk reductions may motivate customers and organizations to adopt blockchain-based solutions in the future. For instance, research could focus on how reducing risk translates into purchase behavior and brand involvement. How do customer perceptions of goods/services not registered on a blockchain change and to what extent does this induce switching behavior? Do customers become more skeptical or risk-averse toward goods or services that are not verified or is this dependent on the type of good/service?

5. Implication #4: Sustainability

A final implication of blockchain relates to its ability to enhance **sustainability** by helping service organizations improve their sourcing and recycling practices (Saberi et al. 2019), as well as giving customers the ability to verify the sustainability of their purchase decisions (Nikolakis et al. 2018). Today, many service organizations make use of sustainability labels to verify their triple bottom-line impact on people, planet and profit. Yet, these labels merely check certain minimum requirements of their (aspiring) members and fail to acknowledge the inherent heterogeneity that still exists. Service organizations boosting the same labels may still differ considerably in their sustainability practices and impact. On top of this, labels are facing challenges in terms of measurability (University of Canterbury 2019). This is mostly due to a lack of data, inconsistent record-keeping and confidentiality issues, with the result that it is not possible to assess any organizations' full economic, environmental and social impact.

Blockchain offers the possibility to provide more detailed insight into, but also foster a fair competition among various sustainable organizations in terms of wages, carbon emissions and resource usage during production. In the near future this could give customers visiting a coffee shop, for instance, the possibility to scan a code associated with the cup of coffee they bought and see the date and location of every transaction from collection at the coffee farm to washing and drying, milling, export, roasting and retail. One such example working towards this is the Coda Coffee Company serving many cafes and restaurants. The company sources coffee while providing proof of living-wage payments made to its farmers, all traced and immutable within a blockchain (Vu 2018). In order to realize this, the firm uses machine vision, AI and IoT to analyze deposited coffee cherries, instantaneously rewarding farmers for better quality while tracking the produce across its life span. Not only do such practices foster transparency and sustainable consciousness in the supply chain, but they also offer a way of countering increasing greenwashing practices by organizations nowadays (i.e., providing false, inaccurate or inflated information/marketing about an organization's sustainable performance – Delmas and Burbano 2011). Moreover, as customers increasingly seek to engage with truly sustainable brands, blockchain may offer a fitting solution to help in the selection of the right brands.

More research is needed here, relating to questions like: What service industries are most apt to adopt blockchain technology for sustainable purposes? To what extent are consumers willing to pay extra for additional insights in supply chain sustainability? How does this differ for a variety of goods and services? How does this impact brand perceptions? Interestingly, although blockchain has piqued the interest of environmentalists, it is also the technology behind energy-hungry digital currencies such as Bitcoin. Per transaction, Bitcoin is thought to be five times more energy intensive than its VISA counterpart (Digiconomist 2020). More work is needed to consider how the energy usage of blockchain systems may be limited. The use of private blockchains may be one answer, limiting data access and hence enhancing energy efficiency. This, however, comes at a trade-off with increased risk of fraud and stands against the grand promise of blockchain's public access.

6. Conclusion

Blockchain holds great promise for enhanced transparency, disintermediation & service automation, risk reduction, and ultimately more sustainable services and accompanying goods. Adoption, however, remains slow and much progress is needed to let the technology become mainstream. The challenge lies in developing the practical applications that provide the basis for the real breakthrough of blockchain as the foundation of the digital economy and society in general. In the years to come, practitioners and academics across disciplines will have to work together to make the world blockchain-ready. We hope this viewpoint may offer an additional starting point to foster new blockchain-focused research efforts.

An Introduction into Service-Potentials of Universal Wallets in Blockchain Systems

By Kim Peiter Jørgensen and Roman Beck

1. Introduction

Cryptographic wallets will play an important part in the emerging blockchain economy (Guri 2018) which allow for procurement, selling and sending, and receiving of cryptocurrencies. As of today, there are more than 200 crypto wallets available, dealing with more than 1,600 cryptocurrencies handled by more than 50 million users (Statista 2020). The next generation of crypto wallets, called universal wallets can be defined as digital wallets "that support cryptocurrency, verifiable credentials and cards." (W3C 2020 I). Universal wallets will be able to handle more than just cryptocurrencies (Scholte 2008), such as identities, identifiers (Bharathan 2020) and credentials such as driver's licenses (Alper 2020). The first of these wallets related to blockchains emerged in 2012 and were already able to handle any type of digital assets as described in (Grinyaev et al. 2018) essentially anywhere (Williams 2018).

Digital assets are not just cryptocurrencies but can be also digital tokens from loyalty coupons in supermarkets offering discounts to security and bona fide tokens that can be used to raise capital in an unregulated environment. A natural progression from this is the use of universal wallets to manage digital identities. In principle, digital identities are data-strings with a unique identifier pointing to something or somebody. Driving licenses, social security cards, passports, membership cards and identity cards of any kinds can be considered as identity granting examples. The practical application of these identity types of course depends upon international acceptance and related standardization of such purposes.

In this research, we are elaborating on the role of universal wallets from a service accessing and initiating point of view. We investigate the central role of managing identity and identifiers through wallets to interact with all kinds of blockchain-based services and will discuss future research direction to explore this emerging area.

2. Research Methodology

We conducted a structured literature research for blockchain related wallets and did a forward and backward search to also cover literature that might not be blockchain specific, but relevant to understand the concept behind universal wallets and their use for accessing and managing services.

The field of universal wallets is still very new which is the reason why even when including the term "crypto wallet" into our search, we were able to only identify 18 peer-reviewed publications, of which six were found of core relevancy, while the remaining twelve merely mention wallets without really contributing to that topic. We used the six papers to outline dimensions for investigation either through treating relevant aspects of wallets as globality (Scholte 2008) or the process of interaction between digital asset and wallet (Grinyaev et al. 2018) or mentioning of need for generality of services (Collomb et al. 2019) or within a more specific field as charity collection (Farooq et al. 2020). We decided to widen our search and included non-academic publications in our research, to give credit to the newness of the topic, as well as being able to capture the latest developments around universal wallets and their use to access and manage services. For example, using universal wallets as the fundamental gateway for managing digital identifiers and credentials in a blockchain economy is extensively discussed in non-academic publications. Further references from our other research activities were added according to relevance to services, like multi-signature wallets, reputation systems, service development, smart cities, wallet systems architecture to bridge the elements to facilitate overview of status and opportunities.

3. Universal Wallets – Functionalities and Services

Services are the central element of economic exchanges in the digital sphere. This is also the case in the blockchain economy, which is the reason why we first outline the functionalities and potentials of universal wallets, before we discuss their importance from a services point of view. The first generation of cryptocurrency wallets stored the user's public and private keys, thereby enabling the owner to buy and sell cryptocurrencies. What followed were easy-to-use wallets to store and exchange all kinds of crypto assets, which also raised the interest and concern around the need for privacy protection in that area (Krombholz et al. 2016). With an increasing number of digital assets, identifiers, and credentials to be managed through wallets, the next generation must be easy to use. Wallets need to be usable by everyone, not just by tech savvy people, as they are the portal (Antonopoulos and Wood 2019) to the emerging blockchain world (Beck 2018).

From a service perspective, the wallet is both a practical container for the owner's data, as well as a tool for digital identity and identifier management. Two of the main wallet functionality areas are ease-of-use and security/safety regarding the handling of the wallet (Antonopoulos and Wood 2019). A large number of functionalities can be modelled as design criteria for universal wallets (*Tab. 3*), following a service perspective (Vargo and Lusch 2008).

3.1. Affordance

Affordance, the action possibilities of a service, is an important design criterion for a service as it enables "certain desired affordances in order to support certain desired behaviors, but does not possess certain undesired affordances in order to avoid certain undesired behaviors" (Maier and Fadel 2009). Current wallets have a limited range of functionalities (Antonopoulos and Wood 2019) both for security and performance reasons. The expanded range of functionalities implied in trade references and workgroup specifications (Hyperledger 2018) will not be successful without considerable ease-of-use concern. The whole transaction experience around the wallet needs to

Functionality	Service	Comment
Affordance as a key design criterion	Ease of use with high security	Prerequisite for a high degree of automation in society
Access Management	Facilitating the task of legal access to services and documenting this process for the user's convenience	Both enabling 'easy' access for the user, managing what we access and who accesses 'us', the user
Security	A selection of personas matching each user's profile requirements with very high security	Increasing security and off-loading responsibility from individual
Identification and Authentication	Sub-services for access management	Automated or manual according to situation
Credentials	Managing the user's claims and proofs by presenting credentials as needed	Different series of credentials can be linked to the user's different personas
Reputation Management	Access to services based upon history	Wallet managed access based on previous performance
Privacy	Protection managed by the user against intrusion	Subject to legal requirements from authorities

Tab. 3: Mentioned functionalities mapped against supported services.

be designed with a user-centric perspective in mind (Chen and Ko 2019; Moniruzzaman et al. 2020).

With proliferation of autonomous services, universal wallets will become necessary in machine-to-machine communication. New services such as provided by robots like semi-autonomous "smart" fridges that can be authorized to order from the local supermarket once a week, all done via the universal wallet of the fridge (Warburg 2017). All such new service platforms enable other emergent platforms and functionalities (Salikhov et al. 2016).

3.2. Access Management

Access management is about allowing access to services while preventing unauthorized users to access, as they do not have the rights or required identity to access the service (ITIL 2018).

Human beings tend to make mistakes. One of the biggest security risks in systems is the habit of users to jot down their passwords on some paper. While forgotten or lost personal keys might be a problem already in non-blockchain environments, one can reset a password or call an operator to retrieve credentials to access a system again. As private keys once lost cannot be retrieved in a blockchain environment, their safe and yet user friendly storage is of essential importance for accessing blockchain-based services. Universal wallets must provide solutions for not losing keys anymore, e.g., by providing advanced personalized access functionalities (Rezaeighaleh and Zou 2019).

3.3. Security

Security from a systems perspective can be defined as the protection and confidentiality and integrity of information (ISO/IEC 2009). One key to success for a universal wallet is justified trust. There are two aspects to trust. The first is related to the security and integrity of the wallet itself. One needs to be certain that the software of the universal wallet is secure enough to host digital identities, identifiers and credentials, as well as digital assets and tokens such as cryptocurrencies (Pillai et al. 2019). The other is certainty about that the user's universal wallet links to the human beings or legal entities intended and not something else. Even the best security system can be bypassed if the necessary codes are abducted by criminals through phishing (Holub and O'Connor 2018). A high enough level of security is only achieved by sophisticated, high quality programming. A security or stability breach in any universal wallet and associated systems would be critical and erode trust. The risk of identity theft will be smaller than today due to the high security from blockchain encryption.

Multi-signature is a promising new security service, as well as a potential attack vector. Multi-signature is an encryption technique allowing "multiple signers to jointly authenticate a message using a single compact signature" (Bellare and Neven 2007), is increasingly used in wallets to heighten security (di Angelo and Slazer 2020). However, it increases the complexity of the solution as more parties have access (Bellare and Neven 2007).

3.4. Identification and Authentication

Decentralized identifiers (DIDs) are a new type of identifier that enables verifiable, decentralized digital identity (W3C, 2020 II). Universal wallets can facilitate our everyday life but require an identifier system to operate. Every time our identity is required, we can provide it automatically or manually as required by the situation. A universal wallet can also store our current identity papers, passport, driver's license, health certificate etc. Such generalized blockchain-based electronic ID systems for identity management and particularly self-sovereign identity promoted by the EU are key areas for wallet development with benefits for the individual user being the clear focus of sovereign identity. Based upon the concept of identity several applications become feasible when a service is requesting identification and authenticating of the requested service.

