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BREAKING DOWN THE BLOCKCHAIN HYPE – TOWARDS A BLOCKCHAIN MARKET ENGINEERING APPROACH

Benedikt Notheisen
Karlsruhe Institute of Technology, Karlsruhe, GER, benedikt.notheisen@kit.edu

Florian Hawlitschek
Karlsruhe Institute of Technology, Karlsruhe, GER, florian.hawlitschek@kit.edu

Christof Weinhardt
Karlsruhe Institute of Technology, Karlsruhe, GER, christof.weinhardt@kit.edu

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Research paper

Notheisen, Benedikt[1], Karlsruhe Institute of Technology, Karlsruhe, GER, benedikt.notheisen@kit.edu

Hawlitschek, Florian, Karlsruhe Institute of Technology, Karlsruhe, GER, florian.hawlitschek@kit.edu

Weinhardt, Christof, Karlsruhe Institute of Technology, Karlsruhe, GER, christof.weinhardt@kit.edu

Abstract

The blockchain has reached the tip of a global hype across a variety of industries. The potential of this technology, inter alia building the fundament of Bitcoin, is assumed to be immense and disruptive – particularly for the financial industry. FinTech start-ups as well as established players however are just about to explore the true potential of blockchain technology as the fundament of (financial) markets. Before this backdrop, Information Systems research is making valuable contributions to the field by integrating the technical view on blockchain with interdisciplinary research approaches. Our contribution to the growing body of Information Systems literature in the context of the blockchain is twofold: First, we conduct a comprehensive literature review of the most relevant and recent IS research on blockchain. Second, based on the findings of our review, we build on existing research and propose a Blockchain Market Engineering Framework, which can support researchers as well as practitioners in analyzing and designing the elements of blockchain-based markets on an individual and global level. In addition, we go beyond a purely analytical perspective and provide a toolbox to support the active construction of blockchain-based ecosystems and infrastructures. In doing so we pave the way for future research that will help to break down the blockchain hype.

Keywords: Blockchain, Literature Review, Market Engineering, Research Framework

1 Introduction

Recent developments in financial technology and the "FinTech"-start-up scene are about to transform the financial services industry (Gimpel et al., 2016). Motivated by the huge opportunities for both, consumers and industry, the European Commission (EC) announced to set up an internal task force on financial technology (Mock, 2016). In a corresponding EC blog post it is stated that: "*The Fintech revolution as we are experiencing it right now really is the result of a confluence of technological developments that have come to the market [...] ranging from continuing increase in processing and storage capacity, [...] [to] distributed ledger technology or blockchain which is high on the agenda of the whole sector*." (Viola and Guersent, 2016).

In fact, the blockchain is frequently referred to as one of the main technological innovations of the 21st century that has the potential to reshape and disrupt a plethora of economic activities such as consumer-to-consumer transactions in the realm of the sharing economy (Puschmann and Alt, 2016) or banking (Alt and Puschmann, 2016). Introduced as the underlying technology of Bitcoin (Nakamoto, 2008) – a

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digital peer-to-peer payment system that allows transactions between two parties without the need for a central institution – blockchain technology emerged from its origins and heads to a broad field of economic applications. Today visions of decentralized peer-to-peer platforms, contract management systems, clearing and settlement of securities transactions without the need for a trusted third party, and trust-free transaction systems announce disruptive changes in market structures. Building on the fundament of smart contracts (Wattenhofer, 2016; Szabo, 1994), the "trust machine" (Economist, 2015) – which is basically a combination of a distributed database, a decentralized consensus mechanism, and cryptographic security – sets out to revolutionize banking, financial services, and a wide range of economic and technological applications.

Driven by the expectations about the disruptive and transformational impact on business, the blockchain hype is just about to reach the peak of the Gartner Hype Cycle for Emerging Technologies (Gartner, 2016). While start-ups as well as established companies like *Deutsche Börse* and the *Deutsche Bundesbank* put a considerable amount of effort in the development of pioneering blockchain-based market solutions (Bundesbank, 2016), many researchers and practitioners still struggle to grasp the true potential of the blockchain (Beck et al., 2016). Since "[...] the technical protocols and implementations [of distributed ledgers, decentralized consensus systems, and decentralized applications based on smart contracts] are quite complex" (Glaser and Bezzenberger, 2015), the engineering and implementation of sophisticated market settings is a nontrivial problem that requires knowledge from various disciplines (Gimpel et al., 2008). The Information Systems (IS) community, focusing on both, the IT-artifact (i.e. blockchain technology) *and* the surrounding (economic) structures and contexts (Benbasat and Zmud, 2003) is therefore particularly well suited to conflate and extend the work from different technological and economic disciplines to interdisciplinary research approaches (Giaglis and Kypriotaki, 2014).

