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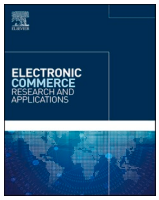

The impact of blockchain on e-commerce: A framework for salient research topics

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ABSTRACT

Blockchain-based technologies are predicted as major disruptors for numerous business applications and processes, which bears huge implications for e-commerce. Given the ability of blockchain and related technologies to create so-called "trustless systems" with idiosyncratic properties, various business models and established processes that have emerged over the years to ensure trust, reliability and enforceability in business-to-consumer (B2C), business-to-business (B2B), business-to-government (B2G) and consumer-to-consumer (C2C) relations need to be questioned and potentially adjusted. Blockchain has the potential to shake the foundation of e-commerce by enabling exchange relations that are trustless and operate without dedicated intermediaries or even central authorities in the case of permissionless blockchains. Furthermore, the exchange of information and value between companies and consumers might change considerably by enabling unified access to immutable data along the entire supply chain. In this paper, a framework and 19 high-level research questions are developed to inspire researchers to closely investigate the potential impact of blockchain on e-commerce. The main categories include (a) technological, (b) legal and (c) organizational and quality issues as well as (d) consumer issues. This paper illustrates how blockchain potentially impacts different elements of e-commerce in these respective areas.

1. Introduction

The concept of blockchain was first described in 2008 by Satoshi Nakamoto, who introduced Bitcoin as a peer-to-peer electronic cash system (Nakamoto, 2008). As Narayanan and Clark (2017) point out, most of the technologies presented in the paper had been developed in the decades preceding the publication, but it was their novel combination that finally led to a solution for the double-spending problem that denotes the multiple spending of the same digital asset (DeSantis et al., 2008). Most noteworthy, already in 1983, David Chaum presented a solution in which so-called blind signatures (i.e., the content of a message is disguised prior to signing it) allow for an untraceable payment system (Chaum, 1983). This system, however, was still dependent on a central authority. In the years following the publication of Bitcoin, the concept of blockchain and related technologies was mainly discussed in dedicated computer science and cryptography communities without having a major impact on society, industry or the economy. To some extent, this resembles the humble beginnings of the Internet, which are rooted in the ARPANET, an early packet switching network based on TCP/IP that was developed at the end of the '60 s and was initially used primarily for communication and resource sharing in academic and military institutions (Oppliger, 1998).

Public awareness of blockchain increased considerably around the year 2015, when not only the exchange value of Bitcoin started to soar, but several books were published that mainly targeted practitioners and clearly outlined the potential economic value of the technology (Swan, 2015; Tapscott and Tapscott, 2016). Soon after that, widely read journals such as *Nature*, *Harvard Business Review* and *MIT Sloan Management Review* started to scrutinize the business value of blockchain (Chapron, 2017; Iansiti and Lakhani, 2017; Tapscott and Tapscott, 2017). At around the same time, the first publications and calls for papers in information systems and business-related journals were published (Beck et al., 2017; Fanning and Centers, 2016), and the focus of attention shifted to the question of how business value can be generated from blockchain technology (Bahga and Madisetti, 2016; Önder and Treiblmaier, 2018). In the meantime, several authors have suggested blockchain-based research agendas for areas such as governance (Beck et al., 2018), supply chain management (Treiblmaier, 2018) and the sharing economy (Hawlitschek et al., 2018) and have developed frameworks that differentiate various levels of analysis (i.e., users and

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society, intermediaries, platforms, firms and industries) (Risius and Spohrer, 2017).

Blockchain was readily embraced by the industry, which led to exaggerated expectations during the hype while the interest in exploring profitable use cases of blockchain has continued unabated. When it comes to supply chain solutions, industry giants with different roles in extensive value networks such as IBM, Maersk, Carrefour and Walmart all explore how blockchain can lead to more transparency, faster processing and the elimination of paperwork in an industry that is plagued by fraud and suffers from substantial inefficiencies (O'Brien, 2019). Amazon recently filed a patent for a blockchain-based authenticator to verify the authenticity of customer goods (Joshi, 2020). Overstock.com founded a subsidiary, Medici Ventures, with the mission to advance blockchain technology (Pollock, 2019). More specifically, their goal is to facilitate peer-to-peer transactions without any major intermediaries. Another example is the envisioned $870 million free trade zone for e-commerce in Dubai named Dubai CommerCity that goes along with Dubai's vision to become the "happiest city on earth" by leveraging blockchain technology for government efficiency, industry creation and international leadership (UAE Government Portal, 2020). According to Research and Markets (2020), the global blockchain market will grow from USD 3.0bn in 2020 to USD 39.7 bn by 2025 at a compound annual growth rate (CAGR) of 67.3%. Across all application areas, they further predict that the retail and e-commerce segment will exhibit the highest growth rates. Fueling this development, the COVID-19 pandemic has led to an increase in cryptocurrency payments during the time of crisis (Chamola et al., 2020).

Recent research indicates that while blockchain will also have a major impact on e-commerce (Subramanian, 2018), it remains underresearched (Liu and Li, 2020). E-commerce can be succinctly defined as "buying, selling and marketing on the Internet" (Targett, 2001, p. 4). A more detailed description can be found in Turban et al. (2004, p. 3): "E-commerce describes the process of buying, selling, transferring or exchanging products, services and/or information via computer networks, including the Internet". Given the ongoing evolution of blockchain applications and their potential implications for commercial organizations and customers alike, pending issues related to e-commerce in several areas need to be addressed. These areas include the potential impact of blockchain, the role of virtual assets, the emergence of new topics and the design and deployment of systems:

- *How can blockchain and related technologies impact e-commerce?*
- *How can virtual assets (*i.e.*, digital representations of value such as cryptocurrencies), as a salient application of blockchain, impact e-commerce?*
- *What are salient research topics that need to be tackled in order to analyze, explain and predict the impact of blockchain and related technologies on e-commerce?*
- *How can e-commerce systems be designed that capitalize on the strengths of blockchain?*

Although the term "blockchain" has received most attention in the media, this analysis considers all systems based on Distributed Ledger Technology (DLT) (Treleaven et al., 2017) since the focus of this paper is on generic features and not on a particular data structure. Accordingly, the term e-commerce also includes related technologies such as m-commerce (mobile commerce) (Clarke III, 2008).

Blockchain promises to enable a transformation from the "Internet of information" to the "Internet of value" (Tapscott and Euchner, 2019) via the transfer of valuable virtual assets as digital information between peers, which can potentially affect many intra- and inter-organizational processes related to e-commerce. Research in this particular area is scarce, but so-called Darknet markets and several scientific publications have already indicated the disruptive potential of "decentralized blockchain-based electronic marketplaces" (Subramanian, 2018), which denotes, in a wide sense, places where buyers and sellers directly interact by electronic means (Wang and Archer, 2007, p. 91).

In this paper, 19 research questions regarding the impact of blockchain on e-commerce are systematically derived by matching key elements of e-commerce with potentially disruptive characteristics of blockchain. This paper starts with a short discussion of the relevant characteristics of e-commerce and blockchain, respectively. Next, technological, legal and organizational and quality issues as well as consumer issues are discussed, and research questions are derived that are intended to serve as starting points for further studies. Finally, all questions are summarized into a comprehensive research framework, and the potential implications for academia and the industry are discussed, followed by several limitations and a brief outlook on future research.