With Internet of Things (IoT) and smart everything everywhere our needs for access to systems and services and logging of these events are increasingly demanding (Cardenas and Kim 2020). Universal wallets are enabling us to access these smart services when and where allowed (Panarello et al. 2018). We need not to bring out our wallet to use it, we can authorize it to automatically make the necessary connections and authorizations. Our wallets communicate with the wallets of the smart applications with whom we interact (Warburg 2017), (Cardenas and Kim 2020). Interaction between wallets apply interoperable digital wallets and credentials using the W3C verifiable credentials standard (Ledger insights 2020).

Further, some of our identity data cannot easily be condensed, for instance our health record. Our human genome can be used as a very certain identifier further to the medical uses (Gürsoy et al. 2020) being voluminous and thus difficult to store in a universal wallet.

3.5. Credentials and Reputation Management

Credentials can be defined as a set of claims the issuer of the credential is holding. In order to be able to verify credentials the need to be tamper-resistant so that the authorship can be cryptographically verified (W3C 2019). Universal wallets allow for management of data flow to different reputation systems, thereby allowing the owner to stay in control of her own data (Yang et al. 2017). Reputation can be built by allowing third parties to assess data credibility through past behaviours of data generating persons (Dai 2018). Credentials as well as management of intellectual property rights will also be supported by universal wallets and allow owners in case of digital rights violations to use sniffers looking for owned assets that are used in an unauthorized context.

3.6. Privacy

"Information privacy refers to the ability to control the acquisition and use of an individual's personal information" (Rossi et al. 2019). A key functionality of a universal wallet is the ability to monitor conducted transactions and whom one has given permission to access credentials or other information of your digital asset portfolio. All transactions can be logged. These logs are relevant for later analysis but need to be stored securely. Over time these logs will grow large, particularly when more and more elements in the environment become smart and it becomes necessary to log our interactions with them.

A wallet does not participate in the external events of executing transactions in the applications as smart contracts do. Wallets merely allow the applications necessary access and logging of these transactions. The universal wallet may have internal rule systems taking care of access management, e.g., "does a certain person or service need access to my data and for how long", but it does not participate directly.

4. Discussion and Implications: Universal Wallet Services – Appearance in Society

It is important to consider universal wallets as enablers and the key to seamless interaction with services provided virtually (Antonopoulos and Wood 2019) p. 97: "Wallets are the foundation of any user-facing blockchain application". Not least due to ubiquitous/pervasive computing, smart devices will be everywhere and connected to our systems via our universal wallet.

This will bring the smart home or smart city development to a whole new level (Xu et al. 2020). It will allow for proactive, (semi-)autonomous systems, e.g., where the passport control at the airport is conducted and access is granted even before the passenger landed, as the identity and all credentials have been checked and approved already. All this being achieved through autonomous proactive systems rather than current reactive systems, where a service is only performed on request, and not upfront.

4.1. Change of Existing Services

Amending existing services ought to be one of the first areas to proliferate since building atop of what people and the market already know seems evident (Jokić et al. 2019). One example could be any area where the users' longer-term involvement in the data-sharing process is beneficial, such as ongoing sharing of fitness data, but also general healthcare where the active involvement of the individual person is necessary or charity collection (Farooq et al. 2020).

Another area is lifelong learning and support in specific subjects (Gräther et al. 2018). It will be possible to provide micro- and nano-learning modules fit for specific situations and subjects being organized and accessed via the wallet. An example could be just-in-time-on demand educational services that can guide us, e.g., through the city we are about to visit with augmented reality.

4.2. Making Old Services Redundant

This is a difficult area where development due to competition between incumbent solutions and the new offerings is to be expected. Classical examples are transfer of money to anybody anywhere – done safer, faster, less cumbersome, and far less expensive via crypto wallets than by banks. It should be noted that it is not just banks but generally non-value adding middlemen that are getting redundant by these faster, more service-oriented blockchain-based applications.

One general trend is the development toward micro-services, allowing the configuration of each as a bundle of loosely coupled micro-services. Staying in control of those connected services can increasingly be managed through universal wallets. A number of current micro-services fit well into our discussion of services here, e.g., the UNICEF project in Kazakhstan of providing transparent ways for the public and donors how funds are spent, while increasing internal efficiencies in the process (UNICEF 2020).

5. Conclusion and Future Research

Universal wallets can lift management and use of digital assets and identities into the forefront of modern digital transformation, even broadening the perspective from human use to any automated entity's more or less smart use. The wallet is a key portal for interaction with other systems including other wallets as well as with persons and services either manually between human beings or automatically via a dialogue between machines and their wallets. This leads to research questions around the different manifestations of wallets which asks for a structured research approach toward a wallet taxonomy, wallet affordance, as well as governance-related aspects of wallets.

Universal wallets will enable autonomous services which asks for revisiting the service concept as such. While services are typically co-created and perishable, we do not consider yet services in advance that are proactively and autonomously triggered. Such "services in advance" will be possible via universal wallets. While service research can look back on a body of knowledge from service interactions with technologies such as electronic data interchange, those services have previously been reactive and automatic, but not proactive and autonomous. One key aspect for successful rollouts of any technology however has been its usability and promise to generate value. While autonomous services provided through universal wallets may without any doubt provide value, it might take a while to generate user-friendly interfaces allowing customers to develop an understanding of what is going on, and how it works. Particularly the shift in availability and use of identity data from manual presentation of credentials to automated, always and everywhere are expected to create new services of large societal effects. For example, through universal wallets shared ownership of a car or a piece of art is possible and enforceable, and buying and selling authorization can be given on the go. The societal consequences are expected to be immense even if somewhat unforeseeable.

Blockchain-Based Interorganizational Information Sharing: Creating Triple Value of Trust, Transparency and Cost-Savings

By Olivier Rikken, Marijn Janssen and Zenlin Kwee*

1. Introduction

Blockchain technology has been heralded for its many benefits and transformative nature (Carson, Romanelli, Walsh, & Zhumaev 2018; Ølnes, Ubacht, & Janssen 2017). Being seen just as revolutionary as the Internet (Dai & Vasarhelyi 2017), blockchain has gained a lot of attention from both academia as well as industry. Blockchain technology is considered as being an emergent disruptive technology for many sectors (Kogure, Kamakura, Shima, & Kubo 2017). For instance, Davidson, De Filippi, and Potts (2016) argued that this technology can reshape the way governments are able to interact with citizens, economic operators, and many others. Blockchain applications can provide a wide range of benefits including reduction of cost and process complexity, shared trusted processes, modularized dependencies, accountability and transparency through meliorated tracking of audit trails, data integrity and secured recordkeeping (Chen, Xu, Shi, Zhao, & Zhao 2018; Grover, Kar, & Janssen 2019; Ølnes et al. 2017) . Yet, there is limited evidence for the actual value created in practice (Grover et al. 2019).

In a review of blockchain applications, Casino, Dasaklis, and Patsakis (2019) found that many issues (e.g., suitability, latency and scalability, interoperability, data management) need to be addressed to make blockchain efficient and scalable. The many challenges encountered during the implementation of blockchain technology and the foresight that it still takes three to five years for blockchain to reach "feasibility at scale" (Carson et al. 2018, p2) have resulted in skepticism about the potential value of this technology. Beneficial blockchain characteristics as transparency and immutability can also pose problems. Among the problems, privacy is mentioned as a central concern (Biswas & Gupta 2019), particularly in the context of information storage in a public ledger, such as the issue of transactional privacy (Kosba et al. 2016) that refers to the traceability of transactions. Although users can hide behind a pseudonym, since transactions are transparent, immutable and public, it is still possible to reveal users' identities through mechanisms like datamining, de-anonymization and transaction pattern exposure; hence causing real privacy threats (Feng, He, Zeadally, Khan, & Kumar 2019). Furthermore, the literature argues that only a few commercially viable blockchain applications currently exist (Hughes et al. 2019). Despite such advancements, the application of blockchain in practice remains underexplored (Dai & Vasarhelyi 2017).

In this paper, we investigate two cases of the application of blockchain technology to better understand its value creation mechanisms. We investigate what is viewed as successful in the cases and which technology elements result in the creation of the triple value of trust, transparency and cost-savings. To this end, we focus on information sharing in interorganizational settings. Such interorganizational settings are most suitable for blockchain-based information sharing applications as parties need to share information with each other, but, for various reasons, they cannot. Using blockchain technology, a trusted common infrastructure without the need of a trusted third party can be created to facilitate information sharing in networks. These applications are based on permissioned blockchains controlled by the owners who alone can provide access and assign new nodes to new users or network participants if needed.

2. Cases of Value Creating Blockchain Applications

The scope of our case research is on improving information sharing in situations in which two or more organizations need to share information (i.e., interorganizational information sharing). Two cases were selected from different domains. The two cases in The Netherlands were selected for two main reasons: (1) they deal with creating triple value of trust, transparency and cost-savings and (2) they match the scope of our study by investigating interorganizational information sharing. In analyzing the two cases, we collected and analyzed internal project and publicly available documents, presentations and webinar recordings. Additionally, we conducted unstructured interviews and informal discussions with business owners, innovation leads and technical leads to conduct a retrospective analysis of understanding how the value was created (i.e. to capture the value creation mechanism).

2.1. Case 1: Declaration of Healthcare Hours

Since 2015, Dutch municipalities have partially taken over healthcare responsibilities from the central government, ranging from youth care to long-term care needs for elderly people. Based on a diagnosis of the situation at hand, a budget is allocated to a client by the municipality. Using this budget, the clients who need healthcare can select one or more healthcare providers for fulfilling their needs. Examples of such healthcare providers are maternity care, physiotherapy, or home help. Such healthcare can be provided at home and in other healthcare facilities (e.g., hospitals, care for the disabled).

When providing the actual healthcare, therapists, nurses, and other staff have to fill in a timesheet to determine how much time is spent on a client. The manual hour registration on a paper timesheet may result in three issues. First, paper-based contracts may be subject to different interpretations. For instance, the municipalities may interpret it differently than the care providers. Second, the hour registration in the timesheets may sometimes result in conflicts, e.g., the client and the healthcare providers might have administrated a different number of hours, resulting in disagreement. Also, when the healthcare providers send their invoices directly to the municipality, the number of hours is sometimes not registered correctly or the number of hours might exceed the budget allocated by the municipality. Finally, the family of the client might not agree on the healthcare provided and hence will not approve the hour registration.

A blockchain-based solution was designed based on smart contracts to tackle the above situation. The operational performance arrangements of the healthcare agreements are stored in the ledger and smart contracts. The smart contracts define the different states of the timesheets and govern the registration and approval processes of the timesheet by healthcare providers and clients. The budget is allocated to a client in a municipality by providing *tokens*. The client can subsequently spend the tokens. When the tokens are fully spent, it means the client has utilized his or her maximum healthcare budget. The timesheet is stored in the distributed ledger enabling information sharing among clients, healthcare providers, and the municipality. More specifically, after the healthcare provider enters the hours, the client and the municipality have to approve the hours before the hours can be registered in the system. If needed, the family of the client can be authorized to check and approve the hours on behalf of the client. If the client rejects the hours, the invoice will be rejected. If the client is non-responsive, the healthcare provider can approve the hour declaration after a certain amount of time, based on a four-eye principle in which at least two persons approve the hours. All in all, this solution allows for crosschecking if the healthcare is actually provided and for overseeing if the maximum hours of healthcare that are budgeted will not be overspent should there be no further agreement on increasing the number of budgeted hours.