So far however, IS research on blockchain-based solutions is still in an early stage and mainly focuses on use case analyses and design science aspects of proof of concept prototypes (Beck et al., 2016). At the same time, research approaches and findings are dispersed across a variety of other disciplines such as computer science or economics and finance and therefore would benefit from an interdisciplinary view on a macro level (Giaglis and Kypriotaki, 2014). Consequently, an interdisciplinary (research) framework is needed to guide “the process of consciously setting up or re-structuring market mechanisms and market infrastructure” (Gimpel et al., 2008) for blockchain-based markets.

The contribution of this work is twofold: First, we provide an overview of the most relevant IS-related research on blockchain by conducting a concept-centric review of IS literature. Our findings indicate a strong dispersion with regard to the focus, methodology and specific issues addressed in present IS research, emphasizing the need for a structured approach to guide future research. Second, we therefore suggest a multidisciplinary framework to further guide researchers and practitioners in engineering blockchain-based (financial) markets. Based upon the work of Weinhardt et al. (2003) and Gimpel et al. (2008), the framework differentiates between four layers, and takes into account the socio-economic and legal environment, the characteristics of the deployed blockchain protocol (i.e. the IT-infrastructure), the application’s micro- and business structure, as well as the outcomes of the (economic) agents’ behaviors.

The remainder of this paper is structured as follows: In the next section, we provide the theoretical background of this study. In doing so, we introduce blockchain as a technology and briefly outline the potential role of blockchain for FinTech. In the subsequent section 3, we describe the methodology of our literature review, addressing both the literature search and selection process. In section 4 and 5, we present the results of our literature review and discuss challenges and opportunities with a particular focus on the most relevant IS literature respectively. Based on our findings we propose our Blockchain Market Engineering Framework in section 6, sketch out future research directions in section 7, and finally conclude with section 8.

2 Theoretical Background: Blockchain

Since its introduction as the underlying technology of Bitcoin (Nakamoto, 2008), blockchain emerged from its use as a verification mechanism for cryptocurrencies and prepares to revolutionize a broad field of economic applications. From a technical perspective blockchain-based systems comprise a distributed transactional database, cryptographic security measures, and a consensus mechanism, that allows decentralized time stamping (Gipp et al., 2015). Eventually, the transactional data is immutably stored in the distributed database in form of a potentially infinite chain of sequentially interconnected blocks, providing a complete and transparent history of past transactions.

Consequently, blockchain technology allows the resolution of conflicts among interacting agents and dismantles information asymmetries without the involvement of a central institution. This allows conflicting agents to agree on the correct order of transactions and a shared system state at any given point in time. In practice, the employed consensus mechanism can vary with respect to the specific use case. In public and anonymous scenarios on one hand, the creation of new blocks, i.e. database entries, has to incur a sufficient amount of (computational) costs in order to prevent the dissemination of corrupted information (Lamport et al., 1982; Dinger and Hartenstein, 2006). As a result, mechanisms such as proof of work (Wattenhofer, 2016) or proof of stake (Lee Kuo Chuen, 2015; Ethereum, 2016) help to the increase byzantine fault tolerance (Lamport et al., 1982) and mitigate the risk of sibyl attacks. In permissioned or private networks, where all agents have a known and unique ID, on the other hand, identity-based authentication schemes provide computationally less expensive alternatives (Li et al., 2015; Bellare et al., 2009). All of these mechanisms however rely on the correctness of predefined rules. In consequence, it is crucial to make sure that they are secure, reliable, and accurate (Ahangama and Poo, 2016). In addition to the complexity of the deployed blockchain protocol, fully decentralized ecosystems pose new challenges to their human users as well (Glaser and Bezzenberger, 2015). With the lack of a central authority, Lustig and Nardi (2015) argue, that trust will shift from institutions towards algorithms.

