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Empirical Insights in the Current Development of Smart Contracts

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Research-in-Progress

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Abstract

Blockchain technology enables a lot of knowledge possibilities in an even more digital business environment. Besides the well-known bitcoin application, another implementation so called smart contracts recently arised. Smart contracts profit from the blockchain mechanism benefits (e.g., transaction security). A huge advantage of smart contracts is, that they provide trust between transaction partners without integrating a third party. Practice has already noticed their advantages and implementing smart contracts more and more into their business. However, research is still under development and a common scientifical foundation is still missing. Particularly, research lacks in empirical and practical findings. This paper responds to that gap. Conducting an expert study relevant data was collected and analyzed regarding empirical standards. The results we found and present in this on-going research paper give insights about basic aspects, challenges in the implementation as well as the use cases of smart contracts.

Keywords: Smart Contracts, ICT, blockchain, empirical research, expert study

Introduction

Trust in partners is essential for performing transactions and processes. Up to now, third parties such as the state and its jurisdiction enabling trust creation (Nicholas and Metzger 2008). Also organizations built on these legal foundations such as banks and notaries support the execution of transactions and processes requiring trust between the business partners (Tapscott and Tapscott 2016). However, recently, the necessity of these third parties is put under scrutiny because of increasingly grown cost and risks (Tapscott and Tapscott 2016). The value consumed by third parties for establishing trust is criticized as same as the increasing number of cases in those security breaches and other harmful events disappointed the confidence (Tapscott and Tapscott 2016). Now, in the context of cryptocurrencies and

blockchains, smart contracts arise as a new way for building trust in digital transactions. Their basic idea was developed already by Szabo (Szabo 1997). Smart contracts enable the transfer of digital assets according to arbitrary pre-specified rules (Buterin 2014). Smart contracts are defined in formal languages that can be executed by using blockchain technology. This technology allows to define conditions that are tested and trigger actions when fulfilled (Peck 2017). By putting them into a transaction it is possible to increase correctness and safety by assuring that all requirements for the transaction are met before carrying out. Smart contracts built up on this technology unlock the potential to create trust without using intermediaries (Tapscott and Tapscott 2016). Therefore, smart contracts increasingly gaining more and more interest in research and practice (e.g., Christidis and Devetsikiotis 2016; Ream et al. 2018). This is confirmed by the investments in smart contract related firms, which is increasing continuously (Ream et al. 2018). Also incumbents like the French insurance company AXA (2018) adopt smart contracts. Contrary to the disruptive effects of smart contracts, research in this field is still in the early stages of development. Past research mostly focuses on more technical and even on non-empirical aspects (e.g., Christidis and Devetsikiotis 2016). Current research lacks in empirical insights about current practice of smart contracts. A clear understanding regarding the current development, use cases, challenges as well as potentials is crucial to appreciate the implementation and the usage of smart contracts in a proper way. However, without empirical research and empirically supported foundation, information systems research cannot be accurate in describing and predicting the use and development of (specific) smart contracts. We respond to that gap in two ways. On the one hand, we conducted a study using an empirically expert research design. On the other hand, we enlarge findings of prior research by focusing on the investigation of smart contracts from a practical point of view. We want to investigate the research question: *"What are the basic concepts, use cases, challenges of implementing and use potentials of a smart contract in practice"?*

This paper, which is part of an ongoing-research project, aims to create a deeper understanding of smart contracts and to provide an empirical foundation for further research. The paper is structured as follows. In the background section we give at first an overview about smart contracts and the necessary technological background. In the third section, the research method, the data collection as well as the data sample are described and explained. Following this, the results of the conducted study are presented and discussed. Finally, we end up with the conclusion and future research section.

