BLOCKCHAIN TECHNOLOGY AND APPLICATION POSSIBILITIES IN THE DIGITAL TRANSFORMATION OF TRANSACTION PROCESSES

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ABSTRACT

The term 'blockchain' describes a technical concept, which records data in a predetermined way on the different systems of all associated users in a cryptographic mode. This procedure is a revolutionary technology for business models in different fields. Currently, many enterprises are searching for feasible applications and the implementation of this new technology. In order to take advantage of these applications, it is important to understand the underlying principles and implications. The scientific purpose of this paper is twofold: firstly, to explain selected characteristics of the blockchain principle to understand the advantages for its application in transaction processes; and secondly, to show concrete possibilities for its application related to transaction activities. For this reason, particular areas of transaction-based processes in sales and procurement will be shown and explained. The methodology is analytical and theoretical. Based on statistical data, the expectations and requirements of users will be matched with blockchain characteristics. It can be deduced that the most important requirements pertaining to efficiency and cost reduction as well as security and trust can be fulfilled by using blockchain. The theoretical foundation leads to conceptual considerations of a deductive approach to application possibilities, though the question of research into the possibilities of broadening blockchain technology to encompass transaction-based business activities in general will be answered.

KEY WORDS

Blockchain, business processes, cryptography, digitalisation, procurement, sales management, smart contracts, technology, transformation, trust.

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Introduction

Currently the topic of blockchain is being discussed intensely in IT as well as in business management and is supposed to foster innovation in business operations (Morabito, 2017). With this upcoming technology, new applications and disruptive business models will be enabled (Nofer et al., 2017). The first comprehensive experience is visible in the form of digital currency, using blockchain technology. However, there is a huge range of application possibilities beyond finance and currency (Grand View Research, 2019).

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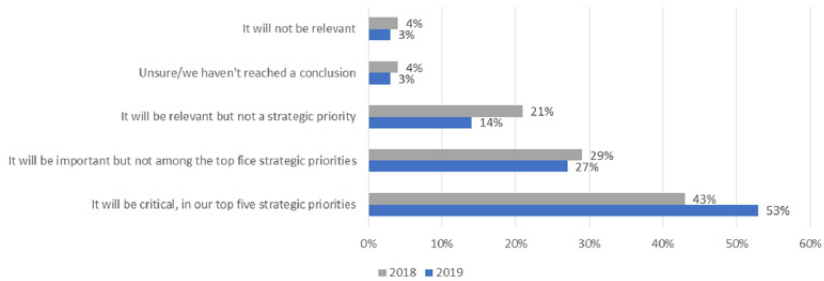
Figure 1 shows the views pertaining to the relevance of blockchain within global enterprises in 2019 versus 2018, where 1386 (2019) and 1053 (2018) companies respectively were surveyed (Deloitte, 2019).

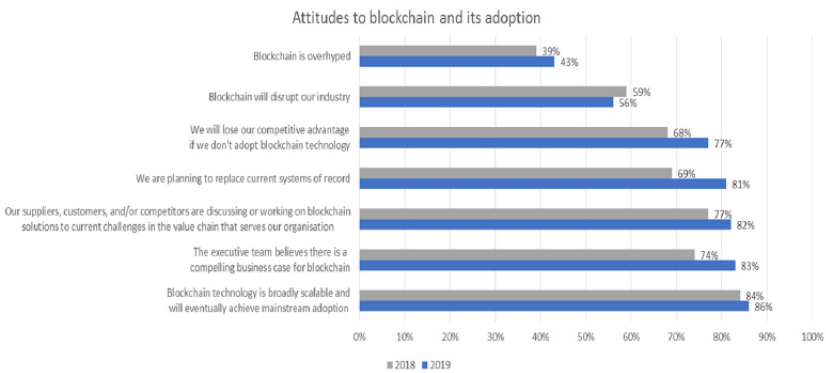
Figure 1. Views on the relevance of blockchain



Source: Deloitte, 2019: 4.

Figure 1 shows the significance of this topic, from which it may be derived that most respondents consider blockchain a top-five strategic priority, with a jump of 10 percentage points in comparison to 2018. This justifies the question of research into broadening the applications of this technology. In Figure 2, the attitudes of global enterprises to blockchain and its adoption are listed from the same survey as in Figure 1.

Figure 2. Attitudes to blockchain and its adoption



Source: Deloitte, 2019: 5.

It can be concluded that there was a significant increase in positive attitudes towards blockchain from 2018 to 2019. This technology, consisting of cryptography and algorithms, forms the basis for the decentralised documentation of transaction processes. The principle of a self-controlling, decentralised data chain provides various opportunities for use, wherever confidence and data transparency are important. An additional centralised institution which verifies that data is no longer necessary.