In total, blockchain technology offers a distributed software architecture (Xu et al., 2016) that has no central point of failure, a transparent, secure and tamper-free record of data transactions, and enables cost-efficient micro transactions (Beck et al., 2016). However, blockchain systems are still an emergent technology exhibiting a variety of problems that still need to be solved, such as scalability issues related to security and network size, limited transaction loads, and high (computational) costs (Beck et al., 2016; Glaser, 2017; Malone and O'Dwyer, 2014).

3 Literature Review Methodology

To explore blockchain-related research in the field of IS, we follow the guidelines of Vom Brocke et al.(2009), Webster and Watson (2002), and Cooper (1988) to conduct an exhaustive and selective concept-centric review of literature related to blockchain technology. We focus on tangible research results but also shed light on applied research methods to provide a structured overview of the central concepts of blockchain research and the current status of the field. The literature search and selection, as well as the classification process will be described in the following.

3.1 Literature Search and Selection

In order to ensure the relevance and quality of the reviewed publications, we focus on the top eight peer-reviewed, scientific IS journals from the AIS Senior Scholars' Basket[2] and selected IS conferences[3]. To identify relevant literature, we follow a four step approach based on Webster and Watson (2002), as depicted in Figure 1.

[2] See https://aisnet.org/?SeniorScholarBasket.

[3] See http://www.acphis.org.au/index.php/is-conference-ranking.

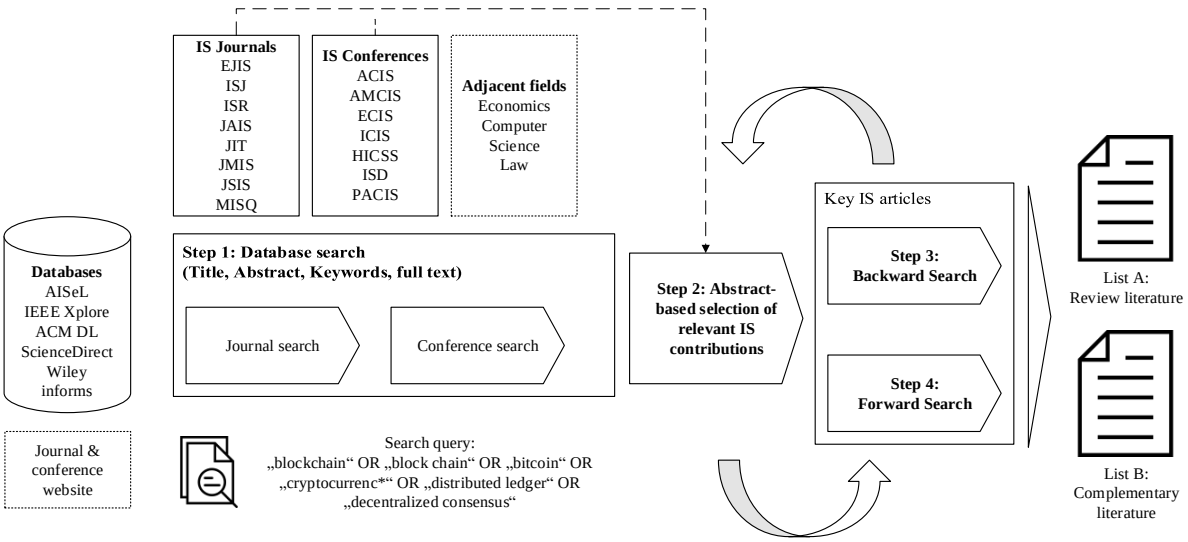

Figure 1. ***Literature Search and Selection Process:*** *This figure displays the four step approach employed in the literature search and selection process. In the first step, we conducted an extensive database search to identify key articles in the top eight peer-reviewed, scientific IS journals, recommended IS conferences, and adjacent fields. In Step 2, we selected articles for the detailed review. Based on those, we performed backward and forward searches in step 3 and 4, respectively. We repeated steps 2, 3, and 4 until our search did not yield any new results.*

First, we selected a comprehensive set of scientific databases, such as AISeL, IEEE Xplore, ACM DL, EBSCO Business Source Premier, ScienceDirect, the Wiley Online Library, and informs. Within these databases, we searched titles, keywords, abstracts, and full texts by applying the following search string: “blockchain” OR “block chain” OR “bitcoin” OR “cryptocurrenc*” OR “distributed ledger” OR “decentralized consensus”. Since blockchain technology was introduced in 2008 (Nakamoto, 2008), we limited the search to dates later than January 1, 2008. The first database queries were conducted in June 2016. However, to take the most recent articles into account, we updated the search between the 16th and the 20th of November 2016. Whenever there were no database entries for one of the selected IS journals or conferences, we checked the journals’ or conferences’ websites to retrieve the latest research articles. To account for the interdisciplinary nature of the field of IS we furthermore extended our search scope to adjacent fields such as economics and finance, computer science, and law. Within those fields, we exclude publications not labelled as research papers, such as research commentaries, keynotes, news, editorials, extended abstracts, book reviews, PhD-theses, or posters. The review of literature in adjacent fields preserves a complementary character and does not claim to be a complete overview of existing blockchain-related research.