Background

In general a so-called blockchain mechanism is used to implement the distributed ledger (Mills et al. 2016). Information entered into a blockchain cannot be erased (Crosby et al. 2016), thus the durability of the contracts is assured. Blockchains establish trust without the involvement of third parties such as the government, banks etc. In this way they enable the disintermediation of traditional providers of trust (Ransbotham 2016). Blockchains are able to reduce the cost of verifying the attributes of transactions (Catalini and Gans 2016). By allowing to agree about the true state of currency, intellectual property equity and assets blockchains may become a general purpose technology (Bresnahan and Trajtenberg 1995; Catalini and Gans 2016). Furthermore, building marketplaces using blockchain technologies increases competition, lowers entry barriers, improves privacy and avoids assigning market power to a platform operator (Catalini and Gans 2016). Therefore, blockchain was quickly identified as a new mechanism to establish trust in a digital world (Tapscott and Tapscott 2016). Early blockchain technologies such as the one used for bitcoins allow to execute only currency specific transactions but not general purpose transactions (Mills et al. 2016). It is based on a distributed ledger (Mills et al. 2016) that assures the correctness of a distributed storage of transactions using cryptographic means. The role of bitcoins is two-sided. They are both a unit for storing value and an incentive for supporting the distributed ledger mechanism. This dual role becomes obvious in networks such as filecoin (Labs 2017). They provide a currency for paying the hosting of files. Later ones such as Ethereum (Buterin 2014), which could be applied for the implementation of smart contracts, support the distributed execution of arbitrary transactions (Ransbotham 2016). The transaction fees are dependent on the size of the transaction (Buterin 2014). In this way, smart contracts create a transaction processing infrastructure that leverages the advantages of a fully distributed architecture based on blockchains (Buterin 2014). By using a distributed architecture (Tanenbaum and Van Steen 2007) a scale-out approach (Ferdman et

al. 2012) can be implemented. A distributed system is also more reliable and scales better (Tanenbaum and van Steen 2007). Further, it is possible to use commodity hardware (White 2012) instead of specialized and thus expensive hardware systems. Nevertheless of these technological achievements, current research lacks about empirical insights about the current understanding, use cases, challenges as well as use potentials of smart contracts from a practical point of view regarding the published literature (Webster and Watson 2002) referenced in leading IS databases like AISeL, SpringerLink, IEEEXplore or Sciencedirect.

Research Method and Data Collection

For the investigation of smart contract's basic concepts, use cases, implementation challenges as well as use potentials, we conducted a qualitative expert study according to general recommendations found in literature (Myers 1997; Recker 2013; Strauss and Corbin 1994). Qualitative research approaches are often used in information systems research and can generate interesting and valid insights (e.g., Myers 1997; Schmidt et al. 2017). We have chosen this method, because we want to gain first insights in a very open-minded way. A quantitative way would be much more restrictive since statements (aspects) must be preselected and subsequently the answers are limited to this selection (Recker 2013; Strauss and Corbin 1994). The qualitative data has been analyzed with different coding techniques like open and axial coding following the guidelines found in literature (Recker 2013; Strauss and Corbin 1994). The study was implemented through a web-based online tool from November 2017 until January 2018. Experts for the study sample were identified by the information given on business social networks like LinkedIn, expert blogs, conferences and seminars. We contacted the preselected experts in a formal as well as an informal way. At the beginning of the survey we implemented two check questions regarding the participant's knowledge and expertise in the field of smart contracts to ensure a high quality of research and validity of the results. Afterwards, we asked several open questions regarding the practical view of the basic concepts, use cases, challenges as well as use potentials of smart contracts from the viewpoint of the experts. Finally, we collected business related aspects (such as industry sector) as well as socio-demographics. We collected answers from n=51 experts for our study. After data cleaning (due to missing data, unsatisfied expert level/check questions) we got a satisfying final sample of n=36. Regarding our sample, 42% of our experts are using smart contracts already and 31% are in the planning and implementation phase of the concept. Most of our experts have more than 15 years professional working experience in countries like Germany, Switzerland, Poland. The experts are working in industry sectors like information and communication technology, finance, public administration, research, engineering and research.

Results

Regarding the qualitative data and related analysis, we found the following results.

Smart contracts are very important for all our experts. The importance is clarified by the following statement of one expert:

> *"Smart contracts will disperse complete (traditional) sectors – however, on the other side completely new business models will changed in their ways or even build up in a new one."*

Smart contracts will cause change in practice as well as in research. More and increasingly diverse business models will be impacted by their smart contracts. It is obvious, that the interest in smart contracts for research and practice will increase continuously. Therefore, a more common understanding and an empirical foundation must be developed to support practice as well research. We contribute with our results to this by defining basic aspects, use cases and implementation challenges s well as use potentials of smart contracts. In the following picture (Fig. 1) the main findings are summarized. The upper part of Figure 1 defines the basic aspects and the technical background of smart contracts. The lower part of Figure 1 derives three practical implications of smart contracts, which are shown via arrows and boxes (use cases, the challenges of implementation and use potentials).