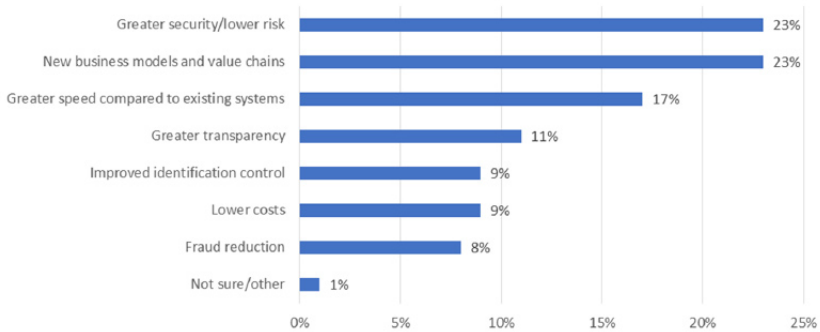
The paper is structured as follows. Section 1 deals with the formulation of the problem and the research question. For the implementation of blockchain in terms of digital transformation, it is important to understand the underlying principles. Therefore, selected issues pertaining to the blockchain principle, which have an impact

on users, are explained in section 2. Subsequently, the discussion of the status quo, about the current situation in Germany, will be outlined in section 3. Concrete examples of application in transaction-based purchase and sales activities will be given in section 4. Finally, conclusions are presented in the last section.

1. Formulation of the problem and research question

The basic problems with new technologies arise when they are applied for the first time. There are restrictions on their application, because only a few specialists know about the possibilities, advantages and disadvantages inherent in application (Dumitrescu, 2018), resulting in a lack of experience and confidence. In addition to that, most business and transaction partners are not yet using the new technology, because the advantages are undetermined. Figure 3 shows the most significant advantages related to blockchain applications. Respondents (N=1386 global enterprises) see lower risk and new business models as key advantages (Deloitte, 2019).

Figure 3. Advantages of blockchain application



Source: Deloitte, 2019: 6.

With regard to the gap between expectation and implementation, the basic research question is about the valuable integration of blockchain applications into management processes. In these processes, all related activities have to be executed in the most effective and efficient way to create competitive advantage and to earn profits (Dhillon et al., 2017). Value can be created by executing these processes better, faster and with lower cost expenditure and risk exposure than competitors do (Carson et al., 2018).

The basic hypothesis of this paper can be formulated to state that the potential benefit of digital transition with respect to blockchain applications has not yet been fully popularised and exploited. The research question at hand is how blockchain applications can be employed in transaction processes in order to take advantage of that potential. As a consequence, the network effect for rapid diffusion among all stakeholders will be set in motion.

The benefit of this paper is the presentation of a conceptual framework of the blockchain concept applied to selected transaction-based processes such as sales and procurement activities. The purpose is to identify and introduce further concrete application possibilities. The argumentation is based on the latest statistical data. This potential should become the purpose of academic discussion as well as evidence for industrial implementation.

2. Literature review

A blockchain is a concept consisting of cryptography and algorithms that enables decentralised data storage and management of stored and transferred data (Abeyratne and Monafared, 2016). The execution is based on clearly defined value-creating activities, which are connected continuously without any interruption. Even if many participants are involved in the blockchain, a consensus can still be reached on the correct condition of the documentation, without involving a centralised institution. This concept is referred to as "distributed ledger technology" (Babich and Hilary, 2018; Bitkom, 2016: 1). The type of data contained in a block is irrelevant to the term 'blockchain'. It is important that succeeding transactions can be built on the basis of the previous ones and validated by proving the link to these previous transactions. This inherent relation makes it infeasible to manipulate or erase the existence or content of previous transactions without destroying or invalidating the subsequent transactions that have confirmed the earlier ones. Other participants in the blockchain network, who are also aware of the later transactions, would recognise the manipulation based on the inconsistency of the calculations and invalidate it (Babich and Hilary, 2018).

2.1. Blockchain components

It is important to understand the composition of each block, in order to understand how the entire blockchain system works. As the name implies, it consists of a sequence of different data blocks, which are connected via a so-called "hash" (Asolo, 2018).

The Hash functions

In simple terms, hashing means to take the input string of any length and to produce an output that always has the same length. In the blockchain, the data to be stored is used as an input and converted by an algorithm into a hash of a certain length. For example, the SHA-256 (Secure Hashing Algorithm 256) is shown (Figure 4).