In the second step, we selected a primary set of relevant IS research papers by reviewing each paper’s abstract, as suggested by Vom Brocke et al. (2009). Studies that did not contain any of the keywords previously specified in the search query in their abstract or that did not have a primary focus on blockchain research were not considered any further.

For the remaining papers we third, performed a backward and fourth, a forward search. IS articles identified in these steps were added to the selection of relevant literature and both a backward and forward search were performed again. Articles that were not published in one of the top eight IS journals or one of the selected conferences were added to the list of adjacent research efforts and excluded from the IS review. We repeated the steps 2, 3, and 4 until we did not find any new articles. Eventually, we obtained two lists of publications related to blockchain research. List A contains all IS articles included in our

structured review, whereas list B contains all articles excluded in step 2 of the search process as well as all complementing articles from adjacent fields.

4 Literature Review Results

4.1 Summary Statistics and Research Perspectives

The literature search process yielded a total of 427 articles, whereof 1 was published in the Senior Scholars' Basket of Eight and 49 in one of the selected IS conferences. Furthermore 29 complementary papers were published in other renowned IS journals such as "Business & Information Systems Engineering" and "Communications of the Association for Information Systems", or specialized IS conferences. The exclusion of papers only vaguely related to distributed ledgers and blockchain technology, resulted in a list of 26 IS conference papers and no IS journal contributions. Table 1 depicts the distribution of the relevant articles across (complementary) journals and conferences.

IS Literature	Hits	Relevant
Management Information Systems Quarterly (MISQ)	1	0
Australasian Conferences on Information Systems (ACIS)	1	1
Americas Conference on Information Systems (AMCIS)	12	5
European Conference in Information Systems (ECIS)	17	12
International Conference on Information Systems (ICIS)	8	3
Hawaii International Conference on System Science (HICSS)	8	3
International Conference on Information System Development (ISD)	0	0
Pacific Asia Conference on Information Systems (PACIS)	3	2
Total	50	26

Table 1. ***Core IS Literature:*** *This table shows the number of articles published in the core IS journals and conferences and differentiates between found (hits) and relevant contributions.*

In Table 2, we display the chronological distribution of articles across different fields, starting with the introduction of the blockchain in 2008. Similar to economics and finance, the number of IS publications, remained substantially low until 2014, while the fields of computer science and legal studies started to pick up the topic one year earlier in 2013. These developments seem to coincide with the increasing popularity of Bitcoin, which exceeded the weekly moving average of 50,000 transactions per day[4] at the beginning of 2013. Overall, 86.4% of blockchain-related research was published within the year 2014 or later. In total, articles published in the field of computer science account for more than half of the publications related to blockchain today. The IS community contributes a comparatively small share of 19.4%..

Before summarizing the most important insights from the IS literature, we will give a brief overview on the different views on blockchain from the perspectives of economics and finance, computer science and informatics, and legal sciences in the subsequent paragraph. While researchers in the field of economics and finance mainly concentrate on the characteristics of cryptocurrency markets by analyzing Bitcoin price formation, market efficiency (Nadarajah and Chu, 2017; Fry and Cheah, 2016; Dyhrberg, 2016a), or portfolio diversification effects (Dyhrberg, 2016b; Brière et al., 2015; Bouri et al., 2016), blockchain research in computer science is quite diverse. While some efforts aim to improve the performance of mining technology (Dev, 2014) or solve scalability issues (Karame, 2016), others assess the technology's potential aside of cryptocurrencies (Xu et al., 2016; Hari and Lakshman). However, one

[4] See https://blockchain.info/en/charts/n-transactions?timespan=all&daysAverageString=7.

of the most discussed topics is privacy and security (Zyskind et al., 2015; Kosba et al., 2016; Gervais et al., 2016; Eyal, 2015). In turn, research in the field of law follows two major streams: The first one analyzes the use of cryptocurrencies for criminal activities, such as funding terrorism, online black markets, or white-collar crimes (Irwin and Milad, 2016; Barratt, 2015; Marian, 2013). The second stream focuses on the calls for regulatory actions and the need for legal innovations in the face of cryptocurrency markets and blockchain applications (Farmer, 2014; Burleson, 2013; Varriale, 2013; Gump and Leonard, 2016).