Apart from ensuring transparency and trust in the data sharing, this blockchain-based application had an immense impact on the efficiency of the administrative processes. According to one interviewee, a reduction of more than 40 % in administration time and cost is achieved through a blockchain-based information sharing application. Consequently, these time and cost savings can be allocated for the provision of healthcare more effectively. At the time of writing, these reductions in numbers are being validated by comparing the original and redesigned administrative processes.

2.2. Case 2: Debt Insight

There are about 1.4 million people in The Netherlands having debts of which an increasing number are not able to, but are willing to, pay the fines of their outstanding debts (Derks et al. 2019). Indiscriminately collecting these payments and providing additional fines due to delayed payment often exacerbate their situation. In addressing the debt problem, the government strives for a proper balance between the interests of debtors and creditors. For this, the Central Judicial Collection Agency (Centraal Justieel Incasso Bureau in Dutch, CJIB) has developed the Debt Alert algorithm. Data about the propensity of debtors to pay are already mostly available within the government, in particular, by municipalities who provide debt assistance. If this information would be available for the CJIB, they could have been aware that the citizen is not able to pay the total amount in the first six weeks (the Dutch legal term for a fine). However, such data is not allowed to be shared due to the European Union General Data Protection Regulation (GDPR). The GDPR does not allow for the sharing of personal information (European Parliament and European Council 2016). At the same time, debtors are reluctant to share all their detailed information, as they are concerned that this information will be misused for other purposes (note that this is not allowed by the GDPR either).

With the idea of empowering citizens to control access to their own personal data a general digital data safe was developed. This digital data safe is based on a blockchain *Self-Sovereign Identity* (SSI) solution and *Zero Knowledge Proof* (ZKP). The application provides the citizens with the possibility to decide for themselves which organization can see which part of their personal data. In this case, particularly regarding debts insight, a Dutch municipality declares, through a verified credential, that a certain citizen receives debt assistance and releases this declaration to the citizen, but the general concept is easily transferable to other credentials, industries and countries. This verified claim can then be stored in the wallet of the citizen. With the help of a social worker, the citizen decides whether the debt agency is allowed to see this credential by providing authorization to this data using the wallet. The scheme then allows the CJIB to query this information without having access to unnecessary or less relevant private financial information from citizens. The debt agency only needs to know the propensity of a client to pay the fine. Above all, the citizen can revoke this access at will. Using these mechanisms, the approach ensures compliance with the GDPR.

In sum, the digital data safe application ensures that the outcomes provided by the application can be trusted and followed. By using this blockchain-based application, a verifier can check if the verified claim is valid and not revoked, and thus the debt agency knows which citizens are actually not able to pay the fine. For citizens who are unwilling but are able to pay the fine, the debt agency can continue collecting the money without being worried about the citizens' inability to pay the fine. Using information sharing enabled by the blockchain digital safe, transparency is created. The system helps to avoid the creation of more debt for people who are willing to pay but cannot. Simultaneously, through the use of SSI, the privacy of the citizen is guaranteed. The data sharing also helps to reduce the administration cost and to save cost.

As shown in Table 4 (*Tab. 4*), in both cases, the rationale behind the development of blockchain-based information sharing applications originates from the idea of re-using data that is already available but could not be shared for various reasons. The key target is to ensure data integrity through data sharing needed to overcome the underlying problems. In both cases, no single entity had complete control of the data, and there was a lack of trust, while in the second case there were also privacy issues.

Although both cases are similar in some aspects, they show different types of solutions to tackle the problem of re-using data and ensuring data integrity. This suggests that the value creation mechanism can vary per situation.

3. Conceptualizing Value Creation Factors

From the two case studies, as shown in *Fig. 1*, we draw an integrated conceptual framework that demonstrates value creation mechanisms leading to value drivers and ultimately the creation of value. The underlying mechanisms resulting in the creation of value required needed both changes in the technology and governance elements. Technology is an enabler for changing the information sharing arrangement and sound governance is needed to guide the blockchain-based arrangement.

The integrated conceptual framework is built upon privacy-by-design principles. First of all, the value creation mechanisms incorporate many aspects. The creation of values is not solely dependent on the blockchain technology, but it is achieved through the combination of various technologies (distributed ledger, encryption, smart contracts, zero-knowledge proof), governance (user consent, data stewardship, service level agreements) and re-engineering of information flow. Figure 1 (Fig. 1) shows that technologies influence only one or two value drivers. There is no direct connection between encryption and privacy, as encrypted personal data can still be personal data and could be reidentified (Laan & Rutjes 2017; EDPS 2019). Also, there is no direct connection between distributed ledger technology and accurate data, as data stored in a distributed ledger is not necessarily accurate in itself.

Case name	Declaration of healthcare hours	Debts insight
Objective	Create a trusted and transparent hours registration system	Gain insights into individuals who might not be able to meet the obligations to pay their fine, but are willing to pay
Existing problem	Scattered information storage resulting in inconsistent information and discussion about which is the right amount of hours.	GDPR does not allow to share personal data among organizations
Technology solution	Distributed ledger network having a smart contract at the heart for approval hours	Blockchain with SSI and zero-knowledge proof
Main mechanisms	Re-using trusted data and ensuring agreement on the accurateness of data	Re-use of information by using privacy-aware information sharing
Value creation	• Efficiency: reduction of administrative costs • Trust in the data by approving spending in advance, less chance of conducting fraud by having multiple parties to agree and not being able to spend more than allowed • Transparency: All parties have the same information position (resulting in less fraud)	• Efficiency: being able to collect more fines • Trust in the outcomes by the debtors by ensuring that only the CJIB will be informed, and the debtors remain in control of their data, instead of the government agencies • Transparency: Providing insights that are under current circumstance unavailable due to privacy constraints

Tab. 4: Overview of the two cases

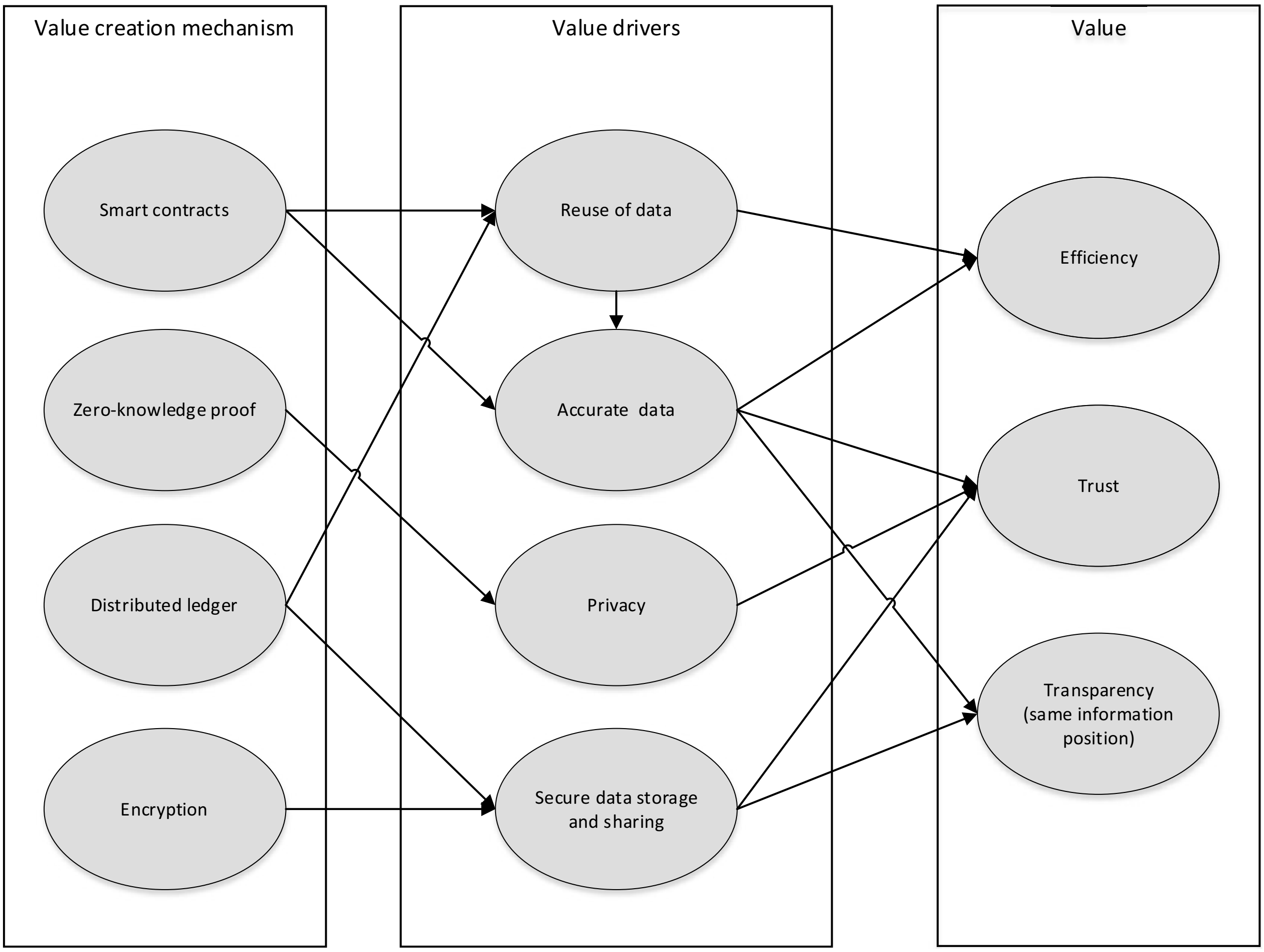


Fig. 1. Integrated conceptual framework for value creation

The distributed ledger ensures only that data cannot be easily altered since it was stored as the result of the immutability (Aste, Tasca, & Di Matteo 2017).

The four value drivers influence the triple value. The reuse of data influences the accuracy of the data (Vetrò et al. 2016). This assumes that the information stored is accurate. Privacy affects trust in the system. Secure storage is needed for creating trust and efficiency. All three values contribute to the adoption of the system by the organizations and users.

The main value originates from ensuring *data integrity* in an interorganizational setting in which organizations would not previously have shared their data if there had not been a trusted third party. The created values in the new situation include efficiency, trust in the data, and transparency. Although privacy can be viewed as a value (Shin & Bianco 2020), in our cases, privacy is primarily a value driver for creating trust in the blockchain-based information-sharing applications. Transparency might influence trust, but might also result in distrust, for example, when hours are found to be incorrect in our first case. As this relationship is discussable, we refrain from making this connection.

The above findings demonstrate situations for which blockchain-based applications are suitable for addressing the issue of interorganizational information sharing, i.e. those situations that have the following three characteristics:

1. *Information is fragmented over multiple organizations*: Information is needed, but pieces of the information are collected and stored by different organizations.
2. *A lack of trust hinders one-to-one information sharing*: Similar information is stored among multiple organizations that result in inconsistency and inaccuracy of the data, e.g., it is unclear which information stored by which organization is accurate.
3. *Privacy legislation does not allow to share information*: Personal data is involved and should not be shared among organizations.

For these types of situations, blockchain can contribute to ensuring integrity in information sharing. The solutions can be characterized by the following characteristics, which are mutually dependent and strengthen each other.

1. *Blockchain enables the re-use of information*. The main driver for using blockchain in the cases is the lack of access to data stored by others, the inability to authenti-

cate the accuracy and origin of data, and the regulations that prevent the simple use of data. In this case, blockchain can create a single source of information.