2. E-Commerce and blockchain

It took the Internet several decades to transform from a network that was primarily used for communication purposes at and between military and educational institutions into a technological platform that was able to host and realize commercial applications (Mueller, 2002). However, after the introduction of the World Wide Web (Berners-Lee et al., 1994), it took only a few more years before commercial websites were soaring (Mukhopadhyay et al., 2008; Tian and Stewart, 2006) and e-commerce became a worldwide business model, with retail e-commerce sales amounting to 4.89tn US dollars in 2021 with an expected growth of up to 6.39tn US dollars by 2024 (Statista, 2021b), which has been amplified by the global COVID-19 outbreak as indicated by early research (Hasanat et al., 2020). In comparison, the total market capitalization of cryptocurrencies amounted to 566.26bn US dollars in 2017, 128.78bn US dollars in 2018, 237.1bn US dollars in 2019 and 758.06bn US dollars in 2020 (Statista, 2021a), showing a strong decline after the 2017 hype, but also a rapid recovery and growth afterwards. Payments with cryptocurrencies only have a 2% share of digital payment transactions, but are growing in importance (Markham, 2019).

The following sections briefly describe the advent of e-commerce and highlight several important research topics that have emerged. Next, relevant developments in the area of blockchain are summarized that even surpass the speed of the e-commerce era with respect to expectations and, to an extent, also market adoption. The focus of the discussion lies particularly on those characteristics of blockchain that have the potential to significantly impact e-commerce.

2.1. E-Commerce characteristics

Various review papers exist that systematically classify and structure the existing e-commerce literature. One of the earliest e-commerce review papers authored by Ngai and Wat (2002) structures the domain into different areas: (a) applications (e.g., inter-organizational systems, payment systems, marketing), (b) technological issues (e.g., security, network technology, support systems) and (c) support and implementation (e.g., public policy, corporate strategy). Subsequent e-commerce review papers have focused on topics such as trust building for consumer relationships (Papadopoulos et al., 2001), e-commerce in specific geographical regions (Vaithianathan, 2010), online consumer behavior research (Hwang, 2016; Thomas et al., 2019), recommendation systems (SLi and Karahanna, 2015) and reference architectures (Aulkemeier et al., 2016). Besides identifying the major success factors of e-commerce, these frameworks are of interest for both practitioners and academics since they help to identify criteria that might help to promote the widespread adoption of e-commerce and provide guidelines on how to develop successful applications.

Numerous academic papers rigorously investigate the antecedents of successful e-commerce. Kauffman et al. (2010) illustrate how information technologies have changed the face of e-commerce through the creation of business network-based value and conclude that the industry underwent a digital transformation. In their analysis of the intensity of e-

business adoption and its impact on business performance, Wu et al. (2003) develop a model in which firm characteristics such as top management emphasis, organizational learning ability, customer orientation and competitor orientation as well as the competitive environment, measured by customer power and normative pressures, are adoption antecedents and success factors. The actual impact on performance outcomes is moderated by market and technological uncertainty. Roberts and Toleman (2007) extend this model by adding the regulatory environment (i.e., e-government services and e-government compliance processes), the size of the firm and supply chain power, which also includes supplier power, as additional antecedents. Various additional studies are based on theoretical models such as the Technology Acceptance Model (TAM) (perceived usefulness, perceived ease of use) and Unified Theory of Acceptance and Use of Technology (UTAUT) (performance expectancy, effort expectancy, social influence, facilitating conditions) (Pavlou, 2003; Shih-Tse Wang and Pei-Yu Chou, 2014; Wirtz and Göttel, 2016) and differentiate between decision-maker characteristics, innovation characteristics and environmental characteristics (Ching and Ellis, 2004) or include additional consumer-specific variables, such as social influence, trust, perceived risk and satisfaction (Guzzo et al., 2016). Taken together, the existing body of academic literature that has been published over a period of two decades allows for a comprehensive understanding of the factors that contribute to effective and efficient e-commerce practices.

2.2. Blockchain technology characteristics

According to Mougayar (2016, p. 4), blockchain can be defined from three different angles. Technically, it is a database that maintains a distributed ledger that can be inspected openly. Business wise, it is an exchange network for moving transactions, value and assets between peers without the assistance of intermediaries. Seen through a legal lens, it validates transactions, thereby replacing previously trusted entities. Since the focus of this paper is on the specific characteristics of blockchain rather than on a specific algorithm or technology, related technologies that are frequently labeled as DLT or trustless systems are also considered. DLT is an umbrella term that refers to technologies that distribute information in either private or public ledgers across several nodes (Crosby et al., 2016). So-called trustless systems do not fully eliminate the need for trust, but rather they minimize the level of trust needed from any single participant (Wright and De Filippi, 2015). This is done by providing various cooperation incentives for actors that reward the kinds of behavior that benefit the system as a whole (Böhme et al., 2015; Möser and Böhme, 2015). Following widespread practice in the academic literature, the remainder of this paper uses the term "blockchain" as a synonym to encompass this set of related technologies; the reader should be aware, however, that this naming rather follows the typical usage of the term and is not a precise delimitation to other terms. This does not matter so much in the context of this paper, since we focus on well-understood characteristics common to the set of underlying technologies as opposed to any specific manifestation or implementation of these technologies in the constantly evolving socio-technical ecosystem.

Blockchains allow their users to maintain a common database without the need for a trusted central controller or mutual trust, such that any participant may enter or leave the system at any time (Böhme et al., 2015). Algorithms establish the chronological order of time-stamped entries by cryptographically linking individual transaction sets ("blocks") to each other through cryptographic hashes (Chaffey, 2007). Each block is linked to its predecessor via a hash reference, thereby establishing both order and integrity across the chain of blocks. These ideas were first implemented in the decentralized online transaction system named Bitcoin that is based on a particular distributed ledger (Nakamoto, 2008) named blockchain. The Bitcoin blockchain includes a full transaction history, including the allocation of all existing Bitcoins to specific cryptographic identities. Following the example of Bitcoin, various alternative systems were developed in the ensuing years that have expanded the potential applications beyond virtual asset transactions (Zhang and Lee, 2020). For example, by extending both the data structure and algorithms to support the execution of general-purpose code, blockchain systems such as Ethereum allow participants to store not only transaction code, but also general-purpose program code. Such code allows participants to predefine a set of operations to be executed under certain conditions. As this is particularly interesting for the (practical) automation of contractual exchanges, these programs are called smart contracts (Szabo, 1997), and they might have substantial implications for all kinds of e-commerce (Subramanian, 2018).

These systems have no central authority by design, and the participants themselves add new entries to the shared data structure. Newly received entries that have not yet been included in the blockchain are forwarded to other participants and successively propagated through the system. However, the participants cannot simply add unconfirmed entries to their own copies of the blockchain, since they might not necessarily receive them in the same order as other network nodes and single participants may miss some entries. In order to keep all copies of the blockchain consistent, participants therefore need to achieve consensus on the state of the chain through a decentralized majority voting process. This process is especially complex in those blockchains where each participant can generate and use an unlimited number of cryptographic identities (e.g., in Bitcoin). If each of these cryptographic identities were entitled to one vote in the consensus-building process, malicious participants could easily compromise the majority vote and thus the system state by controlling most cryptographic identities. In order to avoid such manipulations, the voting weight of participants is based on other factors that are not arbitrarily scalable, unlike the number of cryptographic identities. Many blockchain systems therefore require participants who add new entries to the blockchain to expend an increasing amount of computing power (proof of work) or to stake value to commit to a vote (proof of stake). Other mechanisms exist, but are less frequently used at the time of writing (Baliga, 2017). Consensus mechanisms have several goals, the most important of which are (a) leadership selection and (b) rate limiting. The first ensures that the system fairly selects a primus inter pares tasked with briefly leading the network toward a new state that is accepted and shared by all (Gramoli, 2020). The second ensures that there is a limit to the rate at which new leaders are selected and consequently the rate at which the state of the blockchain changes. This not only slows down attacks, but also increases fairness between participants that might not be able to devote the same resources (Böhme et al., 2015; Möser et al., 2013; Möser and Böhme, 2015). For example, in the Bitcoin system, the computation of a valid block requires a participant to not only validate the transactions to be included in the block, but also to repeatedly perform simple computational operations. Each new block is slightly modified by trial and error until it meets certain mathematical conditions. As participants only add validated blocks to their copies of the blockchain, the resulting chain represents the consensus of computing power in the system. It is therefore relatively robust against manipulation attempts because the computing power necessary to recalculate parts of the blockchain exponentially increases with each additional block. As an incentive to expend computing power, participants who add valid blocks to such a type of blockchain are rewarded with fresh virtual asset units (e.g., Bitcoin) and fees paid by those whose transactions were added to the blockchain (Nakamoto, 2008).