Year	IS Journals	IS Conf.	Comp.					Total	
			IS	Eco	CS	Law	Total	Abs.	Rel.
2008	0	0	0	0	3	0	3	**3**	**0.7%**
2009	0	0	0	0	1	0	1	**1**	**0.2%**
2010	0	0	0	0	1	0	1	**1**	**0.2%**
2011	0	2	0	3	7	0	10	**12**	**2.8%**
2012	0	4	0	1	7	1	9	**13**	**3.0%**
2013	0	0	0	2	21	4	27	**27**	**6.3%**
2014	1	11	4	15	34	9	62	**74**	**17.3%**
2015	0	19	9	36	56	3	104	**123**	**28.8%**
2016	0	13	16	46	83	14	159	**172**	**40.3%**
2017	0	0	0	1	0	0	1	**1**	**0.2%**
Total Abs.	**1**	**49**	29	104	213	31	377	**427**	
Total Rel.	**0.2%**	**11.5%**	7.7%	24.4%	49.9%	7.3%	88.3%		

Table 2. ***Summary Statistics:*** *This table provides a chronological distribution over all research perspectives, namely IS, economics and finance (Eco), computer science and informatics (CS), and legal sciences (Law).*

4.2 Literature Classification

As a basis for the concept matrix of our literature review, we performed a keyword analysis on the relevant IS literature (list A) identified in the literature search and selection process. In a first step, we calculated the Levenshtein or edit distance (Levenshtein, 1965) between all keywords, in order to measure the number of morphological changes required to transform a random keyword into a search keyword. This allowed us not only to account for transpositions and similar keywords, such as "cryptocurrencies" and "cryptocurrency" but also to identify subsets of keywords, such as "bitcoin" and "bitcoins". For clustering, we then joined the strings with "[…] the minimum number of insertions, deletions and substitutions to make both strings equal" (Navarro, 2001). In the second step, we then grouped keywords related to similar concepts, such as "bitcoin" and "cryptocurrencies" for instance. Based on these groupings we devised the following four concepts: "Blockchain technology", "Trust-free economic systems", "Bitcoin & cryptocurrencies", and "Financial Service Innovation & FinTech". All papers that addressed more than one of the identified concepts or emphasized blockchain or Bitcoin as a use case in the context of another concept (e.g. payment systems) were assigned to their primary field of interest.

4.3 Blockchain in the Information Systems Literature

As stated in the previous section, we identified four central areas of interest within the most important IS journals and conferences related to blockchain – "Blockchain technology", "Trust-free economic systems", "Bitcoin & cryptocurrencies", and "Financial service innovation & FinTech". Table 3 depicts the allocation of the most relevant IS articles within the corresponding concept matrix.

	Blockchain technology	Trust-free economic systems	Bitcoin & crypto-currencies	Financial service innovation & FinTech
Beck et al. (2016)		x		
Brenig et al. (2016)	x			
Dhillon (2016)			x	
Frey et al. (2016)	x			
Geng (2016)				x
Ingram and Morisse (2016)			x	
Wörner et al. (2016)	x			
Baiyere and Salmela (2015)				x
Brenig et al. (2015)			x	
Connolly and Kick (2015)			x	
Dahlberg et al. (2015)				x
Glaser and Bezzenberger (2015)	x			
Greiner and Hui (2015)		x		
Hur et al. (2015)			x	
Ingram et al. (2015)			x	
Kazan et al. (2015)			x	
Lustig and Nardi (2015)		x		
Mai et al. (2015)			x	
Morisse (2015)			x	
Fürstenau and Kliewer (2014)			x	
Glaser et al. (2014)			x	
Kazan and Damsgaard (2014)				x
Kazan et al. (2014)				x
Liebenau et al. (2014)				x
Moser et al. (2013)			x	
Hjelholt and Damsgaard (2012)				x
Puschmann et al. (2012)				x