2. *Creation of accurate information*. By having controls embedded in the technology and smart contracts for ensuring the proper execution, accurate information is created. Data is only added or altered after multiple organizations have confirmed the accuracy of the data.
3. *Ensuring privacy*. Data is shared between participating organizations while complying with the GDPR. Using the zero-knowledge proof mechanism, data is shared based on the need-to-know principle. Only the answers with regard to the ability to pay a fine by the debtors are given, but raw data is not shared.
4. *Secure and immutable storage*. The secure data exchange using encryption and hard-to-mutate nature based on distributed ledger technology reduces the possibility of misuse and manipulation by others.

The major challenge here is determining the information flows, i.e., who is responsible for the source of information and who is involved in updating or changing information. Building on the common best-practice in re-engineering (Hammer 1990), it is important to address the issues of reducing the need for multiple data storage, increasing accuracy and making the source responsible for the data. People become the stewards of their own personal data, but simultaneously multiple organizations have to provide their consent for changing the data. There are also many governance issues (Rikken, Janssen, & Kwee 2019), and consequently, there is a need for making arrangements among members before making implementation decisions. In the two cases organizational and governance changes were needed to benefit from blockchain technology.

4. The Potential of Blockchain

Blockchain-enabled systems will allow organizations to deliver a range of new solutions and service designs that have the potential to redefine the relationship between the information-sharing organizations in terms of transparency, trust, and efficiency, resulting in higher levels of data integrity. Blockchain initially was a technology looking for applications, but this has shifted to a technology suitable for various applications as for example shown in the described use cases. Regarding some shortcomings like privacy and scalability, as mentioned in the literature (Biswas & Gupta 2019), we did not encounter these issues for the realization of these applications in our two cases. In contrast, we found that blockchain technology combined with zero-knowledge proof mechanisms, can ensure privacy.

There are three recommendations that can be derived from the two cases. First, there are three situational characteristics for which blockchain is a suitable solution for information sharing, 1) fragmented information, 2) a lack of trust, and 3) privacy legislation constraints. In sum, blockchain for interorganizational information sharing is suitable when there is no single entity who has complete control of the data and when there is a lack of trust or privacy issues hindering straightforward information sharing. Second, there is a need for process re-engineering and transformation before benefitting from blockchain technology. There might be a need to change the organization before using blockchain technology. Third, blockchain solutions and benefits remain contingent on the context, and different situations demand different solutions. Different technologies might be needed to tackle the problems at hand. The two cases show that blockchain makes complicated interorganizational information sharing straightforward and can result in immense benefits.

On Flash Loans and Decentralized Finance

By Fabian Schär

1. Introduction

Decentralized Finance (DeFi) is on track to disrupt the financial services industry. The emergence of various smart contract-based protocols created a rich ecosystem of interoperable and transparent financial services (Schär 2021). Most of these protocols replicate existing services and are therefore covered by traditional academic literature. However, some concepts are truly innovative and only possible due to the technical characteristics of open smart contract platforms and public Blockchains.

In this short essay, we analyze smart contract-based lending platforms and show how the properties of the Ethereum Blockchain (Buterin 2013; Wood 2015) allow for a novel form of credit: so-called *Flash Loans*. These loans do not require any collateral and work in the absence of an established trust relationship. As such, Flash Loans may be an interesting addition to the financial services industry and can contribute towards creating more efficient and transparent financial markets. In particular, they remove capital constraints for a certain set of applications and may lead to equal opportunities and more efficient capital allocation.

Flash Loans recently gained a lot of traction. On the one hand, their usage for legitimate activities such as arbitrage and portfolio restructuring has increased. On the other hand, Flash Loans have also been employed in a series of attacks on various decentralized third-party financial services protocols. In the remainder of this short essay, we will discuss opportunities, risks, and potential implications for the financial services sector.

2. Lending Protocols

In finance, there are two well-known forms of credit, i.e., secured and unsecured credit.

Secured credit requires that the debtor locks some collateral – usually in the form of an asset they want continue to use or maintain exposure to. Among the most popular subtypes of secured credit are mortgages and Lombard credits. In case the debtor fails to honor the contract and repay the loan, the creditor will be able to claim and sell the collateral. To some extent, this approach mitigates counterparty default risk and allows the debtor to borrow liquid funds while remaining the owner of its assets.

Unsecured credit, as the name suggests, is not secured by any form of collateral. The creditor trusts that the debtor will repay the loan, or, to be more precise: the interest rate is set to compensate for the expected loss. This approach requires that the creditor knows the debtor's identity and can perform due diligence before granting the credit, allowing the creditor to adapt the terms of the loan to the perceived risk and, in case something goes wrong, pursue legal action.

In the pseudonymous world of public blockchains, secured credit is much more popular than unsecured credit. *First*, prior identification requires a lot of paperwork and time, undermines many of the advantages of public Blockchains, and eventually raises the question of why one would use a public Blockchain when there already is an established trust relationship. *Secondly*, in the absence of adequate identification, it would be nearly impossible to take legal action against an unknown debtor who refuses to honor their debt. It is, therefore, rather unsurprising that most of the credits on public Blockchains are overcollateralized. Well known examples of smart contract-based lending platforms that use overcollateralization are Maker, Compound, Aave, and dYdX.

In traditional academic literature, there are numerous research articles studying credit and its implications. In the place of many: Bernanke (1993) provides an overview of secured credit in the macroeconomic context, and Kiyotaki and Moore (1997) propose a model to analyze secured credit in the context of credit cycles.

3. Flash Loans

Flash Loans are loans that do not require any sort of collateral and work in the absence of an established trust relationship. If implemented properly, Flash Loans can be used to borrow large amounts with no requirements for revealing the debtor's identity or providing collateral. On the negative side, Flash Loans are limited to a relatively narrow set of applications, i.e., anything that can be settled atomically and entirely on-chain. To understand how Flash Loans work, we first have to analyze the atomic nature of transactions on the Ethereum smart contract platform.

Atomicity means that something is inseparable. If, for example, two parties strive to exchange assets securely and with no requirement for either one of them to trust the other party, they can perform an atomic swap. Let us assume that Alice currently holds *A* tokens and Bob holds *B* tokens. Let us further assume that they want to exchange these tokens. With an atomic swap, both actions, i.e., Alice's transfer of token *A* and Bob's transfer of token *B*, would be embedded in a single, inseparable transaction, meaning that either both tokens get transferred, or none of them.

This relatively simple concept can be extended to more complex transactions. Despite the increasing complexity, the general idea remains unchanged. Each transaction corresponds to a chain of inseparable actions that will succeed if and only if the overall transaction succeeds. If the transaction fails, any changes due to the individual actions will be reverted, and the database will remain in its original state, i.e., the state before this particular transaction has been executed.[3]

Flash Loans use this atomicity principle and create something that can be best referred to as a *transaction sandwich*. At the beginning of the transaction, the initiator calls a function of a smart contract-based liquidity pool and is able to borrow any amount $x \leq LP_x$, where x is the number of tokens the transaction initiator wants to borrow and LP_x is the liquidity pool's token holdings before the call. At the end of the transaction, there is a mandatory validation step which verifies that $x \cdot (1 + \rho) + \varphi$ of these tokens are returned to the liquidity pool, where $\rho \geq 0$ represents the interest rate (or proportional fee) and $\varphi \geq 0$ corresponds to a flat fee. In between this sandwich of the lending and the validation action, the debtor is free to execute any code of their choice. However, if the transaction does not return the amount due, the validation action throws an error, and any code executed in the transaction sandwich will be ignored. More precisely, any state changes that may have occurred due to the transaction will not be reflected on the Blockchain. It is important to note two things: First, a Flash Loan has no time component. Every step we have described happens at the same time, i.e., within the same transaction. As such, the Blockchain will either reflect all state changes of the transaction or none of them. Second, Flash Loans in this form are only possible due to the special characteristics of the Ethereum Blockchain. In particular, they require an interoperable smart contracts platform and transaction atomicity.

3 Network fees will still be deducted from the person who has initiated the transaction, leading to a state change in this person's holdings.

4. Applications

Flash Loans are limited to the duration of one transaction. At the end of the transaction, the loan has to be repaid. While this property certainly limits the scope and area of applications, Flash Loans can still be used in a variety of ways. Frangella (2020) provides a collection of various use cases. We have slightly adapted and extended his categorization and discuss these applications below.

4.1. Arbitrage

The most prominent use case for Flash Loans is arbitrage. Let us assume that there are two types of tokens: X and Y. Let us further assume that the token pair has a significant price difference on two decentralized exchanges. Consequently, an arbitrageur may be able to profit from this opportunity by buying tokens on the low-price and selling on the high-price exchange. Under normal circumstances, these types of trades require that the trader has equity, collateral, or a trusted relationship to obtain credit. With Flash Loans, anyone is able to borrow any number x (s.t. the pool's liquidity constraint[4]) of X-tokens, sell them on the high price exchange against *Y*-tokens, and use these *Y*-tokens to buy x^* amount of *X*-tokens on the low-price exchange. All of these steps can be conducted within a single Blockchain transaction. The corresponding profit function is shown in the equation below, where ε corresponds to the network fee of the smart contract platform.

$$\Pi = \max(x^* - [x(1+\rho) + \varphi]\ , 0) - \varepsilon \quad (1)$$
$$\text{s.t. } x \le LP_x$$

Note that if the trade resulted in a loss, the transaction would fail, and the containing actions not be executed. In particular, if $x^* < x(1 + \rho) + \varphi$, all actions would be reverted. This limits the transaction initiators' potential losses to the network fee ε. The relationship is visualized in *Fig. 2.*

[4] A novel concept called flash minting may ultimately remove the pool liquidity constraints and allow anyone to create a quasi-unlimited number of tokens, provided these tokens (plus interest) are returned and destroyed within the same transactions. This concept has to be implemented on the token contract itself.

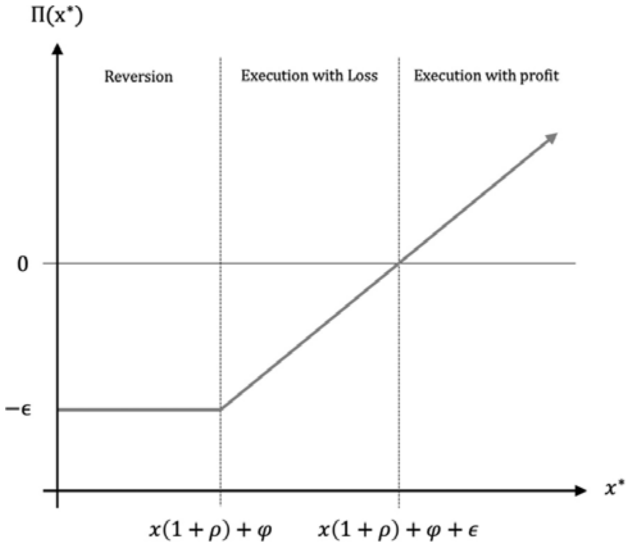


Fig. 2: Flash Loan Payoff Diagram

The low-risk nature, combined with the general availability of funds, make Flash Loans a financial innovation that might be able to remove some frictions and could lead to significantly more price-efficient markets. In addition to the classic arbitrage between two exchanges, there are many other forms of arbitrage opportunities, such as the liquidation of undercollateralized debt positions. As such, Flash Loans create individual incentives for each individual to act on behalf of a more efficient financial system.