Blockchains can be classified into public vs. private as well as permissioned vs. permissionless chains. Combinations of these characteristics give rise to three different types of blockchain technology (Beck et al., 2018): (1) in public permissioned chains, all nodes can read transactions, but only authorized nodes can write them; (2) in public permissionless chains, all nodes are able to read, submit and write transactions; and (3) in private permissioned chains, only authorized nodes can read, submit and write transactions (Tsai et al., 2017). These distinctions have significant implications in terms of the design of the

blockchain and the amount of trust required from the individual participants as well as the effort needed to prevent malicious attacks. In case the blockchain is used to support information exchange among companies along a supply chain where the participants know each other, permissioned and private chains that do not depend on energy-intensive consensus mechanisms might often be the preferred choice. In the context of e-commerce, different types of blockchain might apply simultaneously. For example, companies might deploy private and permissioned chains for their supply chains while allowing for payment via Bitcoin that is based on a public and permissionless chain. To incorporate this diversity, the research questions developed in the following sections operate on a rather high level of abstraction to include all different types of blockchain technologies. In case a specific technology is particularly affected, or differently affected, this is noted in the respective discussion and emphasized in the framework.

3. Literature search

To address the pending issues of blockchain in e-commerce as presented above, we conducted a narrative literature review. This approach is mainly used to describe and evaluate published articles without focusing on methodological details, and it fosters exploratory research by enabling the creation of a solid foundation for future investigation. Given the novelty of the subject, we preferred this approach over a systematic literature review (SLR), the latter of which is the method of choice when selection criteria as well as the methods of extraction and synthesis of the data are explicitly defined (Ferrari, 2015). We started our search process in academic databases, such as EBSCOhost Business Source Premier, Scopus and Google Scholar, but did not limit ourselves to academic peer-reviewed articles in the following phases of our research. Most notably, we found that in spite of getting numerous hits when using search terms such as "blockchain," "DLT" or "e-commerce" in full text searches, the number of relevant papers was drastically reduced when we filtered for articles that actually discuss the impact of the former two on the latter. The scope of our research also included the analysis of articles that investigate the topic of blockchain and e-commerce from different angles. We therefore screened the abstracts of all potentially relevant papers and created and selected several categories (Mayring, 2000), which finally led to the framework that we present in this paper. In line with the tenets of qualitative research, the final structure we discuss in the remainder of this paper emerged during the analysis and categorization process.

4. Research framework

Blockchain is a technological stack that impacts e-commerce via technological, legal, organizational and quality issues as well as consumer issues. It opens up new opportunities by offering unprecedented technological possibilities, but at the same time, it necessitates a critical evaluation of current business processes, such as practices that involve sensitive customer data or the design of communication channels along the supply chain. Technological issues relate to the handling of data, privacy and security issues, development, implementation and the design of the underlying system as well as the potential impact of novel technologies, such as the Internet of Things (IoT), big data, cloud computing, artificial intelligence (AI) and machine-to-machine (M2M) communication. Legal issues are related to problems arising from the gathering, storage and analysis of data as well as potential security breaches and compliance requirements that pertain to regulations designated as "know your customer" (KYC) and "anti-money laundering" (AML). Additional issues concern the legal conformity of processes that are automated by the blockchain and of novel business structures, including fully decentralized autonomous organizations (DAOs) in the most extreme case. Blockchain also opens up new opportunities for access to capital markets that still operate in a legal grey area in many countries. While the fundraising side of this phenomenon has garnered most public attention and has led to an unsustainable bubble (Zetzsche et al., 2017), the fundraising aspects are only the first step as the underlying virtual assets sold during the fundraising process were almost always sold with a promise of usability and utility with the projects' internal e-commerce market system. This implies the potential emergence of multiple joint and disjoint virtual-asset-based e-commerce systems.

Organizational and quality issues include information, system and service quality as well as the traceability of data and payments, which relates to problems of data protection and security. Additionally, the structures within organizations might change leading to new business models as well as the need to reconfigure relations between organizations that might potentially impact the complete value network. Finally, consumer issues include the proliferation of cryptocurrencies, the integration of blockchain features into mobile applications, data-related aspects, with a special focus on security and privacy from a customer point of view, and topics that emerge from new opportunities for data use, such as the possibility to better target customers. Such developments imply relationships and customer service, but blockchain may also widen the digital divide. Each of the following sections has the same structure, briefly summarizing several elements of e-commerce followed by a discussion of four to six relevant research questions. Tables are shown that juxtapose important elements of e-commerce and potential blockchain-induced changes.

4.1. Technological issues

The technological characteristics of blockchain are major drivers of innovation (Swan, 2015). However, it is presently unclear how to capitalize best on these properties to create business value as a substantial amount of uncertainty persists in regard to how to approach designing such systems. In the following sections, the extant e-commerce literature on these topics is briefly summarized and considered in the context of the opportunities and perils arising from blockchain. In the following sections, we discuss four important areas of e-commerce, namely, accessibility and traceability, privacy and security, novel technologies and system development and the corresponding blockchain-induced changes. In the following sections, we present each research question, followed by an in-depth discussion.

- Research Question T1: How does blockchain impact accessibility and traceability in e-commerce?

Accessibility and traceability of data and payments have previously been identified as major success factors for e-commerce. Nederstigt et al. (2014, p. 296) point out that "E-commerce is one of the areas in which growing data congestion on the Web impedes data accessibility" and propose a framework that can create a semi-automatic ontology population of product information that can be found in web stores. Traceability is defined by ISO 9001:2000 as the ability to trace the history, application or location of an entity throughout its entire supply chain. In order to achieve traceability of data in general and payments in particular along the whole supply chain, sophisticated models have been proposed (Bechini et al., 2008). E-commerce transactions that are conducted via blockchain store purchase-related data in an ordered and immutable manner, which helps to improve data provenance and traceability—depending on the technical implementation of the blockchain system (Lo et al., 2017). Depending on the underlying virtual asset, the exchange might be denominated in a fiat currency, but settled through virtual assets priced market-to-market (Hardjono, 2020). Alternatively, the parties may agree to settle in virtual currencies or the virtual currency may itself be recognized as a government-sanctioned means of payment in which case it is either central bank-issued digital currency (CBDC) or e-money (i.e., so-called stable coins). In the European Union, electronic payments are regulated by the E-Money directive (European Parliament and Council, 2009). While both CBDC and e-

money can be realized without an underlying blockchain technology, different forms of distributed ledgers are currently being tested to both better understand potential benefits and to get a better understanding of negative side effects (Baker, 2020).

Bahga and Madisetti (2016) and Nakamoto (2008) show how data provenance in combination with the immutability of blockchain can significantly contribute to the overall quality of available data, which in turn leads to better decisions based on that data. Furthermore, this can help to swiftly identify problems in case of food poisoning or to ensure fair remuneration along the supply chain (Bumblauskas et al., 2020; Garaus and Treiblmaier, 2021). Traceability is a central element of all types of blockchain, while accessibility can be restricted depending on the respective blockchain type as discussed above (Zheng et al., 2017).

- Research Question T2: How does blockchain impact privacy and security in e-commerce?