Figure 4. Blockchain hashes created with a SHA-256 algorithm

INPUT	HASH
Hello	185F8DB32271FE25F561A6FC938B2E264306EC304EDA518007D1764826381969
Hello World	A591A6D40BF420404A011733CFB7B190D62C65BF0BCDA32B57B277D9AD9F146E
hello world	B94D27B9934D3E08A52E52D7DA7DABFAC484EFE37A5380EE9088F7ACE2EFCDE9

Source: Asolo, 2018.

As one can see in Figure 4, no matter which input is given, a different hash with a fixed 256-bit length is generated each time. This is an important factor when dealing with large amounts of data. Instead of capturing the entirety of all input data, which may be of considerable size, it is sufficient to store and track it over the hash value (e.g. Asolo, 2018).

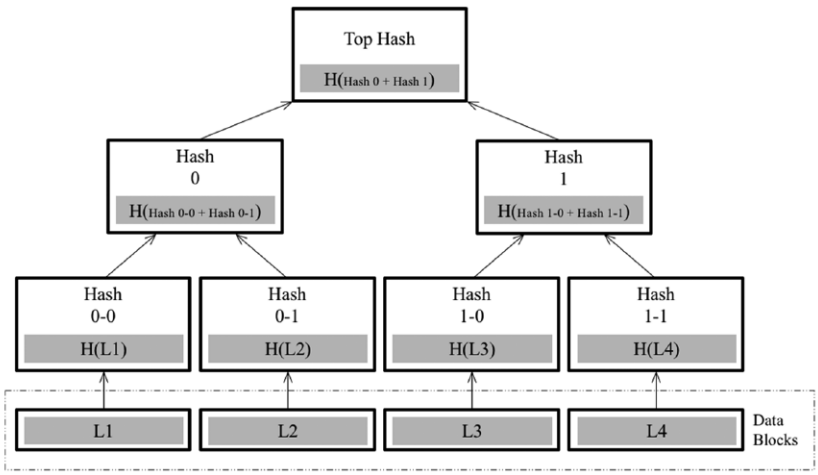
Cryptographic hash functions must fulfil the following requirements (blockgeeks, 2017) in order to be considered secure, wherein security is one of the most important reasons for using blockchain technology: a) deterministic: for every particular entry mode, the result always has to be the same, no matter how often it is analysed by a hash function. This is critical, because only then is it possible to track the input through a hash; b) fast computation: The hash function should be able to quickly return the hash of an input to ensure the efficiency of the system; c) pre-image resistance: For a given hash of X, it is infeasible to figure out the input X. It might be possible to obtain a hash by inserting a value

and comparing it to the hash of X, so as to obtain the correct input X after several attempts. Due to very large amounts of data, it is almost impossible to conclude a hash of the data stored in it; d) hash changes in the input: As shown in figure 4, small changes in the input cause a completely new and different hash; e) collision-resistant: If we have two different inputs X and Y, it is infeasible that the hashes of both inputs are identical. For a function such as SHA-256, it is very likely that the inputs are identical for identical hashes; and f) puzzle-friendly: The solution of the computing task to add a new block to the blockchain is very difficult, but checking the answer is easy for every participant in the blockchain.

The Merkle Tree

Since the data volumes in blockchains are very high, it would be highly inefficient to store all the data in a block as a series. For efficiency reasons and to facilitate the location of a specific transaction, the blockchain uses the principle of the Merkle tree. This makes it much easier to determine if a particular transaction belongs to a block, because it is possible to simply track the data by following the trail of hashes leading up to the data (Figure 5).

Figure 5. The Merkle Tree



Source: flawed.net, 2018.

The tree shown in Figure 5 consists of leaf nodes, child nodes and the root node. The leaf nodes are located in the lowest tier of the Merkle tree. They contain the actual data. Each non-leaf node has the hash of the values of its child nodes. The coming together of all nodes forms the root node and is recorded as the top hash in the respective block of the blockchain (Merkle, 1988). This data stored in the lowest tier of the Merkle tree could be, for example, transaction documents such as offers, quality certificates, delivery notes or invoices.

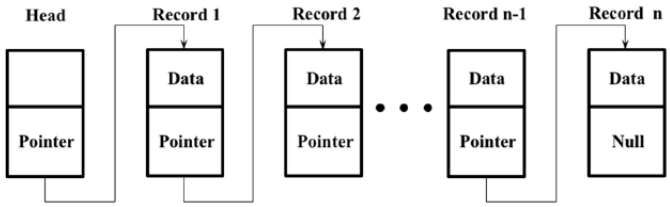
Data Structure

The data structure is the particular way in which the data is stored. In the case of blockchain, this data structure consists of a linked list and pointers. Pointers are variables in programming that store the address of another variable. They literally point to the address of other variables.