4.2. Swaps and DeleverAging

Many investors want to take on leveraged positions. Leverage can be obtained on smart contract-based financial protocols by locking cryptoassets in a liquidity pool and using these assets as collateral to borrow more stablecoins, which can be sold for cryptoassets and locked in the pool to borrow even more assets. This strategy essentially corresponds to a balance sheet extension and may be used to obtain a leveraged position or to farm yield. The extent to which leverage can be obtained with a given collateral depends on the collateralization factor and the number of nesting steps N one is willing to take. The problem with these leveraged positions is that they (a) require multiple steps to set up and dissolve and (b) are at risk of being liquidated, if the owner is unable to react quickly to exogenous shocks, which may shift their position into an undercollateralized state. In fact, if we assume that the person does not have any additional resources, establishing and closing these positions takes $1 + 2N$ steps, respectively. If the person has access to Flash Loans, a position with any N can be established or closed in a single transaction.[5] Similarly, the approach can be used to perform platform or collateral swaps (Wang et al. 2020).

4.3. Price Manipulation and Wash Trading

Like most innovations, Flash Loans can also be employed for illicit activities. In particular, the capital can be used for wash trading and for price manipulation on decentralized exchanges. While the former may severely distort information on volume and create misinformation on the liquidity of a token, the latter is particularly problematic when the price information is being used for the resolution of derivatives. As such, it is rather unsurprising that Flash Loans have been employed in a series of attacks on various Decentralized Finance protocols (Qin et al. 2020). One particular attack was conducted through a transaction that got confirmed on 15. February 2020 01:38:57 +UTC. The attacker used a Flash Loan to borrow 10,000 Ether on the decentralized exchange *dYdX* and employed

[5] S.t. the liquidity pool's liquidity constraint.

these funds in a series of actions, making use of a leveraged short position to perform price manipulation on a decentralized exchange (or more precisely, constant function market maker liquidity pool) and cash out using the distorted price. Auguste (2020) and PeckShield (2020) provide an overview of the transaction and the exploit. It is important to note that this, and in fact all Flash Loan attacks, would have also been possible in the absence of Flash Loans. Flash Loans only provide universal access to capital. As such, a wealthy individual or organization may have used the same attack vector without a Flash Loan. The vulnerabilities in the financial protocols are a result of mistakes in the smart contract code or the somewhat naïve use of price data feeds. Consequently, it is essential for any Decentralized Finance protocol to consider and be aware of these attack vectors. For example, if a protocol is reliant on on-chain prices, it should use prices from the last block or some sort of a median. In particular, it should not rely on price information that can be manipulated in the course of the same transaction that queries the information.

5. Discussion

Flash Loans are an interesting and very promising innovation. In contrast to most other financial protocols that are currently being built as part of Ethereum's Decentralized Finance ecosystem, Flash Loans do not replicate an already existing financial service but rather establish an entirely new concept.

In terms of their applications, Flash Loans are somewhat limited. They are very short term, i.e., they have to be repaid within the same transaction in which they have been issued. Moreover, Flash Loans are limited to the smart contract platform, can only be used for actions involving real-world assets if these assets have been tokenized on-chain and do not work with most Blockchain scaling solutions. However, as financial markets become interoperable and more open, Flash Loans may be a valuable new form of credit that should be accounted for by traditional financial services providers.

When talking about attack vectors, one should be aware that Flash Loans only provide open access to capital. An attack that involves Flash Loans should not be seen as a result of the technology. The vulnerability would be there in any case and could be exploited by wealthy individuals or organizations without the need for a Flash Loan. If anything, Flash Loans may allow detecting vulnerabilities earlier and may therefore contribute to a more robust financial system.

Unfortunately, there is little to no peer-reviewed research on this topic. On the bright side, this leaves the field wide open for researchers who want to analyze Flash Loan-related research questions. Some areas that could be explored include the potential application, empirical analyses on how Flash Loans are employed, how these use-cases have evolved over time, how the existence of Flash Loans changes on-chain governance processes and an analysis of Flash Loans in the context of generic front-running attacks.

References

Airbnb (2020). What is the Airbnb service fee. Available at: https://www.airbnb.com/help/article/1857/what-is-the-airbnb-service-fee (accessed 20 July 2020).

Alkhudary, R., Brusset, X. & Fenies, P. (2020). Blockchain in general management and economics: a systematic literature review. *European Business Review,* 32(4), 765–783.

Alper, T., 2020; A Million South Koreans Now Using Blockchain-powered Driver's Licenses; https://cryptonews.com/news/a-million-south-koreans-now-using-blockchain-powered-driver-7406.htm

Andersen, J. V., & Bogusz, C. I. (2019). Self-organizing in blockchain infrastructures: Generativity through shifting objectives and forking. *Journal of the Association for Information Systems*, *20*(9), 11.

Androulaki, E., Karame, G. O., Roeschlin, M., Scherer, T., & Capkun, S. (2013, April). Evaluating user privacy in bitcoin. In *International Conference on Financial Cryptography and Data Security* (pp. 34–51). Springer, Berlin, Heidelberg.

Anonymous 2020. Universal Wallets – The Gateway to Managing Digital Identifiers and Credentials in a Blockchain Economy; in process

Ante, L., Sandner, P., & Fiedler, I. (2018). Blockchain-based ICOs: Pure hype or the dawn of a new era of startup financing?. *Journal of Risk and Financial Management*, *11*(4), 80.

Antonopoulos, A. M., & Wood, G. (2018). Mastering ethereum: building smart contracts and dapps. *O'reilly Media*.

Aste, T., Tasca, P., & Di Matteo, T. (2017). Blockchain technologies: The foreseeable impact on society and industry. *computer*, *50*(9), 18–28.

Auguste, K. (2020). bZx Hack Full Disclosure (With Detailed Profit Analysis). https://www.palkeo.com/en/projets/ethereum/bzx.html

Babich, V., & Hilary, G. (2018). What operations management researchers should know about blockchain technology. *SSRN Electronic Journal. Available at: http://dx. doi. org/10.2139/ssrn*, *3131250*.

Bakos, J. Y., & Nault, B. R. (1997). Ownership and investment in electronic networks. *Information Systems Research*, *8*(4), 321–341.

Bala, H., & Venkatesh, V. (2007). Assimilation of interorganizational business process standards. *Information systems research*, *18*(3), 340–362.

Basden, J., & Cottrell, M. (2017). How utilities are using blockchain to modernize the grid. *Harvard Business Review*, *23*, 1–8.

Beck, R. (2018). Beyond bitcoin: The rise of blockchain world. *Computer*, *51*(2), 54–58.

Beck, R., Avital, M., Rossi, M., & Thatcher, J. B. (2017). Blockchain technology in business and information systems research.

Beck, R., Müller-Bloch, C., & King, J. L. (2018). Governance in the blockchain economy: A framework and research agenda. *Journal of the Association for Information Systems*, *19*(10), 1.

Bellare, M. and Neven, G, 2007; Identity-Based Multi-Signatures from RSA. https://citeseerx.ist.psu.edu/showciting?doi=10.1.1.207.2329

Bernanke, B. S. (1993). Credit in the Macroeconomy. *Quarterly Review-Federal Reserve Bank of New York*, *18*, 50–50.

Berry, L. L., Davis, S. W., & Wilmet, J. (2015). When the customer is stressed. *Harvard Business Review, 93*(10), 86–94.

Bharathan, V., 2020, "Digital Wallets Are The Killer App For Blockchains" Forbes, May 24, 2020; ttps://www.forbes.com/sites/vipinbharathan/2020/05/24/digital-wallets-are-the-killer-app-for-blockchains/?sh=379367726552. Accessed Dec. 4th. 2020

Bick, S., Spohrer, K., Hoda, R., Scheerer, A., & Heinzl, A. (2017). Coordination challenges in large-scale software development: a case study of planning misalignment in hybrid settings. *IEEE Transactions on Software Engineering*, *44*(10), 932–950.

Biswas, B., & Gupta, R. (2019). Analysis of barriers to implement blockchain in industry and service sectors. *Computers & Industrial Engineering*, *136*, 225–241.

Bloomberg 2020. "Crypto Is Beating Gold as 2020's Top Asset So Far". https://www.bloomberg.com/news/articles/2020-09-22/defi-mania-puts-crypto-ahead-of-gold-as-2020-s-top-asset-so-far . Accessed 2020-09-23.

Blut, M., Heirati, N., & Schoefer, K. (2020). The dark side of customer participation: when customer participation in service co-development leads to role stress. *Journal of Service Research*, *23*(2), 156–173.

Bolici, F., Acciarini, C., Marchegiani, L., & Pirolo, L. (2020). Innovation diffusion in tourism: how information about blockchain is exchanged and characterized on twitter. *The TQM Journal*.

Brown, T. (2008). Design thinking. *Harvard business review*, *86*(6), 84.

Buterin, V. (2013). Ethereum: A Next-Generation Smart Contract and Decentralized Application Platform. http://ethereum.org/ethereum.html

Cardenas, I. S., & Kim, J. H. (2020). Robonomics: The Study of Robot-Human Peer-to-Peer Financial Transactions and Agreements. In *Companion of the 2020 ACM/IEEE International Conference on Human-Robot Interaction* (pp. 8–15).

Carson, B., Romanelli, G., Walsh, P., & Zhumaev, A. (2018). Blockchain beyond the hype: What is the strategic business value. *McKinsey & Company*, 1–13.

Casey, J. & Wong, P. (2017). Global supply chains are about to get better thanks to blockchain. Available at: https://hbr.org/2017/03/global-supply-chains-are-about-to-get-better-thanks-to-blockchain (accessed 10 July 2020).

Casino, F., Dasaklis, T. K., & Patsakis, C. (2019). A systematic literature review of blockchain-based applications: current status, classification and open issues. *Telematics and informatics*, *36*, 55–81.

CB Insights (2020). Banking Is Only the Beginning: 58 Big Industries Blockchain Could Transform. Available at: https://www.cbinsights.com/research/industries-disrupted-blockchain/(accessed 15 August 2020).

Centobelli, P., Cerchione, R., Esposito, E., & Oropallo, E. (2021). Surfing blockchain wave, or drowning? Shaping the future of distributed ledgers and decentralized technologies. *Technological Forecasting and Social Change*, *165*, 120463.

Chang, S. E., Chen, Y., Lu, M., & Luo, H. L. (2020). Development and Evaluation of a Smart Contract-Enabled Blockchain System for Home Care Service Innovation: Mixed Methods Study. *JMIR medical informatics*, *8*(7), e15472.

Chanson, M., Bogner, A., Bilgeri, D., Fleisch, E., & Wortmann, F. (2019). Blockchain for the IoT: privacy-preserving protection of sensor data. *Journal of the Association for Information Systems*, *20*(9), 1274–1309.

Chatterjee, D., & Ravichandran, T. (2013). Governance of interorganizational information systems: a resource dependence perspective. *Information Systems Research*, *24*(2), 261–278.

Chen, W., Xu, Z., Shi, S., Zhao, Y., & Zhao, J. (2018). A survey of blockchain applications in different domains. In *Proceedings of the 2018 International Conference on Blockchain Technology and Application* (pp. 17–21).

Chen, Y. P., & Ko, J. C. (2019). CryptoAR wallet: A blockchain cryptocurrency wallet application that uses augmented reality for on-chain user data display. In *Proceedings of the 21st International Conference on Human-Computer Interaction with Mobile Devices and Services* (pp. 1–5).

Cheney, J., Chong, S., Foster, N., Seltzer, M., & Vansummeren, S. (2009, October). Provenance: a future history. In *Proceedings of the 24th ACM SIGPLAN conference companion on Object oriented programming systems languages and applications* (pp. 957–964).