Privacy and security are considered to be key features of e-commerce systems. The level of users' trust in web-based applications depends to a large extent on the security features in place (Aljukhadar et al., 2010). Fraudulent schemes that steal personal and confidential information (e.g., phishing websites) are detrimental to the overall success of e-commerce (Ramesh et al., 2017; Zhang et al., 2014). Alharbi et al. (2013) identify information technology systems, accountable business practices, physical design and networked infrastructure as the major antecedents of customers' perceived privacy and security concerns. A previously suggested solution to surmount privacy issues was privacy seals, but these have only been able to partly solve consumers' privacy issues (Moores and Dhillon, 2003). Transactions conducted on blockchains are, in case no privacy-enhancing technologies are used, available to all participants (L. Peng et al., 2020). In the case of public blockchains, transactions are linked to pseudonymous identities. If e-commerce is to be augmented with smart contracts, new security questions arise that pertain to (a) secure implementation, (b) fair execution, (c) secure exchange with other systems and (d) privacy (Halpin and Piekarska, 2017; Kethineni et al., 2018). Blockchain technology, implemented via consensus mechanisms, chained storage and sophisticated signature and verification systems, enables a multitude of new features. These include security features such as consistency, tamper-resistance, resistance to Distributed Denial of Service (DDoS) and double-spending attacks (R. Zhang et al., 2019) as well as the integration of privacy-preserving protection schemes in cases where sensor data is used (Chanson et al., 2019). However, blockchain technology also introduces novel risks, including, amongst others, miners taking over the infrastructure, loss or theft of private keys, double-spending attacks or flaws in smart contracts (Li et al., 2020).

- Research Question T3: How does the combination of blockchain and novel technologies (e.g., IoT, data analytics, cloud computing, AI, M2M) impact e-commerce?

Several authors have highlighted the potential of incorporating novel ways of gathering and analyzing data into e-commerce applications, such as the integration of the Internet of Things (IoT), big data analytics, cloud computing, artificial intelligence (AI) and machine-to-machine (M2M) communication (Piotrowicz and Cuthbertson, 2014; Salah et al., 2019; Yu et al., 2017). In this context, IoT refers to the emerging network of physical objects (i.e., "things") that are embedded with networked sensors and components for the purpose of connecting and interfacing with other devices and systems (Khan and Salah, 2018). Related to the accompanying increase in available data, big data analytics is tasked with extracting value from increasing amounts of data (Russom, 2011). Finally, cloud computing denotes the on-demand availability of computer resources without active management by the user (Velte et al., 2009).

Peng et al. (2016) show how online robots that use an intention recognition model can be used to enhance e-commerce customer service, while Shang et al. (2012) illustrate how a three-layered (perception, network, service layer) IoT infrastructure can be applied to share relevant information. The combination of blockchain with innovative technologies has led to widespread speculation about novel use cases, ranging from combining the IoT with smart contracts in the insurance industry to enabling payments without cumbersome administrative processes (Underwood, 2016). In the field of healthcare, specifically when it comes to the analysis of radiological images and CT scans, Peterson et al. (2016) note that blockchain technology can generate mechanisms to compensate AI service providers for the development and execution of novel machine learning algorithms. Despite the huge potential that is recognized in this area, rigorous research on its implications for e-commerce remains scarce.

- Research Question T4: How can e-commerce systems be developed and designed to capitalize on the technical characteristics of blockchain?

Specific guidelines have been published on how to develop and implement functional e-commerce architectures and system designs (Qin et al., 2009). For example, Peterson et al. (2016) develop a B2C implementation framework that follows the traditional phases of systems planning and selection, systems analysis, systems design and systems implementation and operation, and they also specify various subphases. Eliciting and modeling requirements for e-commerce solutions has been a major challenge for system engineers and developers. Hsia et al. (2008) present a goal-driven methodology for identifying B2C application requirements that identifies core services, develops a use case model, evaluates the goals and integrates alternatives and trade-offs. Asher (2007) examines four electronic data interchange projects and develops a B2B e-commerce framework that provides guidelines for the type of partnership to be pursued. However, with the growing adoption of both general-purpose and specialized blockchains, it will become increasingly challenging for e-commerce businesses to select appropriate platforms and ensure cross-technological compatibility. As Porru et al (2017) and Sillaber et al. (2020) point out, new use cases require further consideration of the resource requirements for blockchains and new processes and design patterns as well as the development of blockchain-specific implementation frameworks. With the emergence of standardized programmable interfaces for smart contracts (e.g., "ERC" in Ethereum), businesses have to increasingly adopt standardized programmable interfaces and data exchange formats (Norvill et al., 2019).

Design-oriented research must therefore carefully document the purpose of the respective system as well as the features of the underlying blockchain and the rationale for using blockchain instead of a traditional database solution. In other words, the characteristics of blockchain, such as data immutability and shared access, need to be purposefully incorporated into the system design. The resulting applications need to be carefully aligned with a company's overall strategy and business processes, which also includes legal issues that will be discussed in the following section. Table 1 summarizes the respective e-commerce elements and the blockchain-induced changes.

4.2. Legal issues

A predominantly technical development in its early years, blockchain now promises a host of new possibilities that regulators need to fully understand before appropriate changes to legislation can be determined. Similar to the early days of e-commerce, legislation is lagging behind current developments in many countries. This pertains to regulations surrounding the treatment of personal data, investing money via virtual assets, the legal implications of smart contracts and the advent of autonomous organizations (De Filippi and Wright, 2018). Additionally, it is currently unclear how issues regarding compliance

Table 1
Technological issues.

	E-commerce elements	Sources	Blockchain-induced changes	Sources
T1	Data accessibility, data traceability, payment traceability	(Bechini et al., 2008; Nederstigt et al., 2014)	Consistent view on data, immutability, CBDC, e-money	(Bahga and Madisetti, 2016; Baker, 2020; Bumblauskas et al., 2020; European Parliament and Council, 2009; Garaus and Treiblmaier, 2021; Hardjono, 2020; Lo et al., 2017; Nakamoto, 2008; Zheng et al., 2017)
T2	Privacy and security	(Alharbi et al., 2013; Aljukhadar et al., 2010; Moores and Dhillon, 2003; Ramesh et al., 2017; Zhang et al., 2014)	Anonymization, security, privacy-preserving protection, novel risks	(Chanson et al., 2019; Halpin and Piekarska, 2017; Kethineni et al., 2018; Li et al., 2020; Peng et al., 2020; Zhang et al., 2019)
T3	IoT, big data analytics, cloud computing, AI, M2M communication	(Peng et al., 2016; Piotrowicz and Cuthbertson, 2014; Russom, 2011; Shang et al., 2012; Velte et al., 2009; Yu et al., 2017)	Scalability, standardization of programming interfaces, formats and processes, automated payment	(Khan and Salah, 2018; Peterson et al., 2016; Underwood, 2016)
T4	Application development and implementation, system design and architecture	(Asher, 2007; Hsia et al., 2008; Peterson et al., 2016; Qin et al., 2009)	Novel engineering processes, design patterns, implementation frameworks, interfaces, data exchange formats	(Norvill et al., 2019; Porru et al., 2017; Sillaber et al., 2020)

will be regulated in the future (Houben and Snyers, 2018; Lai, 2018). According to our review, five major legal topics can be affected by blockchain: data-related issues, compliance, organizational processes and structures, capital market access and the design of legally compliant blockchain-based e-commerce systems.

- Research Question L1: How does blockchain impact the handling of sensitive data in e-commerce?

The fulfillment of data requirements has been discussed ever since the beginning of e-commerce. For example, previous research has investigated the impact of artificial intelligence on the informational requirements of the legal directives for distance selling and e-commerce (Lievonen, 2017). A major concern for consumers and legislators alike is the protection of sensitive data and consequently customer privacy (Desai et al., 2003). In the context of e-commerce, legislation in most countries regulates topics such as data collection, use, disclosure, duration of retention, security and information requirements (Azmi, 2002). While the General Data Protection Regulation (GDPR) has established a global standard for the protection of consumer data (Goldberg et al., 2019), different privacy regulations apply to the processing of personal data in blockchains (Finck, 2017). Blockchain systems include data on virtual asset transactions and, in case smart contracts are used for the execution of legal contracts, on contractual agreements. Although the cryptographic identities used by participants of most existing public blockchain systems are pseudonymous, it is possible to identify participants using additional information under certain circumstances (Pesch and Sillaber, 2017). This raises the question of how e-commerce businesses that process blockchain data can ensure compliance with privacy laws such as the GDPR in the European Union. As soon as data has been validated and included in a public blockchain, it is made accessible to the public and can be accessed by anyone. Pivotal features of the GDPR, such as rights to correction and erasure, cannot be easily applied to these new technologies (Porru et al., 2017). Blockchains that store personal data are subject to the GDPR, which causes concern for many e-commerce operators.