The linked list is a sequence of blocks, containing data that is linked via a pointer to the next block. The connection is established by the pointer variable containing the address of the next node. The last node in

Figure 6 has no value, so we have a null pointer. The first block is called the "genesis block" and has its pointer in the system. This block is created by the developer, so it is not based on the system of decentralised monitoring and it must be trusted. It is a very important prerequisite that data can be stored, traced and trusted.

Figure 6. Linked list



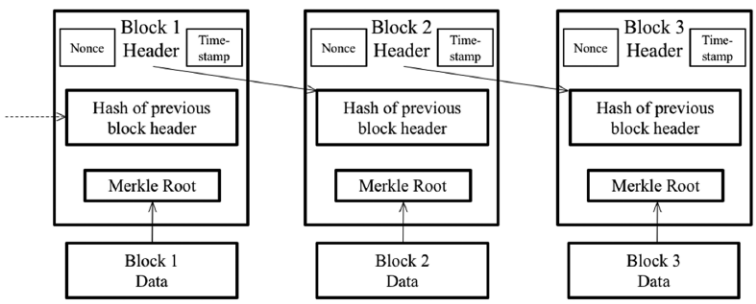
Source: blockgeeks, 2017.

The block header

The linked list together with the hash pointers form the basis of the blockchain. A hash pointer is similar to a pointer, but instead of merely containing the addresses of the previous block, it also contains the data inside the previous block. The interaction of these techniques makes the blockchain traceable and tamper-proof. For example, if the data of a block is being manipulated by a hacker, the result of the hash value change is that all other blocks would become invalid. This fact makes it nearly impossible to change a block that is anchored deeper in the chain, because all subsequent blocks have to be decrypted.

To make a blockchain even safer, each block contains a nonce ("Number only used once"), a 32-bit field that serves as a kind of set screw and alters the top hash of a block. This must be calculated by the miners so that the hash has a certain number of zeroes in the first places. This process is called the "proof of work" and limits the number of blocks created in a given time (Greenfield, 2017). If a block is closed, it receives a consecutive number and a digital timestamp to assign it to a point in time. Figure 7 shows the schematic structure of a typical blockchain (Gupta, 2017).

Figure 7. Simplified scheme of a typical blockchain



Source: Greenfield, 2017.

For security reasons, each block header contains the following:

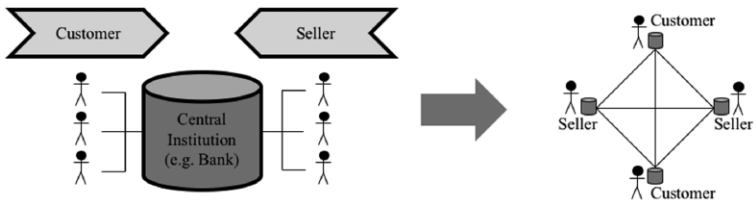
- Version: The block version number,
- Time: the current timestamp,

– Nonce ("Number only used once"),
– Hash of the previous block,
– Hash of the Merkle Root,
– The current difficult target.

2.2. The Blockchain network

Distributed blockchains are based on peer-to-peer (P2P) networks, in which only equivalent computing nodes exist. Unlike in client-server architectures, all participants in the network can perform the same functions. As a result, P2P networks are very resilient to failure, because all computing nodes can perform all functions which are necessary for the operation of the network (Nakamoto, 2008). Furthermore, due to the structure of a P2P network, aspects of load sharing and self-organisation are quite easy to solve. At the same time, this construct leads to increased complexity in the network. A big advantage of a distributed blockchain is that it creates trust between unknown users (Idelberger et al., 2016). This makes it ideal for utilisation in large networks. The blockchain makes a central institution obsolete by having the blockchain monitored by all users. Each active user of this network stores the entire blockchain on his computer (Figure 8).

Figure 8. Centralised (left) vs. decentralised (right) transaction model



Source: Burgwinkel, 2016: 19.

These network participants, who continually check the blockchain and add new blocks to the blockchain, are called "miners". The term "mining" basically refers to the search for new blocks to be added to the blockchain. The miners ensure that the blockchain grows continuously. This means that the computing power of the system has to increase in order for the calculation of new hash values to be made possible. This ensures that a new block can always be generated after a certain time. Without setting a difficulty level, more hash functions would be generated, leading to more frequent collisions. In addition, as several miners create new blocks at the same time, there would be more orphan blocks that will not be part of the blockchain. Due to the high computational power required, the mining process is usually taken over by large server farms, which combine their computing power and try to solve a given computational task (blockgeeks, 2017).