Cho, B., Ryoo, S. Y., & Kim, K. K. (2017). Interorganizational dependence, information transparency in interorganizational information systems, and supply chain performance. *European Journal of Information Systems*, *26*(2), 185–205.

Choi, T. M., Guo, S., Liu, N., & Shi, X. (2020). Optimal pricing in on-demand-service-platform-operations with hired agents and risk-sensitive customers in the blockchain era. European Journal of Operational Research.

Choudhury, V. (1997). Strategic choices in the development of interorganizational information systems. *Information systems research*, *8*(1), 1–24.

Clohessy, T., Treiblmaier, H., Acton, T., & Rogers, N. (2020). Antecedents of blockchain adoption: An integrative framework. *Strategic Change*, 29(5), 501–515.

Collomb, A., de Filippi, P., & Klara, S. O. K. (2019). Blockchain Technology and Financial Regulation: A Risk-Based Approach to the Regulation of ICOs. *European Journal of Risk Regulation*, 10(2), 263–314.

Constantinides, P., Henfridsson, O., & Parker, G. G. (2018). Platforms and Infrastructures in the Digital Age. *Information Systems Research* (29:2), pp. iii-vi, 253–523.

Croman, K., Decker, C., Eyal, I., Gencer, A. E., Juels, A., Kosba, A., & Song, D. (2016). On scaling decentralized blockchains. *Proceedings of the international conference on financial cryptography and data security* (pp. 106–125). Springer.

Cusumano, M. A. (2014). The bitcoin ecosystem. *Communications of the ACM*, *57*(10), 22–24.

Dai, J., & Vasarhelyi, M. A. (2017). Toward blockchain-based accounting and assurance. *Journal of Information Systems*, 31(3), 5–21.

Dai, X. (2018). Toward a reputation state: The social credit system project of China. *Available at SSRN 3193577*.

Dam, H., Phan, D., Vu, D., & Nguyen, L. (2020). The determinants of customer's intention to use international payment services by applying blockchain. *Uncertain Supply Chain Management*, 8(3), 439–456.

Davidson, S., De Filippi, P., & Potts, J. (2016). Disrupting governance: The new institutional economics of distributed ledger technology. *Available at SSRN 2811995*.

De Keyser, A., Köcher, S., Alkire, L., Verbeeck, C., & Kandampully, J. (2019). Frontline service technology infusion: conceptual archetypes and future research directions. *Journal of Service Management*.

De Keyser, A., Schepers, J., & Konus, U. (2015). Multichannel Customer Segmentation: Does the After-Sales Channel Matter? A Replication and Extension, *International Journal of Marketing*, 32 (4), 453–456.

Delmas, M.A. & Burbano, V.C. (2011). The Drivers of Greenwashing, *California Management Review*, 54 (1), 64–87.

Deloitte. (2017). Using blockchain to drive supply chain transparency. Available at: https://www2.deloitte.com/us/en/pages/operations/articles/blockchain-supply-chain-innovation.html (accessed 20 December 2020)

Derks, H., Faber, T., Erkin, Z., Ersoy, O., Van Megchelen, J., Sanders, S., & Hartog, K. L. (2019). THE FINANCIAL EMERGENCY BRAKE. In CJIB app provides citizens with a GDPRproof way to declare payment inability (pp. 30). Retrieved from https://northsearegion.eu/media/9067/cjib-the-financial-emergency-brake.pdf

Di Angelo, M., & Slazer, G. (2020, May). Wallet contracts on Ethereum. In *2020 IEEE International Conference on Blockchain and Cryptocurrency (ICBC)* (pp. 1–2). IEEE.

Digiconomist (2020). Bitcoin Energy Consumption Index. Available at: https://digiconomist.net/bitcoin-energy-consumption/(accessed 8 September 2020).

Dong, M. C., Fang, Y., & Straub, D. W. (2017). The impact of institutional distance on the joint performance of collaborating firms: The role of adaptive interorganizational systems. *Information Systems Research*, *28*(2), 309–331.

Dozier, P. D., & Montgomery, T. A. (2019). Banking on blockchain: An evaluation of innovation decision making. *IEEE Transactions on Engineering Management*, 67(4), 1129–1141.

Dutta, P., Choi, T. M., Somani, S., & Butala, R. (2020). Blockchain technology in supply chain operations: Applications, challenges and research opportunities. *Transportation Research Part E: Logistics and Transportation Review*, 142, 102067.

EBSI 2020 ; Documentation; Technical Specification (1) – Recommendations wrt DIDs, Verifiable IDs, including eIDAS/LoA; https://ec.europa.eu/cefdigital/wiki/pages/viewpage.action?pageId=262505735. Accessed 27.0.2020

Efanov, D., & Roschin, P. (2018). The all-pervasiveness of the blockchain technology. *Procedia Computer Science*, *123*, 116–121.

Elsden, C., Manohar, A., Briggs, J., Harding, M., Speed, C. & Vines, J. (2018). Making sense of blockchain applications: A typology for HCI. *In Proceedings of the 2018 CHI Conference on Human Factors in Computing Systems* (pp. 1–14).

Erceg, A., Damoska Sekuloska, J., & Kelić, I. (2020, March). Blockchain in the Tourism Industry – A Review of the Situation in Croatia and Macedonia. In *Informatics* (Vol. 7, No. 1, p. 5). Multidisciplinary Digital Publishing Institute.

Esmat, A., de Vos, M., Ghiassi-Farrokhfal, Y., Palensky, P., & Epema, D. (2020). A novel decentralized platform for peer-to-peer energy trading market with blockchain technology. *Applied Energy*, 282, 116123.

Espe, E., Potdar, V., & Chang, E. (2018). Prosumer communities and relationships in smart grids: A literature review, evolution and future directions. *Energies*, 11(10), 2528.

European Data Protection Supervisor (EDPS) (2019). *Introduction to the hash function as a personal data pseudonymisation technique*. Retrieved from https://edps.europa.eu/sites/edp/files/publication/19-10-30_aepd-edps_paper_hash_final_en.pdf

European Parliament and European Council. (2016). Regulation (EU) 2016/679 of the European Parliament and of the Council of 27 April 2016 on the protection of natural persons with regard to the processing of personal data and on the free movement of such data, and repealing Directive 95/46. *Official Journal of the European Union*, 59(1–88), 294.

Faraj, S., Jarvenpaa, S. L., & Majchrzak, A. (2011). Knowledge collaboration in online communities. *Organization science*, *22*(5), 1224–1239.

Farooq, M. S., Khan, M., & Abid, A. (2020). A framework to make charity collection transparent and auditable using blockchain technology. *Computers & Electrical Engineering*, 83, 106588.

Fell, M. J., Schneiders, A., & Shipworth, D. (2019). Consumer demand for blockchain-enabled peer-to-peer electricity trading in the United Kingdom: an online survey experiment. *Energies*, 12(20), 3913.

Feng, Q., He, D., Zeadally, S., Khan, M. K., & Kumar, N. (2019). A survey on privacy protection in blockchain system. *Journal of Network and Computer Applications*, 126, 45–58.

Frangella, Emilio. (2020). Flash Loans, one month in. https://medium.com/aave/flash-loans-one-month-in-73bde954a239

Fukawa, N. (2020). Robots on Blockchain: Emergence of Robotic Service Organizations.

Furrer, O., Kerguignas, J. Y., Delcourt, C., & Gremler, D. D. (2020). Twenty-seven years of service research: a literature review and research agenda. *Journal of Services Marketing*.

Furrer, O., & Sollberger, P. (2007). The dynamics and evolution of the service marketing literature: 1993–2003. *Service Business*, *1*(2), 93–117.

Gatteschi, V., Lamberti, F., Demartini, C., Pranteda, C., & Santamaria, V. (2018). To Blockchain or Not to Blockchain: That Is the Question. *IT Professional*, 20 (2), 62–74.

Gaur, V & Gaiha, A. (2020). Building a transparent supply chain. Harvard Business Review. Available at https://hbr.org/2020/05/building-a-transparent-supply-chain (accessed 20 December 2020).

Geneiatakis, D., Soupionis, Y., Steri, G., Kounelis, I., Neisse, R., & Nai-Fovino, I. (2020). Blockchain Performance Analysis for Supporting Cross-Border E-Government Services. *IEEE Transactions on Engineering Management*.

Goes, P. B. (2013). Commonalities across is silos and intradisciplinary information systems research. *Management Information Systems Quarterly*, 37(2), iii-vii.

Gräther, W., Kolvenbach, S., Ruland, R., Schütte, J., Torres, C., & Wendland, F. (2018). Blockchain for education: lifelong learning passport. *In Proceedings of 1st ERCIM Blockchain Workshop 2018*. European Society for Socially Embedded Technologies (EUSSET).

Grinyaev, S. N., Zlotin, R. A., Milushkin, A. I., Pravikov, D. I., Selionov, I. A., Shcherbakov, A. Y., & Shchuko, Y. N. (2018).

On the Creation of a Universal Protected Trusted Digital Asset (Token). *Automatic Documentation and Mathematical Linguistics*, 52(5), 265–273.

Groupe Renault (2020). The Blockchain, Transformation Vector for the Future of the Automotive Industry. Available at: https://group.renault.com/en/news-on-air/news/the-blockchain-transformation-vector-for-the-future-of-the-automotive-industry/ (accessed 10 August 2020).

Grover, P., Kar, A. K., & Janssen, M. (2019). Diffusion of blockchain technology. *Journal of Enterprise Information Management*, 32(5), 735–775.

Guri, M., (2018). BeatCoin: Leaking Private Keys from Air-Gapped Cryptocurrency Wallets, IEEE International Conference on Internet of Things (iThings) and IEEE Green Computing and Communications (GreenCom) and IEEE Cyber, Physical and Social Computing (CPSCom) and IEEE Smart Data (SmartData); https://ieeexplore.ieee.org/document/8726762

Gürsoy, G., Brannon, C. M., & Gerstein, M. (2020). Using Ethereum blockchain to store and query pharmacogenomics data via smart contracts. *BMC Medical Genomics*, 13, 1–11.

Hammer, M. (1990). Reengineering work: don't automate, obliterate. *Harvard business review*, 68(4), 104–112.

Hinz, O., van der Aalst, W. M., & Weinhardt, C. (2019). Blind spots in business and information systems engineering. (61:2), pp. 133–135.

Hoehle, H., Scornavacca, E., & Huff, S. (2012). Three decades of research on consumer adoption and utilization of electronic banking channels: A literature analysis. *Decision Support Systems*, *54*(1), 122–132.

Holub, A., & O'Connor, J. (2018, May). COINHOARDER: Tracking a ukrainian bitcoin phishing ring DNS style. In *2018 APWG Symposium on Electronic Crime Research (eCrime)* (pp. 1–5). IEEE.

Hua, W., Jiang, J., Sun, H., & Wu, J. (2020). A blockchain based peer-to-peer trading framework integrating energy and carbon markets. *Applied Energy*, 279, 115539.

Huang, M.H. and Rust, R.T. (2018). Artificial intelligence in service. *Journal of Service Research*, Vol. 21 No. 2, pp. 155–172.

Huber, T. L., Fischer, T. A., Dibbern, J., & Hirschheim, R. (2013). A process model of complementarity and substitution of contractual and relational governance in IS outsourcing. *Journal of Management Information Systems*, *30*(3), 81–114.