Research Topic L2: How does blockchain impact knowledge requirements regarding customers?

Disclosure requirements are not new to e-commerce companies. Trautman (2015) illustrates the navigation of eBay through a complicated maze of regulatory compliance concerns and estimates that PayPal's cost of accounting and legal fees may aggregate in the range of tens-of-millions of dollars per year. As e-commerce businesses might adopt virtual asset payments for settling purchases, performing KYC & AML could become an integral part of the process for many businesses for the first time in certain jurisdictions (Möser et al., 2013). Globally, the Financial Action Task Force (FATF) and, in the EU, the 5th EU Anti-Money Laundering Directive (AML5D) stipulate certain requirements that depend on transaction volume and transaction type. If e-commerce transactions are to be conducted via pseudonymous or completely anonymous blockchain systems, e-commerce businesses that have not yet faced any direct KYC or AML requirements due to their reliance on third party settlement providers could suddenly be confronted with an expansive and expensive regulatory regime (Yan et al., 2011). Furthermore, as customers may create new identities on demand, profiling and account correlation for tracking purposes might become increasingly difficult (although improving customers' privacy). Several blockchain-based systems have been proposed (e.g., Moyano and Ross (2017) and Jevans et al. (2020)) that conduct the core KYC only once for customers, regardless of the number of institutions they have business relations with.

- Research Question L3: How does blockchain impact legal issues pertaining to organizational structures and processes?

Unlike conventional e-commerce contracts established through digitally communicated words or actions where human beings have the final word, the term "smart contract" is used to describe algorithmic, self-executing and self-enforcing computer programs that provide interactive capabilities and can be used to automate many types of transactions (Szabo, 1997). While it remains to be seen how well the formation mechanisms of the general principles of contract law can be applied to the new technological framework of smart contracts and in which cases smart contracts can create legally binding rights and obligations to their parties, there is little doubt that barriers exist. E-commerce contracts have not formerly been perceived as a technical boundary resource in the sense that platform ecosystems could foster broader network effects by opening their technical contracting interfaces to third parties. Smart contracts in general, and DAOs in particular, provide new opportunities for e-commerce. Virtual DAOs that are built, for example, on Ethereum's blockchain and function by means of smart contract technology can be used to autonomously transact with other parties (Savelyev, 2017).

- Research Question L4: How does blockchain impact capital market access and formation of new e-commerce markets?

Blockchain also opens hitherto unknown possibilities for gaining capital market access. A so-called Initial Coin Offering (ICO) is a fundraising event in which an issuer offers tokens to participants in return for consideration (Catalini and Gans, 2018). Recently, Security Token Offerings (STOs) and Initial Exchange Offerings (IEOs) are gaining more exposure due to enhanced legal security. Such events are typically announced through online channels such as virtual asset forums and websites. Most issuers will provide access online to a white paper describing the project and key terms of the offering (e.g., economic terms, subscription details, timeline) and present information on the status of the project as well as the key team members involved (Klöhn and Parhofer, 2018). In the subscription process, the participant is generally required to transfer virtual asset to the issuer—typically to one or more designated addresses (an online reference for virtual assets similar to an account number) or online wallets belonging to the issuer. Unsurprisingly, this emerging fundraising mechanism has attracted scammers and gamblers (Zetzsche et al., 2017). However, the observed novelty of these types of fundraising is that the asset is frequently sold with the promise that the offeror will accept it in an emerging e-commerce ecosystem where the virtual asset is the sole accepted means of payment (Venegas, 2017).

- Research Question L5: How can e-commerce systems be designed that consider the legal idiosyncrasies of blockchain?

Hoeren and Stauder (2001) put together a collection of e-commerce regulations, including EU directives as well as US-law and other international treaties. These regulations cover topics such as data protection, legal protection of software, information provision, aspects of copyright and marketing of financial services. As outlined above, blockchain systems are confronted with a plethora of obvious and not-so-obvious compliance challenges. As e-commerce businesses explore the use of such systems, regulatory costs and challenges will increase accordingly, and businesses might be confronted with the implementation of expensive controls to achieve regulatory compliance, such as for the GDPR (Finck, 2017). Table 2 summarizes the five major legal topics that can be affected by blockchain.

Table 2
Legal issues.

	E-commerce elements	Sources	Blockchain-induced changes	Sources
L1	Data requirements, data gathering, data protection, data security, compliance of cross-border data transfer, privacy	(Azmi, 2002; Desai et al., 2003; Goldberg et al., 2019; Lievonen, 2017)	Immutability vs. data protection mechanisms, compliance with GDPR, anonymity and pseudonymity	(Finck, 2017; Pesch and Sillaber, 2017; Porru et al., 2017)
L2	KYC, AML	(Trautman, 2015; Yan et al., 2011)	New challenges due to difficulty in token provenance; new AML and KYC regimes	(Jevans et al., 2020; Möser et al., 2013; Moyano and Ross, 2017)
L3	Organizational processes and structures		Smart contracts, new regulatory bases and liability issues, DAOs	(Savelyev, 2017; Szabo, 1997)
L4	Capital market access		Regulatory challenges from different securities laws, new forms of raising money (ICOs, STOs, IEOs), new forms of fraud	(Catalini & Gans, 2018; Klöhn and Parhofer, 2018; Venegas, 2017; Zetzsche et al., 2017)
L5	Designing e-commerce-compliant systems	(Hoeren and Stauder, 2001)	Designing blockchain-compliant systems	(Finck, 2017)

4.3. Organizational and quality issues

This section covers organizational topics that are not related to the legal issues discussed in the previous section. This especially pertains to the importance of aligning organizational structures and processes with the new possibilities offered by blockchain (Treiblmaier, 2018). Apart from just generating value from the data (which was identified as a technological topic), the question arises as to how to best design organizations in order to account for data protection, security and quality concerns while simultaneously benefitting from the data and functionalities at hand. These tensions can result in novel and varying business opportunities for companies. Finally, reductions in transaction costs may result in a shift in organizational boundaries, which can affect internal organizational structures as well as relations between organizations. In our review, we identify four major organizational topics: data-related issues, data protection and security, organizational structures and processes and value networks.

- Research Question O1: How does blockchain impact e-commerce-related quality issues (e.g., information, system, service)?

Lin (2007) shows how quality-related success factors of e-commerce systems, such as information quality, system quality and service quality as well as their respective sub-dimensions, can affect relationship quality and subsequently customer commitment and retention. Similarly, Wang (2008) illustrates how those antecedents impact consumer-related attributes such as perceived value, user satisfaction and intention to reuse, which ultimately determine the net benefits that can be gained from e-commerce. Blockchain can potentially help to increase several aspects of data and information quality by making data immutable and showing their provenance along, for example, a supply chain (Kim and Laskowski, 2018). However, this might lead to additional problems pertaining, for example, to the impossibility of modifying or deleting wrong, illegal or outdated data (Neroda, 2019). As a consequence, systems need to be designed that take privacy issues into account, for example, by using a permissioned blockchain or encryption that separates the communication from the data in smart contracts (Xu et al., 2020, 2016) or deliberately conducting relevant transactions outside of blockchains.

- Research Question O2: How does blockchain impact business models of e-commerce companies?