2.3. Smart contracts

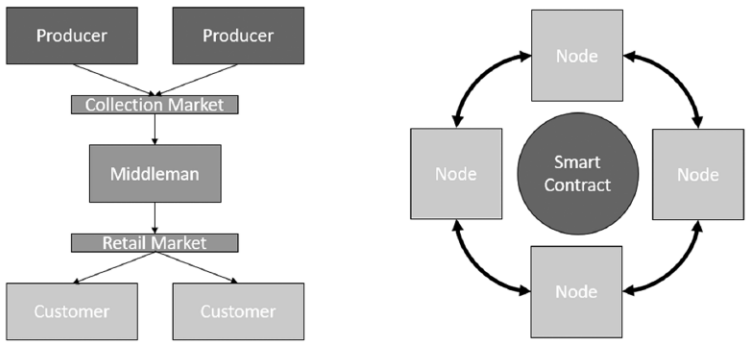
Smart contracts are peer-to-peer applications, distributed through the underlying blockchain technology. These applications act as contracts that are closed independently of third parties, such as notaries, and still ensure legal security (Kaulartz and Heckman, 2016). In addition, they allow the automatic closing of contracts under certain conditions. These contracts are tamper-proof just like the blockchain and can be retrieved at any time. Through the sensible installation of contract terms, these can be monitored in real time (Asharaf and Adarsh, 2017). Alternatively, functions could be activated or deactivated automatically by smart contracts. These functions offer the possibility of concluding

contracts automatically at low cost, which makes them interesting for micropayments as well (Burgwinkel, 2016). For the automated communication of machines, smart contracts could, for example, be used for the payment of parking tickets by autonomous vehicles. There is an enormous variety of possibilities for the application of this technology in future, but implementation is still far off. The following characteristics will serve as a basis for smart contracts in blockchains: 1) details of smart contracts are saved on a shared platform (blockchain); 2) they are executed by blockchain transactions; 3) as a characteristic of the blockchain in general, a smart contract is also accomplished by many computers in the same network (usually the same computers that also run the blockchain); 4) the recorded data of smart contracts will also be saved in the blockchain.

Smart contracts represent a new idea in documentation and the execution of agreements. There are two main reasons that have prevented their use to date. First of all, there was no possibility of controlling physical assets by way of smart contracts. Secondly, a lack of trust (Berg et al., 2017), because computers autonomously execute these smart contracts between two or even more participants. These issues can be eliminated by the use of blockchain, and therefore smart contracts are now increasingly popular (Idelberger et al., 2016).

Figure 9 illustrates the different approaches between traditional transactions (left) and the smart contract-enabled approach (right).

Figure 9. Traditional (left) vs. smart contract-enabled markets (right)

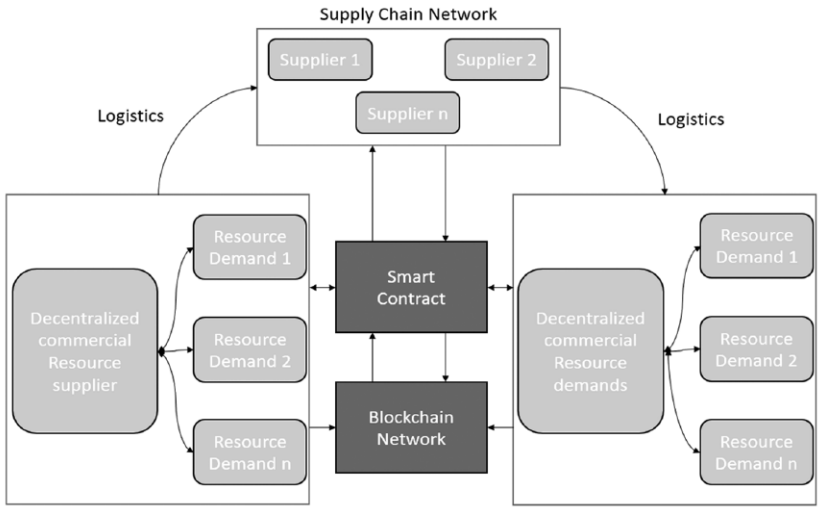


Source: Asharaf and Adarsh, 2017: 46.

With the lack of flexibility in traditional execution, smart contracts in procurement processes, for example, are mostly useful for the purchase of standardised parts, for example raw material. It could work like this: an industrial supplier needs steel as an input factor for the production of a specific part. Since the whole supply chain of the industrial producer is connected by means of blockchain with smart contracts for steel, the supplier just needs to create a block in which all the necessary details are entered (e.g. time of delivery, specification, quantity, price per unit etc.). After the information is mined into the blockchain, the smart contract will immediately search in the blockchain for a matching sales offer.