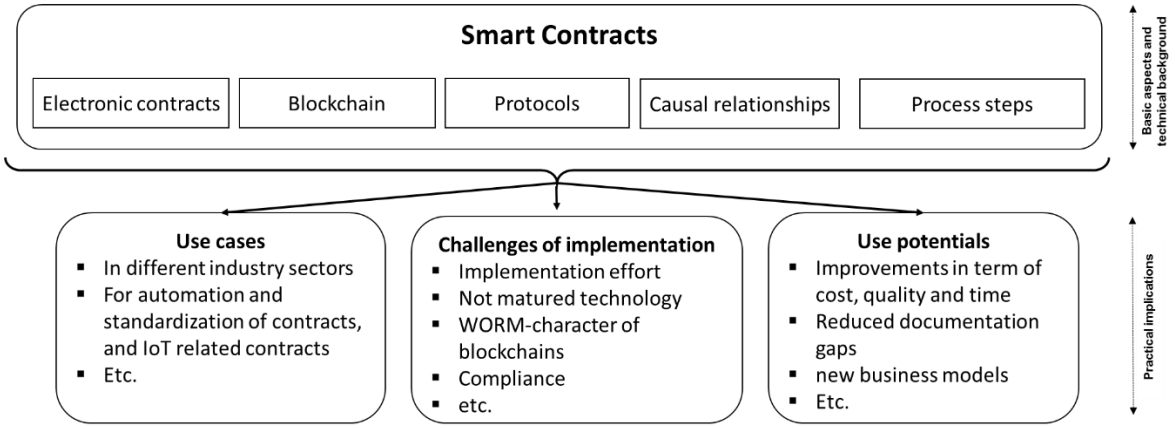

Figure 1: Basic aspects, uses cases, challenges as well as use potentials of smart contracts

Basic aspects of smart contracts

Our experts show us a lot of interesting insights into the basic aspects of smart contracts from a practical point of view. The data analysis revealed five basically aspects determining smart contracts: Electronic Contracts, Blockchain, Protocols, Processes (steps), Causal relationships (e.g., if…, then…) (see Fig 1.). The basic idea of digital contracts was developed rather early (Griffel et al. 1998). However, these theoretical concepts could not be implemented. Only after the availability of cryptocurrencies and the underlying blockchain technology, an implementation has become feasible (Crosby et al. 2016). Blockchains support the implementation of smart contracts by providing a distributed database of records, that contains transactions verified by a majority of participants in the system (Crosby et al. 2016). To define smart contracts, the blockchain has to provide a programming language that is Turing-complete (Buterin 2014). Using the programming language, smart contracts connect a number of steps triggered by events with rules that implement a predefined protocol (Buterin 2014). If certain, defined events happen, further actions such as payments are triggered. If those conditions are not met, payments are not made or contractual penalties are applied (Crosby et al. 2016). In this way causal relationships are implemented in software code, e.g. to give incentives to fulfill the contracts.

Use cases of smart contracts

Most of our experts described the use cases of smart contracts in different industry sectors. Especially, sectors with a high potential for contract participation and automation (e.g., the finance industry) are important. With regards to our results, the most important business sector is the finance and insurance industry. The importance for this area was stated by nearly half of our experts. One expert underlines this use case in the finance industry with the following practical argumentation:

> *„There are a lot of processes and process steps grounded on trust in a third party. In many cases, these are simple tasks, of which the purpose itself is the trustworthiness of this third party such as a notarial act. These processes could be replaced by smart contracts."*

Regarding this expert view, there are different interesting uses cases in the financial and insurance sector. Smart contracts can be used to facilitate such processes by generating trust for a third party as well as between different parties. Furthermore, the energy sector, public administration and private law are important sectors for the use of smart contracts. One expert explains the importance of using smart contracts in the energy sector in his statement:

> *"Decentralization of the energy market through a direct trading of overloads between prosumers."*