An early study of e-commerce business models differentiates between three different market structures (i.e., portals, market makers, product/service providers) and matches these with business model building blocks (i.e., value streams, revenue streams, logistical streams). The resulting framework identifies various potential revenue streams that include, amongst others, reduced transaction costs, online communities, advertising, variable pricing strategies and disintermediation (Mahadevan, 2000). Introducing e-commerce initiatives necessitates the change of business processes that can either be carried out by simple automation or by a thorough redesign (Seethamraju, 2006). A practical application of Web business process refactoring can be found in Distante et al. (2014) that illustrates how the usability of a website can be increased by systematically analyzing and improving e-commerce related processes, such as payment data input and verification, search functions or checkout processes. Similarly, online advertising can be tailored so as to best meet the requirements of a specific business model's strategy (M. Lin et al., 2012). The impact of blockchain on business models is also an emerging field. Nowinski and Kozma (2017) differentiate between internal and external drivers of business model innovation and develop a framework in which they distinguish between

strategic customer-related and market components. Kazan et al. (2015) outlines emerging blockchain-based business models that overlap with "traditional" e-commerce business models. In a seminal article, Szabo (1997) presents the idea of smart contracts as a predefined set of operations to be executed under certain conditions that can help to re-engineer existing processes as well as to design new ones. Such contracts enable decentralized business models and processes that are automatically executed and may help to efficiently settle disputes that may arise between companies as well as in B2C relationships (Waltl et al., 2019). Whether the additional costs when compared to traditional e-commerce systems can be justified by positive attributes remains to be investigated further.

- Research Question O3: How does blockchain impact organizational structures and value networks of e-commerce companies?

The impact of e-commerce on organizational structure, brand architecture and IT structure has been thoroughly investigated by Strebinger and Treiblmaier (2006), who differentiate between external transaction costs incurred by the company, internal transaction costs incurred by the company and transaction costs incurred by the consumer. In their literature review, they illustrate the supposed effect of e-commerce on the respective cost subcategories. Similarly, Treiblmaier and Strebinger (2008) show how e-commerce in combination with integrated IT infrastructure can lead to changes in an organization's overall transaction cost structures. In one of the earlier academic articles on the implications of Bitcoin, Böhme et al. (2015) scrutinize the virtual asset's impact on the economy and governance mechanisms, and they conclude that it can be seen as a social science laboratory that may accommodate a community of experimentation built on its foundations. From a transaction cost perspective, the removal of intermediaries changes a company's boundaries via changes in costs. Within organizations, blockchain technology can lead to new forms of work, with both positive and negative effects. Examples of the former include new types of work enrichment and a higher demand for highly-skilled labor, while high energy consumption (Stoll et al., 2019), increased employee supervision and potential job losses illustrate the latter (Treiblmaier and Umlauff, 2019). An economy based on blockchain is also predicted to lead to a new form of organizational design labeled as a DAO, in which governance rules are specified on blockchain. This has substantial implications on decision rights, accountability and incentive structures (Beck et al., 2018).

- Research Question O4: How can e-commerce systems be designed that consider the organizational impact of blockchain?

Various academic papers provide guidelines on how to best design e-commerce solutions to fit into an organizational structure. As opposed to research topic T4, which covers technological issues, the focus here is more on organizational issues, such as an organization's structure or policies. In a case study in the aerospace industry, for example, Asher (2007) shows how the volume of transactions (i.e., low vs. high) and the complexity of transactions (i.e., simple vs. complex) determine the type of relationship in a B2B e-business partnership. Qin et al. (2009) develop a framework for the design of e-commerce systems that includes users as key stakeholders. An early summary of the impact of design science on e-commerce research and practice can be found in Ball (2001). Table 3 shows the four major organizational topics and lists several postulated blockchain-induced changes that have not been investigated yet.

Table 3
Organizational and quality issues.

	E-commerce elements	Sources	Blockchain-induced changes	Sources
O1	Information quality, system quality, service quality, traceability, data protection, data security	(Lin, 2007; Wang, 2008)	Data immutability, data provenance, data ownership and custody	(Kim and Laskowski, 2018; Neroda, 2019; Xu et al., 2020, 2016)
O2	Effectiveness and efficiency of processes, disintermediation, decentralization, new business models, changes in internal transaction costs	(Distante et al., 2014; Lin et al., 2012; Mahadevan, 2000; Seethamraju, 2006)	Decentralized business models, smart contracts enabling new processes and allowing for the efficient settlement of disputes	(Kazan et al., 2015; Nowinski and Kozma, 2017; Szabo, 1997; Waltl et al., 2019)
O3	Changes in internal and external transaction costs, structures of value networks	(Strebinger and Treiblmaier, 2006; Treiblmaier and Strebinger, 2008)	Removal of intermediaries, new organizational and governance structures, energy consumption, new forms of work	(Beck et al., 2018; Böhme et al., 2015; Stoll et al., 2019; Treiblmaier and Umlauff, 2019)
O4	Design of processes and structures	(Asher, 2007; Ball, 2001; Qin et al., 2009)	Blockchain-oriented design of processes and structures	

4.4. Consumer issues

As recognized in previous research sections, the gathering and use of private data are key issues for e-commerce businesses. The possibility of shared use of data implied by blockchains can potentially benefit not only companies, but also customers. Cryptocurrencies, which launched the blockchain hype, are only infrequently used for online payments, although they promise lower transactions costs. Mobile applications with integrated blockchain wallets such as smartphones have already been introduced that integrate certain blockchain features and hide the complexity of the underlying technology (Biryukov and Tikhomirov, 2019). This might help to increase adoption among consumers who are not used (or unwilling) to take over full control of their private data, which in the case of blockchain goes hand in hand with accepting the risk of total loss that can occur in case private keys are lost or stolen. One example is the hosting of deposits in exchange accounts. Custodial services, albeit partially contradicting the original libertarian blockchain philosophy of self-custody and the removal of intermediaries, might therefore turn out to be an important adoption driver for many end consumers. A key strategy for many companies is to provide high service levels and establish relationships with their customers that are based on trust (Ying et al., 2018). Currently, it is unclear to what extent blockchain may further increase the so-called digital gap or lead to new gaps. Based on the existing literature, we identify six major consumer topics, namely, the proliferation of cryptocurrencies, mobile-based applications as killer applications (i.e., applications that gain such great popularity that they help to boost the underlying technology), data-related issues, targeting of specific customer segments, customer relationships and the digital gap.

- Research Question C1: What factors impact the proliferation of cryptocurrencies and subsequently consumers' payment behavior?

Numerous e-commerce payment systems exist, including invoices, credit cards, PayPal and prepayments, all of which vary in their respective efficiency and transaction costs (Grüschow et al., 2016). Additionally, numerous options for mobile payments exist, many of which have failed (Iman, 2018) or are limited to regional markets (Humbani and Wiese, 2019). In contrast, cryptocurrencies designed as peer-to-peer payment solutions do not depend on traditional intermediaries. Following Metcalfe's law, the value of cryptocurrencies

was predicted to increase proportionally to the square of the number of end users (Alabi, 2017). However, recent history has also shown that most cryptocurrencies are used for speculative purposes rather than for making online payments (Cheung et al., 2015; Stix, 2021). While current levels of acceptance are modest, recent research also indicates that there is substantial interest among retailers to adopt them as an alternative payment method (Jonker, 2019).

As the premier cryptocurrency with the highest market share, Bitcoin suffers from issues of scalability, lack of adoption and transaction costs that are unsuitable for making micropayments (Kasahara and Kawahara, 2019). This situation is mainly caused by the proof-of-work consensus algorithm, which has hitherto protected the decentralized network from malicious attacks, but simultaneously demands a considerable amount of computing power from the miners to ensure a stable network based on game-theoretic incentives. Solutions to existing problems such as alternative consensus mechanisms, different network structures and the lightning network, a payment protocol operating on top of a Bitcoin, have been proposed to increase throughput, but so far this has not resulted in a mass adoption for e-commerce payments. It remains to be seen whether blockchain-based cryptocurrencies will be able to offer advantages to online consumers and subsequently gain widespread adoption.