In case of successful matching, the contract will instantly come into force and be carried out accordingly (Blossey et al., 2019). There is no need to request a quote or offer, or to wait for feedback from the supplier, followed by negotiation and so on (Figure 10).

Figure 10. Example of smart contracts applied in a supply chain network

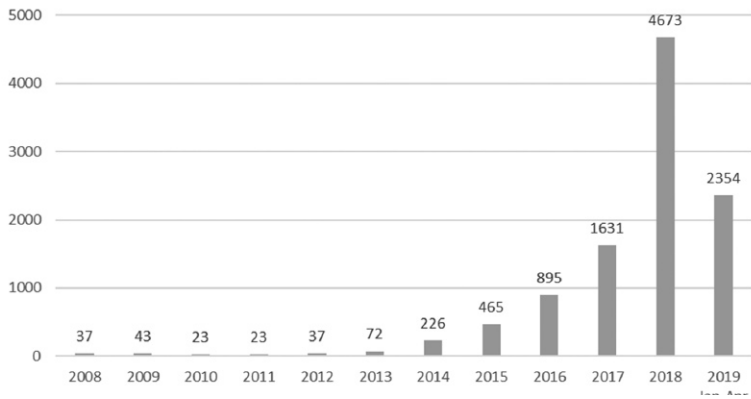


Source: Kaijun et al., 2018: 5.

3. Discussion

As Figure 11 shows, patent application based on blockchain technology is increasing exponentially. As of April 2019, there were 2354 patent applications registered worldwide. The projection for 2019 accounts for more than 7000 patent applications.

Figure 11. Blockchain patent applications per year

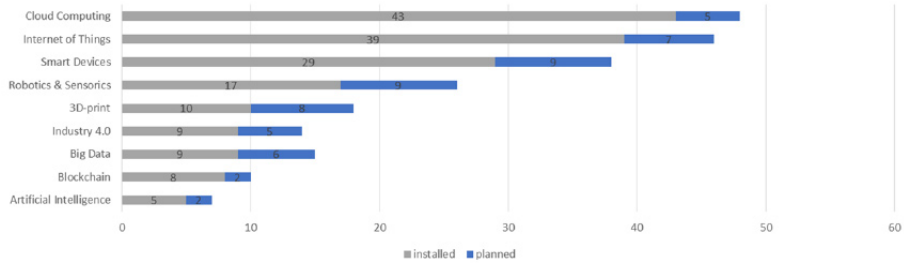


Source: IPlytics, 2019: 3.

The trend visible in Figure 11 is a strong indicator that providers are preparing a wide range of possibilities for the introduction and application of this new technology.

A close look at German companies reveals the following state of play:

Figure 12. Application of innovative technologies in Germany

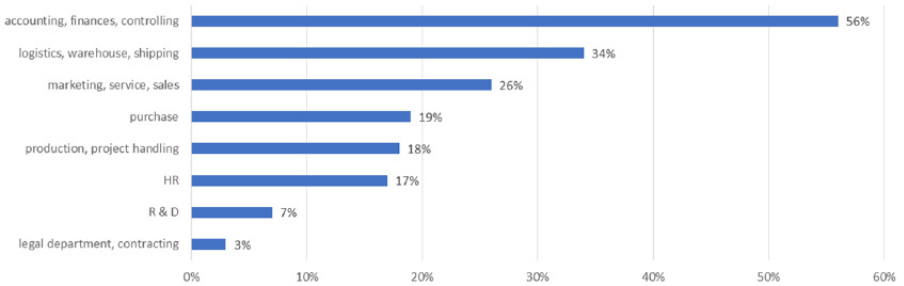


Source: Kantar..., 2018: 10.

Figure 12 represents the results of a survey (N=1061) answering a question about the current or planned application of innovative technologies. The findings reveal that companies are busy working on cloud computing and the Internet of Things. However, blockchain and artificial intelligence are considered to be at the end of the list of priorities, with a very low percentage of utilisation and only 2 percentage points indicating planned application (Kantar..., 2018).

Areas of possible applications are considered as shown in Figure 13.

Figure 13. Possible blockchain applications with reference to departments

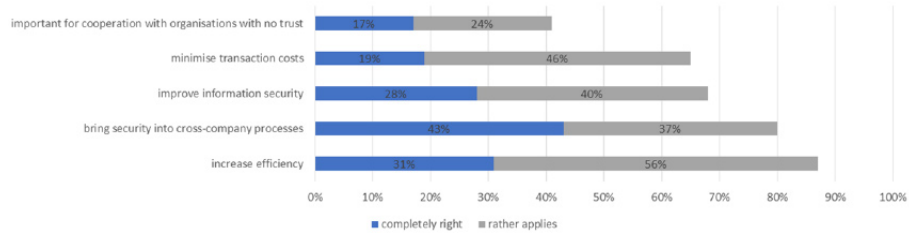


Source: Statista, 2019.