This opinion stands clear in line with our overall finding mentioned above. It shows an example in which a completely new business model could arise due to the usage of smart contracts. However, besides these highly relevant industries, from a more general view point of our experts, smart contracts can be used as described in many different industry sectors, like stated by our following expert:

> *„In cases where highly standardized recurring activities are given, smart contracts can be used to automate these. How so? This proceeding has a lower error rate and significant savings in labor costs."*

Our findings show that in every business sector where standardization and automation of contracts are needed, smart contracts can be applied and are useful. In general, standardization and automation of contracts and related business processes are needed in many different business sectors (Norta et al. 2014; Tregear 2015). Another expert argues the non-business sector specifics of the use cases of smart contracts like this:

> *"They are suitable for all procedures that can be describes as a causal relationship like "If-then-else".*

Therefore, smart contracts can be used in every business case with such a specific causal relationship. Smart Contracts technologies such as Ethereum (Buterin 2014) allow to codify arbitrary deterministic processes into software code. By interpreting the code, smart contracts are enacted. Furthermore, in an Internet of Things (IoT) environment smart contracts can be also very useful. Through the Internet of Things (different devices or things can interact with each other (Atzori et al. 2010). Smart contracts can be used in this environment to define and record contracts and related processes (Christidis and Devetsikiotis 2016).

Challenges of implementing a smart contract

Based on the analysis of the qualitative expert data we found that the majority of our experts (approx. 56%) define the implementation effort of smart contracts as high. Only 25% of our experts think that the implementation is easy. Based on our experts' knowledge, the technology is not mature at the moment. A prediction regarding the effort of the implementation is currently not accurate due to missing referential projects in the past. It is important to define at first a basic concept of implementing smart contracts that identifies related (business) processes. Furthermore, software testing and security checks are also very important to ensure a successful implementation. One expert argues also for a good usability:

> *"Furthermore, the usability must be good to ensure that the user experience is positive, and the user will actively deploy it".*

Besides the importance of usability mentioned by the expert, technical aspects are also very important. Today, public and private blockchains exist. There are blockchains that are public such as Ethereum (Buterin 2014). But there are also blockchain technologies implemented privately, so called enterprise blockchain (Buterin 2014). Different development environments existing now or are under development. The experts show examples like Ethereum or IOTA (Buterin 2014). Two-third of our experts see technical challenges implementing a smart contract, because of a missing technical understanding of all aspects of a smart contract, incorrect or bad implementation of software code. One particular problem is the WORM-character of blockchains (Crosby et al. 2016). They do not allow later changes to once specified contracts. Changes must be implemented by a new version. Therefore, new approaches for change management must be applied. The following expert showed this experience in this quote:

> *"Bugs, because the code is immutable. Once a bug is existing, it cannot be removed anymore (comparable to a Parity wallet bug)."*

There are also challenges regarding the IT skills and related employees or experts according to one expert:

> *"It is complex. There is a lack in personal skills inhouse and established organizational processes must be break up, too."*

One expert argues another very important point besides the technical implementation:

> *"Primarily, that is a paradigm change – the technical obstacles are low."*

Regarding this opinion, it becomes clear that there are not only technical obstacles that might be overcome but also challenges in the acceptance of this new technology. Some experts (n=6) argue point to the challenge of missing acceptance and motivation for smart contracts inside the enterprises. Missing budget and support of the management as well as a good concept for smart contracts are challenges for implementing a smart contract according to our experts. These challenges often occur in IT management (e.g., Carr 2004; Henderson and Venkatraman 1993). Furthermore, safety, trust and transparency (Grabner-Kraeuter 2002) of smart contracts are very important and challenging regarding our experts' view. Questions regarding the compliance are very important for implementing a smart contract. Compliance can be seen as regulations and used laws of the use of smart contract from the viewpoint of the smart contract parties (Buddle et al. 2005). Fifty percent of our experts see these questions as very important and as a crucial point of smart contracts. In line with this, the following expert stated:

> *„How can the liability for mistakes in the programming process or also for a misinterpretation of a declaration of intends or contracts be defined in case of smart contracts?"*

Furthermore, ethical aspects of smart contracts are also a challenge and unexplained question from the viewpoint of our experts, today. In general, a system is ethical if the system is in line with the values of the stakeholders based on the existent normative and moral norms (Mingers and Walsham 2010). One expert about ethical aspects:

> *"An ethical investigation of the conflict: "Code is Law" vs. "Law is Code" is still missing. Indeed, many programmer's belief the first term to be true. However, I think that this way of thinking is to restricted."*

Therefore, ethical aspects should be further investigated in future studies.