- Research Question C2: How do mobile blockchain applications alter consumers' buying behavior?

Several mobile applications have long been heralded as so-called killer applications for e-commerce (Clarke III, 2008). Previous research has both identified sample applications (e.g., SMS) and also important success factors such as convenience, ease of use, trust and ubiquity (Xu and Gutiérrez, 2006) that substantially increase mobile commerce. More recent research has identified those success factors that allow companies to survive through an evolutionary process in which business model variations that do not fit the environment are filtered out and successful components are passed on to the next generation of systems. These include content apps that are efficient, have a lock-in design and add complementary monetization mechanisms (Cristofaro, 2020). Blockchain technology has the potential to add several benefits to mobile applications, such as increased transparency for consumers (e.g., in the context of food supply chains), a reduction in security threats and integrated loyalty programs that could lead to increased integration among marketing channels and a consistent user experience. Additionally, it can enable a social shopping experience in which consumers use social networking services to share their buying experiences with peers, thereby capitalizing on the size of their network (Lim et al., 2019; Rejeb et al., 2020). When it comes to mobile applications and users' sovereignty over their own personal data, blockchain is sometimes viewed critically due to the immutability of the data. However, mobile applications are being developed that allow consumers to determine for themselves which data to share with whom and to be rewarded for the sharing (Travizano et al., 2018).

- Research Question C3: How does blockchain impact the collection of consumer-related data?

Traceability of goods is an important factor for organizations, especially in sectors that are time-critical or deal with perishable products. This especially holds true for the food industry, which has used tools such as Radio-Frequency Identification (RFID) to track and trace products along the supply chain (Costa et al., 2013). However, companies have to be careful when they apply personalization measures based on sensitive data since customers have different thresholds of privacy concerns (Treiblmaier and Pollach, 2011). These issues can potentially be aggravated by the introduction of blockchain, especially when GDPR requirements need to be fulfilled (Pesch and Sillaber, 2017). A comprehensive overview of the consequences can be found in Finck (2017), who concludes that the protection of fundamental rights and the promotion of innovation must be reconciled. This is crucial in cases where personally identifiable data is stored and that data is publicly available. The immutability of the data also raises important legal questions as discussed above.

- Research Topic C4: How does blockchain impact segmentation, personalization and customization in e-commerce?

Previous research has shown the effectiveness of personalization and segmentation methods in e-commerce as compared to generic customer acquisition strategies (Ballestar et al., 2018). A summary of recommendation system studies can be found in Li and Karahanna (2015), who identify the relationships and variables that help to identify consumers, deliver recommendations and ultimately produce a positive impact on consumers and markets. These market forces in combination with the extended data analysis and storage capabilities of blockchain have already raised important questions under relevant regulations, such as GDPR (Finck, 2017).

- Research Question C5: How does blockchain impact e-commerce adoption antecedents?

The Internet has been identified as an ideal medium to initiate and maintain customer relationships (Treiblmaier, 2007) although customer service can still be improved, for example, by using automatisms for predicting customers' intentions (Peng et al., 2016). On the negative side, various types of deception exist in e-commerce, which can be differentiated into concealment (withholding negative information), equivocation (providing vague information) and falsification (selling non-existing products) (Xiao and Benbasat, 2011). All these positive and negative aspects of the Internet impact consumers' decisions to adopt e-commerce. The characteristics of blockchain introduce new antecedents of technology adoption (e.g., new forms of transaction processing, security and control, decentralization) and new risk perceptions on the side of the customers (Abramova and Böhme, 2016). For example, as with most traditional transactions, current blockchain platforms rely on digital signatures that are vulnerable to potential attacks by means of quantum computers. While such threats are limited to theory at the moment, research is already investigating long-term approaches to mitigate emerging risks (Gao et al., 2018; Kiktenko et al., 2018).

- Research Question C6: How does blockchain impact the digital gap?

In terms of the digital divide between those who can reap the benefits of IT and those who cannot, Poon and Lau (2006) take an optimistic perspective and argue that it might be e-commerce that is well-suited to help close this gap. However, as Doong and Ho (2012) illustrate, a sophisticated approach is needed to fully understand ICT development across and within countries as well as the possible ramifications. Since blockchain can also be used to increase security and privacy in smart homes, technology leaders will soon begin to apply this technology in their private homes, which might increase the digital gap (Dorri et al., 2017). Hence, consumers will be confronted with different applications, and in many cases they will not even be aware of the underlying technology that applies equally to all types of blockchains. Table 4 lists the six major consumer topics and how they can be affected by blockchain-induced changes.

5. Discussion and implications

E-commerce research has evolved over the course of two decades and therefore has a strong theoretical and practical foundation. Seminal papers have been published in dedicated journals (Electronic Commerce Research and Applications, Journal of Electronic Commerce Research, Electronic Commerce Research, International Journal of Electronic

Table 4
Consumer issues.

	E-commerce elements	Sources	Blockchain-induced changes	Sources
C1	Payment systems	(Cheung et al., 2015; Grüschow et al., 2016; Humbani and Wiese, 2019; Iman, 2018)	Removal of intermediaries, reduction of transaction costs, enabling of micropayments	(Alabi, 2017; Cheung et al., 2015; Jonker, 2019; Kasahara and Kawahara, 2019; Stix, 2021)
C2	Mobile applications	(Clarke III, 2008; Cristofaro, 2020; Xu and Gutiérrez, 2006)	Privacy, loyalty programs, social shopping, incentives for data sharing	(Lim et al., 2019; Rejeb et al., 2020; Travizano et al., 2018)
C3	Data security and privacy, transparency, traceability of data and payments	(Costa et al., 2013; Treiblmaier and Pollach, 2011)	Increased transaction transparency; new privacy issues	(Finck, 2017; Pesch and Sillaber, 2017)
C4	Segmentation, personalization, customization	(Ballestar et al., 2018; Li and Karahanna, 2015)	Custom-purpose blockchains for individual application use cases, new legal problems	(Finck, 2017)
C6	Relationships, customer service, trust	(Peng et al., 2016; Treiblmaier, 2007; Xiao and Benbasat, 2011)	New antecedents of technology adoption, security and privacy, risk perceptions	(Abramova and Böhme, 2016; Gao et al., 2018; Kiktenko et al., 2018)
C6	Digital divide	(Doong and Ho, 2012; Poon and Lau, 2006)	Resource-intensive blockchains vs.. low powered devices; blockchain scalability	(Dorri et al., 2017)

Commerce, Journal of Theoretical & Applied Electronic Commerce Research) as well as a multitude of other business-related journals that emphasize the importance of the domain. In contrast, blockchain is a relatively new phenomenon that has only recently attracted the interest of academics. Nevertheless, triggered by enthusiastic media reports and publications that have highlighted the potentials of the technology (Swan, 2015; Tapscott and Tapscott, 2016), industry has begun to invest huge amounts into exploring and implementing diverse use cases. The technology is still under development, and it is still too early to fully understand the extent to which blockchain will impact the further development of e-commerce. However, given the claimed disruptive potential of the technology in combination with huge expectations from the industry, frameworks are needed that can guide the systematic evaluation of potential implications for both academia and the industry.

Table 5 summarizes the respective research questions and the associated theory types according to Gregor (2006). Explanatory research strives to identify relations, be it causal or others, while predictive research is concerned with making assumptions on future research and design research focuses on developing and deploying systems. While the suggested theory types do not necessarily exclude other approaches, these would be the most logical choices to start with. It is noteworthy, however, that the theory type refers to the suggested methodological approach and should not be interpreted as restricting researchers to theories such as adoption, success or consumer behavior models. It is therefore up to the researcher to select the most appropriate theory based on the context of the specific study.