Figure 13 shows the results of another survey with N=1004 respondents, representatively selected due to industry sector and company size with more than 50 employees in Germany (Bitkom research, 2018). The results show a high level of acceptance of 56% with regard to financial issues. But there is a gap to the next functions such as logistics, sales and purchasing. These functions could be combined as business functions of transaction.

The goals of blockchain application were the focus of a further question in the same study as referred to in Figure 13. Figure 14 displays the answers, which show that managers know about the advantages of this new technology, but are still cautious when it comes to its usage. It can be stated that the issues are all about efficiency, which is strongly related to cost, and security, which is strongly related to trust.

Figure 14. Goals related to blockchain application



Source: BearingPoint, 2018.

4. Findings and cases of blockchain use

The different characteristics of blockchains provide numerous applications in a wide variety of fields of application (ZYCUS, 2017). Currently, blockchain technology is mainly related to finance and cryptocurrency applications. In the following section, specific applications in different areas of practice in transaction activities are presented to give evidence of the use of blockchain technologies in the context of digital transformation (Hofbauer et al., 2019; Brody, 2017; Blossey et al., 2019; Brandt, 2019).

The term 'digital transformation' contains a wide variety of meanings and definitions. Frequently it is placed on the same level as digitalisation. Digital transformation indicates the integration of technological developments of digitalisation into different areas of business (Hofbauer et al., 2019). In doing so, business processes are required; thus, total value chains can be optimised on the basis of collected, trusted and utilised data. Furthermore, company departments and divisions as well as customers, suppliers and other stakeholders can be networked and consolidated. This is why digital transformation always refers to business activities and processes (Hofbauer and Sangl, 2018). The evolution and rapid progress of new generation digital technologies are fostering a wide range of applications. In particular, the Internet of Things, digital twins and fully automated processes with the assistance of Big Data and artificial intelligence are driving forces in Industry 4.0 in terms of smart implementation and exercise (Tao et al., 2018). The power of smart industry opens manifold potentials for companies to create competitive advantage and to gain added value in terms of executing tasks faster, better and cheaper. Blockchain technology has the capacity to facilitate and combine all these applications in a determined, secured and incorruptible way (Risius and Spohrer, 2017).

The large number of value-creating partners consisting of both the supply and demand sides, such as suppliers, manufacturers, wholesalers and retailers, logistics and financial service providers, makes the transaction process appear an optimal field for the application and utilisation of blockchain technology. In view of the increasing digital transformation, the performance agreements between all the different parties require technologies for secure data exchange (Berg et al., 2017). Particularly in the area of physical service provision, options for optimisation through automation, the latest hardware and software, intelligent planning concepts and smart processes are often already exhausted.

In addition, financial processes in the supply chain are mostly decoupled from the value creation process because of their slow, manual and error-prone processes (Blossey et al., 2019). For example, invoice processing in the B2B business is still 60% paper-based. Through the use of blockchain technology (ZYCUS, 2017), transactions can be handled between the parties using smart contracts, regardless of invoices (Deloitte 2017; Schütte, 2017).

This applies especially for transactions executed by sales management (Hofbauer and Hellwig, 2016) and procurement management (Hofbauer, 2017) including the related exchange of data, goods and money. All business data and relevant information for the exchange of information, goods, services and billing only has to be recorded once and can be used repeatedly (Dhillon et al., 2017). The different phases of transactions and the corresponding results and consequences can be stored in the blockchain and executed automatically (ZYCUS, 2017). These phases of interaction from the selling point of view (Hofbauer and Hellwig, 2016) start with the acquisition phase and follow a determined process flow with request, specification, offer, negotiation, order management, payment and after sales. Consequently, all partners to a transaction will benefit from the transparency and traceability of these entire processes and all intermediate results. With the real-time update of data recorded during the production and transportation of goods, there is no longer a need to provide this data manually to a customer. The customer will be able to obtain the information directly out of the blockchain without any doubts as to the validity or correctness of the data. This will facilitate the work of the sales and procurement departments, since some of their processes may become unnecessary (Hofbauer, 2017; Brody, 2017).