Table 3. ***Concept Matrix:*** *This table shows the allocation of the most relevant IS studies from the Senior Scholars' Basket of Eight journals and selected IS conferences within the concept matrix of our review.*

Blockchain technology: There is only a small set of articles within the IS community that primarily focuses on distributed ledgers, decentralized consensus systems, or the underlying blockchain technology itself. Wörner et al. (2016) investigate the evolution of the blockchain technology and assess the importance of distributed ledgers beyond Bitcoin and financial services. They analyze and classify 704 blockchain start-ups (599 thereof are related to Bitcoin in some form), and briefly discuss their innovative potential. Overall, they provide an overview of the blockchain industry and illustrate use cases for real world blockchain applications, such as notary services, management of digital assets, market places, and financial service providers. Glaser and Bezzenberger (2015) form a basic foundation for future research by increasing the level of abstraction by briefly introducing and devising seven technical archetypes of decentralized consensus systems. The systems are classified based on the underlying mechanism, external and pegged valuation, the characteristics of the community, the service focus, whether the code base was built from scratch or derived from another implementation such as Bitcoin, and

whether tokens are used for transactions or verification. Brenig et al. (2016) extend this approach and develop a framework to evaluate the economic value of decentralized consensus systems as a technical infrastructure for applications that go beyond cryptocurrencies. In contrast to these abstract classification and evaluation frameworks, Frey et al. (2016) propose a blockchain-based approach to address privacy concerns in recommender systems utilizing secure multiparty computation (Zyskind et al., 2015). Their solution "cryptographically guarantees customer's privacy in recommender systems" (Frey et al., 2016, p. 5) and thus allows to store encrypted user data and run computations while access to the raw data is limited to the owner.

Trust-free economic systems: Amongst others, a central feature of blockchain-based economic systems is the enforcement of rules and contracted agreements among conflicting agents in a decentralized setup. Introducing the notion of trust-free systems, Greiner and Hui (2015) propose to address trust issues in peer-to-peer systems, such as Bitcoin, by eliminating the need for trust instead of employing costly trust-building mechanisms and insurance measures. In such a system, governing institutions or interpersonal trust get replaced by cryptographic protocols and decentralized consensus algorithms. Beck et al. (2016) elaborate on this notion and develop a blockchain-based proof of concept prototype to replace a trust-based coffee shop payment system with a system that operates trust-free by completing transactions based on self-enforcing rules. Based on their prototype the authors combine a technological, economic, and user perspective, and argue, that blockchain technology has the potential to replace trust-based payment systems, increasing the cost efficiency of microtransactions. The concept of being trust-free, however remains unclear, since one could argue that trust will not be replaced but rather shift from central institutions or market authorities towards algorithms. These need to be formed by predefined rules that eventually govern the agent's interactions (Maurer et al., 2013). Thus, human users are required to trust in algorithms instead of traditional institutions. To investigate the characteristics of this algorithmic form of trust, Lustig and Nardi (2015) conducted an explorative survey among Bitcoin users. Overall, their findings suggest, that algorithmic trust is not limited to the correct functioning of the algorithm but rather includes a variety of sociotechnical factors (e.g. based on the ecosystem of services offered for the Bitcoin currency).

Bitcoin & Cryptocurrencies: Compared to other concepts discussed before, IS researchers are highly engaged in the analysis of issues surrounding Bitcoin and other cryptocurrencies. Morisse (2015) conducts a systematic concept centric review of 42 IS papers related to digital currencies and groups them into 3 main categories: (i) The protocol layer comprises research that aims to improve the existing Bitcoin protocol. (ii) The network layer covers examinations of the peer-to-peer network of Bitcoin and other cryptocurrencies. The majority of the found papers is assigned to (iii) the ecosystem layer, which focusses on the underlying economic mechanisms of cryptocurrency networks. Across all layers however, Bitcoin is the central focus of the research efforts. Based on his review, Morisse (2015) identifies potential areas of interest, such as cultural implications, the facilitation of novel business models, as well as the resulting challenges for the financial services industry and highlights the opportunities for the interdisciplinary field of IS research. Most cryptocurrency studies however, focus on specific issues in the context of Bitcoin entrepreneurs und users.