Use potentials of smart contracts

Besides the challenges arising with the implementation, our experts also mentioned many different use potentials of a smart contract. In general, use potentials can be defined as the individual perceived capability of using and implementing smart contracts (Schmidt et al. 2015). Old contract processes within the enterprises can be improved by business process improvement in terms of time, quality and costs (Aalst et al. 2016). Generally, approx. 36 % of our experts argued, that smart contracts can save costs. Cost savings can be generated through process automation, reduced HR costs, saving in terms of the distribution network (e.g., less mediator, agents, broker). One expert described the reduced distribution network in his statement like this:

> *"Intermediated third parties such as clearing departments between banks can be dissolved."*

These intermediaries often demand inappropriate high fees and create problems concerning security and confidentiality (Tapscott and Tapscott 2016). Smart contracts could save these expenses. Therefore, the reduced parties of the distribution network lead to savings and a higher use potential of smart contracts. Furthermore, HR costs be decreased as stated by the following expert:

> *"The participation of employees in business processes could be remarkable minimized and they could focus on other productive tasks."*

Also, quality aspects of making a contract can be improved by reducing e.g. manual mistakes. Business processes can be improved (Aalst et al. 2016) and gaps of documentation can be reduced. This is also the opinion of another expert:

> *"The restructuring of longstanding established business processes as well as bridging the gap in documentation."*

Furthermore, inter-organizational business processes like the collaboration with different stakeholders (Norta and Grefen 2007) can be improved by implementing smart contracts from the viewpoint of our experts. Further, time of making a contract can be also reduced (Tapscott and Tapscott 2016). Besides cost and time saving, our experts think that the development of new business models are an important use potential of smart contracts. Smart contracts can be seen as a disruptive technology (Lucas Jr and Goh 2009) that changes the way of making and managing contracts. Enterprises implementing smart

contracts can be a leader as well as innovative and generating new margins over the next years. New partnerships and competencies can be developed. Some experts (approx. 20%) see also an improved level of safety and security as a use potential of smart contracts through reducing fraud and logging each transaction.

Conclusion and Future Research

Our results give broad insights into the implementation practice of smart contracts in Europe. With respect to our research question, we define basic concepts (e.g., blockchain technology), use cases (e.g., prosumers' trading in the electricity market), challenges (e.g., technical obstacles like uncorrectable software code) as well as use potentials (e.g., cost savings) for smart contracts from a practical point of view. Our experts shared with us insights into the current implementation and running of smart contracts in their business. Smart contracts can define as well as generate new business models with high margins in numerous industry sectors. Related business processes can be improved in terms of time, quality as well as costs. There are different challenges implementing smart contracts like the lack of maturity of the used technology, the missing IT experts as well as compliance and budget challenges. We identified a need for further research and practical developments at this point. We contribute to the information systems literature in different ways. We show insights about the real ICT use and challenges related to smart contracts in practice. There was a lack of research, particularly empirical one, in the past. Furthermore, we open new ways of research based on our qualitative insights. Our results can be used as a basement for further detailed studies as well as theory development. Also, managers can use our results for a better understanding of smart contracts related use cases. The awareness about possibilities and challenges might support their decision-making process. This paper is part of an ongoing research project and will use the first results to go deeper into this topic. The next steps include using the findings in a more concrete and rigor way to use a quantitative approach, which generates more significant results and cover related limitations. By doing so, we respond to the limitation of our qualitative approach used in this study. Furthermore, we only addressed European experts (cover biases). The initial situation (e.g., legal aspects) could be different in other countries and the findings could vary. Therefore, future studies should collect data from other countries and compare as well as extend our results. Future studies should investigate the different use cases, challenges and use potentials of smart contracts and the relationships among each other with quantitative research methods (Recker 2013). Furthermore, case study research (Pervan and Maimbo 2005) could be applied to get insights into different industry-specific implementation processes (e.g., for smart contracts in the insurance sector) of smart contracts.

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