Table 5
Research Framework.

Area	Research Question	Theory Type
Technology	T1: How does blockchain impact accessibility and traceability in e-commerce?	E, P
	T2: How does blockchain impact privacy and security in e-commerce?	E, P
	T3: How does the combination of blockchain and novel technologies (IoT, data analytics, cloud computing, AI, M2M) impact e-commerce?	E, P
	T4: How can e-commerce systems be developed and designed to capitalize on the technical characteristics of blockchain?	D
Law	L1: How does blockchain impact the handling of sensitive data in e-commerce?	E, P
	L2: How does blockchain impact knowledge requirements regarding customers?	E, P
	L3: How does blockchain impact legal issues pertaining to organizational structures and processes?	E, P
	L4: How does blockchain impact capital market access and the formation of new e-commerce markets?	E, P
	L5: How can e-commerce systems be designed that consider the legal idiosyncrasies of blockchain?	D
Organization	O1: How does blockchain impact e-commerce-related quality issues (e.g., information, system, service)?	E, P
	O2: How does blockchain impact business models of e-commerce companies?	E, P
	O3: How does blockchain impact organizational structures and value networks of e-commerce companies?	E, P
	O4: How can e-commerce systems be designed that consider the organizational impact of blockchain?	D
Consumer	C1: What factors impact the proliferation of cryptocurrencies and subsequently consumers' payment behavior?	E, P
	C2: How do mobile blockchain applications alter consumers' buying behavior?	E, P
	C3: How does blockchain impact the collection of consumer-related data?	E, P
	C4: How does blockchain impact segmentation, personalization, and customization in e-commerce?	E, P
	C5: How does blockchain impact e-commerce adoption antecedents?	E, P
	C6: How does blockchain impact the digital gap?	E, P

Theory Type: E: Explanation; P: Prediction; D: Design.

5.1. Implications for academia

Building on a huge repository of rigorous research, academia has the methodological tools to explore, explain and predict the impact of various blockchain characteristics on different types of e-commerce. The existing literature has already scrutinized e-commerce in many conceptual and empirical studies. Popular theoretical frameworks that have been applied in this context include theories that deal with technology adoption (e.g., TAM, UTAUT, Theory of Reasoned Action (TRA), Theory of Planned Behavior (TPB) and many modifications thereof) as well as information systems success models (DeLone and McLean, 2004). Previous research has also shown the existence of numerous antecedents of e-business adoption and performance gains in companies, and that different factor combinations lead to varying levels of impact across different e-business process domains (Roberts and Toleman, 2007). The frameworks presented in Tables 1–4 of this paper that were summarized into 19 research questions in Table 5 build on previous research to show how blockchain can be investigated as an upcoming technology that has the potential to radically impact e-commerce. These research questions can serve as a starting point for researchers to further investigate this topic. To better understand these effects, new or modified models and theories need to be built and tested that include blockchain as an independent variable or moderating factor. These models should strive to answer important questions pertaining to the analysis, explanation and prediction of artifacts (Gregor, 2006). Additionally, rigorous design

science research (Hevner et al., 2004) is well-suited for developing blockchain solutions that incorporate academic knowledge pertaining to system design, development and implementation. New approaches have already been suggested in the domain of software engineering to account for the specific characteristics of blockchain, but further refinements are needed (Sillaber et al., 2020). Each of the 19 research questions discussed in this paper can therefore inspire further in-depth studies that use academia's methodological repository to either generate new insights on why specific phenomena exist or to design solutions that improve one or more aspects of e-commerce. None of the research questions are limited to a particular methodological approach (quantitative, qualitative, design science) or theoretical background. It is therefore up to individual researchers to decide on how to tackle these questions alone or in combination in accordance with their personal interests and capabilities.

5.2. Implications for managers

Expectations within the industry regarding the disruptive potential of blockchain are high (Notheisen et al., 2017), yet a large amount of ambiguity exists as to how to capitalize best on the potential benefits of this new technology. This uncertainty was not helped by the rise and fall of Bitcoin's and other virtual assets' prices over the course of a few months in 2017 and 2018. Although many of the major virtual currencies are plagued by high volatility, which is caused by factors such as lack of regulatory oversight, scams, lack of institutional capital and herd mentality (Iinuma, 2018) that hampers broader adoption, the underlying technology has established itself as an interesting solution to a specific set of problems (Bahga and Madisetti, 2016), often enabling leapfrogging of established market players and gatekeepers. The framework presented in this paper can therefore also support companies in systematically investigating the potential impact of blockchain on e-commerce. When it comes to the coverage of blockchain technology in the popular media, most articles are overly enthusiastic in seeing blockchain as a forthcoming revolution in many areas of life (Tapscott and Euchner, 2019), but several authors also express their concerns and warn against a "Blockchain hype" (Kaminska, 2018). Considering these diverse and often conflicting arguments, rigorous and objective investigations are needed that critically and objectively assess the impact of blockchain in potential application scenarios. The framework presented in this paper, as shown in Tables 1–5, summarizes the research questions that can motivate in-depth academic research, but can also easily be applied to the critical assessment and evaluation of blockchain in the industry. These topics can also be adapted to scenarios depending on, for example, industry type, the scope of the development project and the impact on the supply chain.

6. Limitations and further research

The findings of this research are limited by the novelty of the domain and a dearth of literature specifically dealing with blockchain and e-commerce. Besides, the ongoing development of blockchain-based technologies and the media attention given to cryptocurrencies in combination with the globally evolving legal situation makes it hard to predict what the technology will actually be capable of delivering in a couple of years and what legal frameworks will be applicable in different countries. The research questions presented in this paper are therefore not bound to a specific blockchain implementation, legal framework or business model. Instead, they are expressed as generally applicable considerations that necessitate further refinement to focus on clearly defined sub-problems of importance in each respective context. In line with the tenets of narrative reviews, our focus was not on the reproducibility of the results, but rather on the identification of novel research areas. Further research therefore needs to consider the dynamics of the domain, which to some extent was also a characteristic of e-commerce, especially in its early years. Additionally, future studies can identify suitable theories that might provide further insights and use empirical data to investigate the topics developed in this paper. Systematic reviews of the literature might help to extend and refine our framework as soon as enough academic literature has been published on the subject. Considering predictions of a major impact by blockchain on society and the economy, an objective and critical evaluation by academic researchers can help to structure the domain and identify those characteristics of blockchain that contribute value to e-commerce success. A solid foundation of academic literature might provide the basis for inductive research with the goal of generating new theory that will enable subsequent deductive research with the goal of testing these theories as well as individual hypotheses.

Within only a couple of years, blockchain has transformed from an obscure technology known only to a handful of dedicated cryptographers and specialized computer scientists into a mainstream topic that attracts billion-dollar investments and interests researchers from a wide variety of academic fields, including computer science, information systems, mathematics (especially game theory), economics, business administration and even sustainability. Since this development has occurred within a relatively short time frame and the technology is still under development, a lot of uncertainty exists regarding the future development of blockchain and related technologies and their potential impact on the economy and society. In contrast, research surrounding e-commerce as a business model has developed over several years, and academic researchers have systematically structured the domain and identified the most crucial success factors. This paper illustrates how an assessment of the potential impact of blockchain on e-commerce can build on previous research and shows how relevant research questions can be derived. It extends previous research frameworks in this area by providing an explicit focus on how to investigate blockchain-related issues in e-commerce. It is suggested that the domain be split up into four areas: (a) technological issues, (b) legal issues, (c) organizational and quality issues and (d) consumer issues. The current literature on e-commerce success was researched in order to identify relevant antecedents for success across these four areas, and these antecedents were considered in the light of the characteristics and proposed impact of blockchain. This process led to the derivation of 19 research questions that can be used for a structured and thorough investigation of the impact of blockchain on e-commerce.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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