From the entrepreneurial perspective Connolly and Kick (2015), examine factors that distinguish organizational early adopters form non-adopters. They argue that the adoption of Bitcoin as means of payment is critically dependent on the availability of places, where goods or services can be purchased with Bitcoin. Based on their qualitative, categorical analysis they find that early adopters, i.e. firms that already accept Bitcoins, exhibit a higher IT-readiness, innovativeness, and social media presence than their reluctant counterparts. Ingram et al. (2015) and Ingram and Morisse (2016) go beyond the adoption phase and analyze the ability of firm's already in the Bitcoin business to survive shock events and investigate strategies employed by such firms to establish mainstream operations. In a series of semi-structured interviews with CEOs of Bitcoin-related start-ups, Ingram et al. (2015) find that the system's decentralized nature and the resulting entanglement of social and technological aspects facilitates the entrepreneur's belief in the community and thus gives them a joint resiliency and strategic flexibility in

the face of shock events. In addition, Ingram and Morisse (2016) identify the conformation to mainstream rules and leveraging the local position within the Bitcoin community as core strategies to transition Bitcoin-based operations to a broader customer base. Kazan et al. (2015) pose a more general question and investigate the business models of companies within the Bitcoin network and how they create and capture value.

Glaser et al. (2014) discard a purely entrepreneurial perception and investigate the user's motivation when exchanging fiat currency for a digital currency, such as Bitcoin. Within their empirical study, they analyze Bitcoin exchange trading volume and network loads and find indications, that large proportions of the users rather consider Bitcoin as a speculative investment vehicle, i.e. an asset, than an alternative means of payment, i.e. a currency. Mai et al. (2015) ask a similar question and investigate the trading behavior of Bitcoin users by analyzing the impact of social media activity on prices and trading volumes. Their empirical study provides evidence that the number of positive (negative) postings leads to significantly higher (lower) future Bitcoin returns and that disagreement among postings induces higher trading volume – which supports Bitcoin speculative nature. Hur et al. (2015), who analyze the arbitrage opportunities between Bitcoin markets and traditional currencies, mostly support these findings. However, their evidence also suggests, that Bitcoin's speculative nature (Baek and Elbeck, 2014) does not dominate user's behavior entirely and Bitcoin's current incapability as a currency could also be attributed to low levels of interaction and network effects (Fürstenau and Kliewer, 2014) instead of the investors' speculative motives only. Besides the use as investment vehicles, cryptocurrencies also attract white-collar crime and other criminal ventures (Moser et al., 2013), such as funding acts of terror (Irwin and Milad, 2016), money laundering activities, or online black markets. In this context, Brenig et al. (2015) analyze the incentives of criminals to exploit cryptocurrencies for money laundering. Their findings provide evidence for the utilization of digital currencies as money laundering tools. Within their study, the authors list pseudonymous authentication, flexibility, irrevocable and instantaneous transactions, international transferability, and low transaction costs as major drivers. In addition, the use of Bitcoin to buy and sell goods on dark market places, such as the infamous "Silk Road" (Dhillon, 2016), increases the amount of money entangled in criminal activities.

Financial Service Innovation & FinTech: Payment of goods and services through physical means of payment, such as coins, bank notes or credit cards, has been a standard in the financial services and banking industry for decades. However, with the rise of digital payment platforms, such as "Paypal", and other disruptive payment technologies, such as Bitcoin (Baiyere and Salmela, 2015), traditional service providers face a new form of competition. Hjelholt and Damsgaard (2012) (2012) examine the genesis of these new competitors, and analyze how digital payment platforms emerge from socio-technological niches, and evolve to compete with and eventually substitute incumbent services. Based on examples, such as Bitcoin, they devise a conceptual framework to illustrate the transition process and highlight the importance of institutional support in the transition phase. Kazan and Damsgaard (2014) focus on digital payment systems as well and construct a framework to study platform design with respect to technological and business aspects. Within their comparative case study, they focus on mutlisided platforms but do not include cryptocurrencies or any other blockchain-based platforms. Dahlberg et al. (2015) on the other hand, examine how potential disruptive payment technologies, such as mobile payment systems or Bitcoin, might challenge banks and other financial institutions and thus alter payment ecosystems dramatically. They highlight Bitcoin as a role model for an alternative payment system that formed outside the traditional monetary system but still fulfills the key features as medium of exchange and account, means of payment, and store of value defined by classical and neoclassical theory. So although Bitcoin user's do not use these features most of the time (Glaser et al., 2014), they have the chance to utilize them if they want to. Kazan et al. (2014) discard the generic and holistic platform approach and conduct a comparative study of the disruptive potential of centralized and decentralized payment providers. Their findings suggest that centralized platforms, such as "Paypal" seek to create monopolistic structures, while decentralized systems, such as Bitcoin, accelerate market disruption by mobilizing external innovation by third parties through a transparent, non-discriminatory, inclusive, and open strategic orientation. Within this market environment innovative payment platforms and other