Huber, T. L., Kude, T., & Dibbern, J. (2017). Governance practices in platform ecosystems: Navigating tensions between cocreated value and governance costs. *Information Systems Research*, *28*(3), 563–584.

Hughes, L., Dwivedi, Y. K., Misra, S. K., Rana, N. P., Raghavan, V., & Akella, V. (2019). Blockchain research, practice and policy: Applications, benefits, limitations, emerging research themes and research agenda. *International Journal of Information Management*, 49, 114–129.

Hyperledger, 2018; (https://www.hyperledger.org/use/hyperledger-indy) presentation http://bit.ly/2JUcIiT. Accessed 11. July 2020

IBM (2020). What makes IBM Food Trust and Blockchain Right for Food Today?. Available at: https://www.ibm.com/blockchain/solutions/food-trust/food-industry-technology (accessed 2 September 2020).

ICOData (2020) Funds raised in 2020. https://www.icodata.io/stats/2020. Accessed 10 June 2020.

Ingold, P. V., & Langer, M. (2021). Resume= Resume? The effects of blockchain, social media, and classical resumes on resume fraud and applicant reactions to resumes. *Computers in Human Behavior*, 114, 106573.

ISO/IEC, 2009; ISO/IEC 27000:2009 (E). Information technology – Security techniques – Information security management systems – Overview and vocabulary. ISO/IEC.

ITIL, 2018; The ITIL v3 definitions for Access Management; https://www.itilnews.com/index.php?pagename=itil_v3_access_management

Jokić, S., Cvetković, A. S., Adamović, S., Ristić, N., & Spalević, P. (2019). Comparative analysis of cryptocurrency wallets vs traditional wallets. *Ekonomika*, *65*(3), 65–75.

Karamchandani, A., Srivastava, S. K., & Srivastava, R. K. (2020). Perception-based model for analyzing the impact of enterprise blockchain adoption on SCM in the Indian service industry. *International Journal of Information Management*, 52, 102019.

Kim, E., & Tang, L. R. (2020). The role of customer behavior in forming perceived value at restaurants: A multidimensional approach. International *Journal of Hospitality Management*, 87, 102511.

Kiyotaki, N., & Moore, J. (1997). Credit cycles. *Journal of political economy*, 105(2), 211–248.

Kizildag, M., Dogru, T., Zhang, T. C., Mody, M. A., Altin, M., Ozturk, A. B., & Ozdemir, O. (2019). Blockchain: A paradigm shift in business practices. *International Journal of Contemporary Hospitality Management*.

Kogure, J., Kamakura, K., Shima, T., & Kubo, T. (2017). Blockchain technology for next generation ICT. *Fujitsu Sci. Tech. J*, 53(5), 56–61.

Kosba, A., Miller, A., Shi, E., Wen, Z., & Papamanthou, C. (2016, May). Hawk: The blockchain model of cryptography and privacy-preserving smart contracts. In *2016 IEEE symposium on security and privacy (SP)* (pp. 839–858). IEEE.

Kotlarsky, J., Oshri, I., Dibbern, J., & Mani, D. (2018). IS Sourcing. *MIS Quarterly Research Curations*, A. A. Bush and Rai, Arun (eds.).

Kraft, T., Valdés, L. & Zheng, Y. (2018). Supply Chain Visibility and Social Responsibility. *Manufacturing & Service Operations Management*, 20 (4), 601–800.

Krishnan, R., Martin, X., & Noorderhaven, N. G. (2006). When does trust matter to alliance performance?. *Academy of Management journal*, *49*(5), 894–917.

Krombholz, K., Judmayer, A., Gusenbauer, M., & Weippl, E. (2016). The other side of the coin: User experiences with bitcoin security and privacy. In *International conference on financial cryptography and data security* (pp. 555–580). Springer, Berlin, Heidelberg.

Kumar, A., Liu, R., & Shan, Z. (2020). Is blockchain a silver bullet for supply chain management? Technical challenges and research opportunities. *Decision Sciences*, *51*(1), 8–37.

Kumar, V., Ramachandran, D., & Kumar, B. (2021). Influence of new-age technologies on marketing: A research agenda. *Journal of Business Research*, *125*, 864–877.

Kunz, W. H., Heinonen, K., & Lemmink, J. G. (2019). Future service technologies: is service research on track with business reality?. *Journal of Services Marketing*.

Laan, V. I., & Rutjes, A. (2017). Privacy-issues bij blockchain:

hoe voorkom of minimaliseer je die?. *Computerrecht 2017, 253*.

Lacity, M. C. (2018). Addressing key challenges to making enterprise blockchain applications a reality. *MIS Quarterly Executive*, *17*(3), 201–222.

Larivière, B., Bowen, D., Andreassen, T.W., Kunz, W., Sirianni, N.J., Voss, C., Wünderlich, N.V. and De Keyser, A. (2017). "Service Encounter 2.0": An investigation into the roles of technology, employees and customers. *Journal of Business Research*, *79*, 238–246.

Ledger Insights, "IBM, R3, Mastercard join open source digital identity consortium -enterprise block-chain" https://www.ledgerinsights.com/trust-over-ip-digital-identity-consortium-ibm-r3-mastercard/ accessed July 12, 2020

Li, Z., Wang, W. M., Liu, G., Liu, L., He, J., & Huang, G. Q. (2018). Toward open manufacturing. *Industrial Management & Data Systems*.

Lian, J. W., Chen, C. T., Shen, L. F., & Chen, H. M. (2020). Understanding user acceptance of blockchain-based smart locker. *The Electronic Library.*

Lim, S. Y., Fotsing, P. T., Almasri, A., Musa, O., Kiah, M. L. M., Ang, T. F., & Ismail, R. (2018). Blockchain technology the identity management and authentication service disruptor: a survey. *Int. J. Adv. Sci. Eng. Inf. Technol*, *8*(4–2), 1735–1745.

Maier, J. R., & Fadel, G. M. (2009). Affordance based design: a relational theory for design. *Research in Engineering Design*, *20*(1), 13–27.

Malhotra, A., Gosain, S., & El Sawy, O. A. (2007). Leveraging standard electronic business interfaces to enable adaptive supply chain partnerships. *Information Systems Research*, *18*(3), 260–279.

Martinez, V., Zhao, M., Blujdea, C., Han, X., Neely, A., & Albores, P. (2019). Blockchain-driven customer order management. *International Journal of Operations & Production Management*, 39 (6/7/8), 993–1022.

Mediterranean Hospital of Cyprus (2020). Mediterranean Hospital of Cyprus is the First Hospital in Cyprus to offer a Blockchain Enabled Medical Data Management Platform. Available at: https://www.medihospital.com.cy/en/news/274-mediterranean-hospital-of-cyprus-is-the-first-hospital-in-cyprus-to-offer-a-blockchain-enabled-medical-data-management-platform (accessed: 1 December 2020)

Meuter, M. L., Ostrom, A. L., Roundtree, R. I., & Bitner, M. J. (2000). Self-service technologies: understanding customer satisfaction with technology-based service encounters. *Journal of marketing*, 64(3), 50–64.

Moniruzzaman, M., Chowdhury, F., & Ferdous, M. S. (2020, February). Examining Usability Issues in Blockchain-Based Cryptocurrency Wallets. In *International Conference on Cyber Security and Computer Science* (pp. 631–643). Springer, Cham.

Montecchi, M., Plangger, K., & Etter, M. (2019). It's real, trust me! Establishing supply chain provenance using blockchain. *Business Horizons*, 62(3), 283–293.

Morkunas, V. J., Paschen, J., & Boon, E. (2019). How blockchain technologies impact your business model. *Business Horizons*, 62(3), 295–306.

Nakamoto, S. (2008), "Bitcoin: a peer-to-peer electronic cash system", available at: www.Bitcoin.org

Nam, S. O. (2018). How Much Are Insurance Consumers Willing to Pay for Blockchain and Smart Contracts? A Contingent Valuation Study. *Sustainability*, 10(11), 4332.

Nikolakis, W., John, L., & Krishnan, H. (2018). How Blockchain Can Shape Sustainable Global Value Chains: An Evidence, Verifiability, and Enforceability (EVE) Framework. *Sustainability*, 10 (1), 3926.

Ølnes, S., Ubacht, J., & Janssen, M. (2017). Blockchain in government: Benefits and implications of distributed ledger technology for information sharing. *Government Information Quarterly*, 34(3), 355–364.

Önder, I., & Treiblmaier, H. (2018). Blockchain and tourism: Three research propositions. *Annals of Tourism Research*, 72(C), 180–182.

Origin Protocol. (2020). Enabling true peer-to-peer commerce. Available at: https://www.originprotocol.com/en/whitepaper (accessed: 3 December 2020)

Osmani, M., El-Haddadeh, R., Hindi, N., Janssen, M., & Weerakkody, V. (2020). Blockchain for next generation services in banking and finance: cost, benefit, risk and opportunity analysis. *Journal of Enterprise Information Management*.

Ostrom, A. L., Parasuraman, A., Bowen, D. E., Patrício, L., & Voss, C. A. (2015). Service research priorities in a rapidly changing context. *Journal of Service Research*, 18(2), 127–159.

Panarello, A. et al. 2018; Blockchain and IoT Integration: A Systematic Survey. Sensors 2018, 18, 2575; doi:10.3390/s18082575

Patel, V. (2019). A framework for secure and decentralized sharing of medical imaging data via blockchain consensus. *Health informatics journal*, 25(4), 1398–1411.

PeckShield (2020). bZx Hack Full Disclosure (With Detailed Profit Analysis). https://medium.com/@peckshield/bzx-hack-full-disclosure-with-detailed-profit-analysis-e6b1fa9b18fc

Pillai, A., Saraswat, V., & Arunkumar, V. R. (2019). Smart Wallets on Blockchain – Attacks and Their Costs. In *International Conference on Smart City and Informatization* (pp. 649–660). Springer, Singapore.

Popov, A. (2020, March 12th). How Industrial Sectors Are Using Blockchain Technology. Forbes. Available at: https://www.forbes.com/sites/forbestechcouncil/2020/03/12/how-industrial-sectors-are-using-blockchain-technology/?sh=5a59a80d2c30

PwC (2020). Fighting Fraud: a never-ending battle. Available at: https://www.pwc.com/gx/en/forensics/gecs-2020/pdf/global-economic-crime-and-fraud-survey-2020.pdf (accessed 15 July 2020).

PwC (2018). Building Block(chain)s For A Better Planet. Available at: https://www.pwc.com/gx/en/sustainability/assets/blockchain-for-a-better-planet.pdf (accessed: 3 December 2020)

Qin, K., Zhou, L., Livshits, B., & Gervais, A. (2020). Attacking the DeFi ecosystem with flash loans for fun and profit. *arXiv preprint arXiv:2003.03810*.

Queiroz, M. M., & Wamba, S. F. (2019). Blockchain adoption challenges in supply chain: An empirical investigation of the main drivers in India and the USA. *International Journal of Information Management*, *46*, 70–82.

Rachinger, M., Rauter, R., Müller, C., Vorraber, W., & Schirgi, E. (2019). Digitalization and its influence on business model innovation. *Journal of Manufacturing Technology Management*.

Rai, A., & Tang, X. (2010). Leveraging IT capabilities and competitive process capabilities for the management of interorganizational relationship portfolios. *Information systems research*, *21*(3), 516–542.

Rangaswamy, A., Moch, N., Felten, C., van Bruggen, G., Wieringa, J.E., & Wirtz, J. (2020). The Role of Marketing in Digital Business Platforms. *Journal of Interactive Marketing*, 51, 72–90.