From the procurement point of view, there are corresponding phases in the process flow, which will be demonstrated in more detail. The following process phases (Hofbauer, 2017) in the procurement cycle may be influenced by the introduction of a tracking system in the supply chain based on blockchain technology:

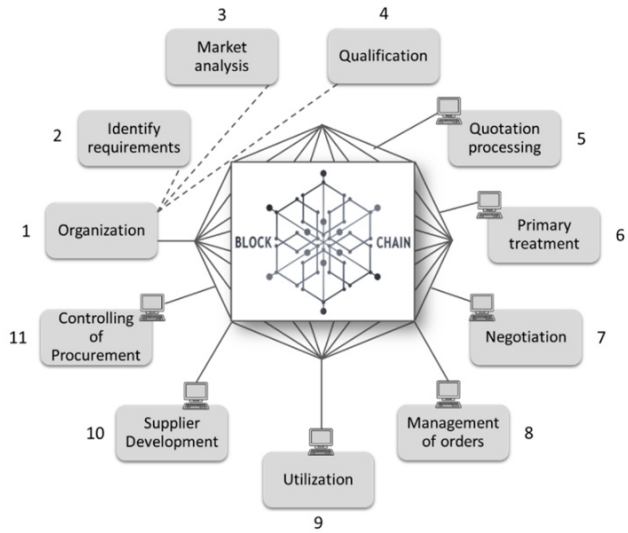
Management of orders: The monitoring of deliveries will be an automated process, with notifications from the procurement department only if an intervention is required. The incoming inspection may be a lot easier since any possible damage done to the good is recorded in the blockchain and the inspectors may already know what they need to look for.

Utilisation: The logistical performance of the supplier can easily be rated by the data recorded in the blockchain. If there is any need to make a complaint, one can easily discern the failure in production or during transportation.

Supplier Development: With the rating of the supplier's logistical performance, one can easily figure out how and where to leverage this information to improve performance. Thus, monitoring suppliers is made a lot more transparent and easier by using the blockchain.

As shown in Figure 15, these three applications of the blockchain directly affect eight (phases 5 to 11) out of 11 phases (solid line) in the procurement processes (Hofbauer, 2017). These phases deal with external partners such as suppliers and customers, and it is highly important to execute the respective transactions of data, goods and money and the corresponding documentation in a safe, immutable and precise way. It is not necessary to apply blockchain technology to internal phases 2, 3 and 4 (dotted lines).

Figure 15. Cycle and phases of the procurement process



Source: Hofbauer, 2017: 25.

The interaction of the various supply chain partners uses the blockchain as a distributed data store, and ensures that all relevant data from the smart contract is accessible to all networked partners. The contents of the contract contained therein are safeguarded by the smart contract as an executing computer program, and compliance with the contract contents is ensured. In addition, a smart contract independently legitimises financial transactions when it comes to the fulfilment of agreed terms and conditions (Asharaf and Ardash, 2017). With the help of decentralised control units, logistical objects in the supply chain network can autonomously make dispositive decisions and issue orders and financial clearing on their own (Carson et al., 2018). Furthermore, it is possible to store data that is provided by all objects at any time without gaps, to create evaluations on this basis and to optimise the entire supply chain (Brody, 2017).

Conclusions

Blockchain technology has the potential to revolutionise business processes in various business fields, as and when digital transformation makes further progress (Hofbauer et al., 2019; Dhillon et al., 2017). Due to the increasing digitalisation and automation in many business areas, there are already numerous application options that are under consideration and are standing by for wider adoption (Grand View Research, 2019). The implementation of blockchain-based systems is not easy, but the attainable benefits are valuable (Dumitrescu, 2018). Some companies are already taking advantage of this technology. Research on the potential applications of this technology is being undertaken in various areas. However, it is still unclear whether and within which time frame blockchain technology will penetrate business processes on a large scale. This probably depends on whether it is possible to make the technology familiar to more users, and to make the benefits apparent (Carson et al., 2018). In future, however, all stakeholders in transaction processes will be increasingly confronted with this technology. Therefore, it is helpful to understand the basic principles of this technology in order to build conviction and trust in its utilisation.

The contribution to science of this paper is to implement the blockchain in transaction processes such as sales and procurement. Typical components of these processes are exchange activities of data, goods and money. The respective processes have already been introduced (Hofbauer, 2017; Hofbauer and Hellwig, 2016). The logical next step is the adoption of the interlinkage system provided by blockchain, of which there are numerous advantages (Zheng et al., 2018). The most important benefit of all those applications is a reliable database, which is not susceptible to manipulation. This fact will add transparency and security to the documentation of relevant transaction activities.

The limitations in this context are twofold. From the physical point of view, there could be a short-term limitation of information-processing capacity, but this can be solved by raising the capacity on demand. From the empirical point of view, there are very few early adopters of blockchain applications and therefore limited operating experience and scarce statistical data of real-world cases. A direction for further research could be longitudinal studies of selected early adopters.

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