Rezaeighaleh, H., & Zou, C. C. (2019, December). New secure approach to backup cryptocurrency wallets. In *2019 IEEE Global Communications Conference (GLOBECOM)* (pp. 1–6). IEEE.

Rikken, O., Janssen, M., & Kwee, Z. (2019). Governance challenges of blockchain and decentralized autonomous organizations. *Information Polity*, *24*(4), 397–417.

Risius, M., & Spohrer, K. (2017). A blockchain research framework. *Business & Information Systems Engineering*, 59(6), 385–409.

Rogers, E.M. (1983). Diffusion of innovations. *The Free Press*, New York, NY.

Rossi, M., Mueller-Bloch, C., Thatcher, J. B., & Beck, R. (2019). Blockchain research in information systems: Current trends and an inclusive future research agenda. *Journal of the Association for Information Systems*, 20(9), 14.

Saberi, S., Kouhizadeh, M., Sarkis, J. & Shen, L. (2019). Blockchain technology and its relationship to sustainable supply chain management. *International Journal of Production Research*, 57(7), 2117–2135.

Salikhov, D., Khanda, K., Gusmanov, K., Mazzara, M., & Mavridis, N. (2016). Microservice-based iot for smart buildings. *arXiv preprint arXiv:1610.09480*.

Schär, F. (2021) Decentralized Finance: On Blockchain- and Smart Contract-Based Financial Markets. *Federal Reserve Bank of St. Louis Review*, Early Edition.

Schilke, O., & Cook, K. S. (2015). Sources of alliance partner trustworthiness: Integrating calculative and relational perspectives. *Strategic Management Journal*, *36*(2), 276–297.

Scholte, J. A. (2008). Defining globalisation. *World Economy*, *31*(11), 1471–1502.

Schuetz, S., & Venkatesh, V. (2020). Blockchain, adoption, and financial inclusion in India: Research opportunities. *International Journal of Information Management*, 52, 101936.

Shin, D. (2019). Blockchain: The emerging technology of digital trust. *Telematics and informatics*, *45*, 101278.

Shin, D., & Bianco, W. T. (2020). In Blockchain We Trust: Does Blockchain Itself Generate Trust?. *Social Science Quarterly.*

Shin, D., & Hwang, Y. (2020). The effects of security and traceability of blockchain on digital affordance. *Online information review.*

Sidorova, A., Evangelopoulos, N., Valacich, J. S., & Ramakrishnan, T. (2008). Uncovering the intellectual core of the information systems discipline. *MIS quarterly*, 467–482.

Statista 2020 "Number of Blockchain Wallets 2020" https://www.statista.com/statistics/647374/worldwide-blockchain-wallet-users/, accessed July 12th. 2020

Stewart, K. J., & Gosain, S. (2006). The impact of ideology on effectiveness in open source software development teams. *MIS Quarterly*, 291–314.

Subramanian, H. (2017). Decentralized blockchain-based electronic marketplaces. *Communications of the ACM*, *61*(1), 78–84.

Tapscott, D., & Tapscott, A. (2016). The impact of the blockchain goes beyond financial services. *Harvard Business Review*, *10*(7).

Thong, J. Y., Venkatesh, V., Xu, X., Hong, S. J., & Tam, K. Y. (2011). Consumer acceptance of personal information and communication technology services. *IEEE Transactions on Engineering Management*, *58*(4), 613–625.

Tiwana, A. (2015). Platform desertion by app developers. *Journal of Management Information Systems*, *32*(4), 40–77.

Trabucchi, D., Moretto, A., Buganza, T., & MacCormack, A. (2020). Disrupting the Disruptors or Enhancing Them? How Blockchain Reshapes Two-Sided Platforms. *Journal of Product Innovation Management*, 37(6), 552–574.

Treiblmaier, H., Leung, D., Kwok, A. O., & Tham, A. (2020). Cryptocurrency adoption in travel and tourism-an exploratory study of Asia Pacific travellers. *Current Issues in Tourism*, 1–17.

UNICEF, (2019). Despite significant increase in birth registration, a quarter of the world's children remain 'invisible'. Available at: https://www.unicef.org/press-releases/despite-significant-increase-birth-registration-quarter-worlds-children-remain (accessed 15 July 2020).

UNICEF, 2020; Digicus: blending the old with the new; https://www.unicef.org/innovation/blockchain/digicus. Accessed 28. Sept AD 2020

University of Canterburry (2019). Blockchain Benefits Sustainable Food Production. Available at https://phys.org/news/2019-07-blockchain-benefits-sustainable-food-production.html (accessed 8 September 2020).

Van Doorn, J., Mende, M., Noble, S.M., Hulland, J., Ostrom, A.L., Grewal, D. and Petersen, J.A. (2017). Domo arigato Mr. Roboto: Emergence of automated social presence in organizational frontlines and customers' service experiences. *Journal of service research*, *20*(1), 43–58.

van Hoek, R. (2019). Developing a framework for considering blockchain pilots in the supply chain-lessons from early industry adopters. *Supply Chain Management: An International Journal*.

Vargo, S. L., & Lusch, R. F. (2008). From goods to service (s): Divergences and convergences of logics. *Industrial marketing management*, *37*(3), 254–259.

Venkatesh, V., Morris, M. G., Davis, G. B., & Davis, F. D. (2003). User acceptance of information technology: Toward a unified view. *MIS quarterly*, 425–478.

Venkatesh, V., & Bala, H. (2012). Adoption and impacts of interorganizational business process standards: Role of partnering synergy. *Information systems research*, *23*(4), 1131–1157.

Venkatesh, V., Thong, J. Y., & Xu, X. (2012). Consumer acceptance and use of information technology: extending the unified theory of acceptance and use of technology. *MIS quarterly*, 157–178.

Venkatesh, V., Brown, S. A., & Bala, H. (2013). Bridging the qualitative-quantitative divide: Guidelines for conducting mixed methods research in information systems. *MIS quarterly*, 21–54.

Venkatesh, V., Thong, J. Y., & Xu, X. (2016). Unified theory of acceptance and use of technology: A synthesis and the road ahead. *Journal of the association for Information Systems*, *17*(5), 328–376.

Venkatesh, V., Thong, J. Y., Chan, F. K., Hoehle, H., & Spohrer, K. (2020). How agile software development methods reduce work exhaustion: Insights on role perceptions and organizational skills. *Information Systems Journal*, *30*(4), 733–761.

Verhoeven, P., Sinn, F., & Herden, T. T. (2018). Examples from blockchain implementations in logistics and supply chain management: exploring the mindful use of a new technology. *Logistics*, 2(3), 20.

Vetrò, A., Canova, L., Torchiano, M., Minotas, C. O., Iemma, R., & Morando, F. (2016). Open data quality measurement framework: Definition and application to Open Government Data. *Government Information Quarterly*, *33*(2), 325–337.

Vu, K. (2018). Bext 360 and Coda Coffee Release the World's First Blockchain-Traced Coffee from Bean to Cup. Available at https://www.globenewswire.com/news-release/2018/04/16/1472230/0/en/bext360-and-Coda-Coffee-Release-The-World-s-First-Blockchain-traced-Coffee-from-Bean-to-Cup.html (accessed 7 September 2020).

W3C, 2019; Verifiable Credentials Data Model 1.0. Expressing verifiable information on the Web; https://www.w3.org/TR/vc-data-model/

W3C, 2020 I; Universal Wallet 2020; W3C Editor's Draft 23 October 2020; https://w3c-ccg.github.io/universal-wallet-interop-spec/accessed 29. Nov. 2020

W3C, 2020 II; Decentralized Identifiers (DIDs) v1.0 Working Draft 08 November 2020; https://www.w3.org/TR/did-core/

Walsh, C., O'Reilly, P., Gleasure, R., McAvoy, J., & O'Leary, K. (2020). Understanding manager resistance to blockchain systems. *European Management Journal*.

Wang, D., Wu, S., Lin, Z., Wu, L., Yuan, X., Zhou, Y., Wang, H., Ren, K. (2020). Towards understanding flash loan and its applications in defi ecosystem. *arXiv preprint arXiv:2010.12252*.

Wang, Y., Han, J. H., & Beynon-Davies, P. (2019). Understanding blockchain technology for future supply chains: a systematic literature review and research agenda. *Supply Chain Management: An International Journal*.

Warburg, B. 2017; "Robots with wallets", https://www.youtube.com/watch?v=QCRIcrja-Zs

White, G. R. (2017). Future applications of blockchain in business and management: A Delphi study. *Strategic Change*, 26(5), 439–451.

Williams, R., (2018). Marriott International Elevates Travel Experience For Chinese Consumers With Enhanced Mobile Functionality And Global Wallet-Free Travel; *Leisure & Travel Week*, 2018-05-12, p. 122.

Wirtz, J., Holmqvist, J. & Fritze, M.P. (2020). Luxury Services, *Journal of Service Management*, forthcoming.

Wirtz, J., Patterson, P. G., Kunz, W. H., Gruber, T., Lu, V. N., Paluch, S., & Martins, A. (2018). Brave new world: service robots in the frontline. *Journal of Service Management*.

Wood, Gavin. (2015) Ethereum: A Secure Decentralised Generalised Transaction Ledger. https://ethereum.github.io/yellowpaper/paper.pdf.

Woodside, J. M., Augustine Jr, F. K., & Giberson, W. (2017). Blockchain technology adoption status and strategies. *Journal of International Technology and Information Management*, *26*(2), 65–93.

Xia, Q. I., Sifah, E. B., Asamoah, K. O., Gao, J., Du, X., & Guizani, M. (2017). MeDShare: Trust-less medical data sharing among cloud service providers via blockchain. *IEEE Access*, *5*, 14757–14767.

Xu, B., Huang, D., & Mi, B. (2020). Smart city-based e-commerce security technology with improvement of SET network protocol. *Computer Communications*, *154*, 66–74.

Yang, Z., Zheng, K., Yang, K., & Leung, V. C. (2017, October). A blockchain-based reputation system for data credibility assessment in vehicular networks. In *2017 IEEE 28th annual international symposium on personal, indoor, and mobile radio communications (PIMRC)* (pp. 1–5). IEEE.

Yli-Huumo, J., Ko, D., Choi, S., Park, S., & Smolander, K. (2016). Where is current research on blockchain technology? – a systematic review. *PloS one*, *11*(10), e0163477.

Zeike, S., Choi, K. E., Lindert, L., & Pfaff, H. (2019). Managers' Well-Being in the Digital Era: Is it associated with perceived choice overload and pressure from digitalization? An exploratory study. *International journal of environmental research and public health*, 16(10), 1746.

Zhang, P., White, J., Schmidt, D. C., Lenz, G., & Rosenbloom, S. T. (2018). FHIRChain: applying blockchain to securely and scalably share clinical data. *Computational and Structural Biotechnology Journal*, 16, 267–278.

Zhang, Y. & Li, H. (2010). Innovation Search of New Ventures in a Technology Cluster: The Role of Ties with Service Intermediaries, *Strategic Management Journal*, 31(1), 88–109.

Zheng, Z., Xie, S., Dai, H. N., Chen, W., Chen, X., Weng, J., & Imran, M. (2020). An Overview on Smart Contracts: Challenges, Advances and Platforms, *Future Generation Computer Systems*, 105, 475–491.

Keywords

Blockchain, Disintermediation, Distributed Ledger, Flash Loans, Governance, Privacy, Security, Service Ecosystems, Smart Contracts, Technology Adoption, Transparency, Trust, Universal Wallets, Value Creation