competitors, such as non-banks or FinTechs put pressure on traditional banks and financial service providers to transform towards more customer-oriented service infrastructures and product portfolios (Puschmann et al., 2012). These new competitors, differ from the incumbents in three ways: They carve out new niches and offer traditional products and services in novel ways, they are built on modular and flexible business models, and enter the market using novel data handling approaches (Liebenau et al., 2014) and superior data analytics techniques (Geng, 2016).

5 Research Challenges and Opportunities

Blockchain in IS literature is an emerging research area with a huge potential, which calls for further attention (Gomber et al., 2016).While to date, issues related to blockchain are scarcely discussed in top tier IS journals, conference proceedings increasingly started to broach the issues of blockchain-based technologies (Table 2) but mainly focus on taxonomy development (Glaser and Bezzenberger, 2015), industry frameworks (Brenig et al., 2016), use case analyses (Wörner et al., 2016), and design science aspects of smart contract-based prototypes (Beck et al., 2016). Moreover, most of these studies put an increased focus on entrepreneurial (Connolly and Kick, 2015; Ingram and Morisse, 2016; Ingram et al., 2015; Kazan et al., 2015) and user-specific issues (Glaser et al., 2014; Mai et al., 2015; Hur et al., 2015) related to Bitcoin but rarely go beyond this use case. Other research streams addressing blockchain technology itself or the role of blockchain in the context of trust-free economic systems deliver first valuable insights on how the blockchain might be understood and leveraged as an IT-artifact, inter alia enabling a shift from trust in institutions to trust in algorithms (Lustig and Nardi, 2015). In addition, research methodologies range from empirical models (Glaser et al., 2014), over semi-structured interviews (Ingram et al., 2015) and surveys (Lustig and Nardi, 2015), to case studies and design science-based prototyping (Beck et al., 2016). At the same time, research approaches and findings are dispersed across a variety of other disciplines such as computer science (50%), economics and finance (24%), and law (7%). IS accounts only for 19% of the journal and conference proceedings listed in Table 2.

While the application of blockchain technology in a variety of financial or other market settings is broadly discussed in the public press (Kassin, 2016) and exhibits an increasing relevance in the business context (Consultancy.uk, 2016), IS research on decentralized economic systems is still in its infancy. Literature on blockchain-based financial market innovation primarily deals with the competitive impact of FinTech start-ups on established financial service providers, neglecting technological aspects of blockchain-based economic systems.

In total, our findings indicate that, IS research rarely goes beyond Bitcoin-related topics and exhibits a strong dispersion with regard to the focus, methodology and specific issues addressed. Without a structured alignment of these different views on blockchain, it is difficult to put existing research results into perspective and to derive clear managerial or research implications. In order to take the lead in this emerging, interdisciplinary research area, efforts should be focused on the central issues of understanding the potential of blockchain technology as an IT-artifact in different (financial) market scenarios. In combination with the rising relevance of FinTech, the complexity and multidimensional nature of this issue, a structured approach to guide future research efforts is imperative. We hence, propose the interdisciplinary research framework of Market Engineering (Weinhardt et al., 2003; Weinhardt and Gimpel, 2007; Gimpel et al., 2008) that helps to structure and understand the characteristics of blockchain-based markets and ecosystems and provides a guideline for the design, implementation, and analyses of blockchain-based platforms and applications. The framework provides a holistic view and supports the active construction of markets by taking the socio-economic and legal environment, market microstructure, IT infrastructure, and business structure, as well as the decisions and behavior of agents, and the resulting outcomes into account.

6 Towards a Market Engineering Approach

"Market Engineering is the process of consciously setting up or re-structuring a market in order to make it an effective and efficient means for carrying out exchange transactions" (Weinhardt and Gimpel, 2007, p. 6). Offering an interdisciplinary, holistic toolbox to systematically analyze, structure, design, and construct the elements of market platforms, to identify areas of application, and to develop theoretically founded design and evaluation procedures, the Market Engineering approach, is well suited to guide research on developing blockchain-based markets. Based on the Market Engineering Framework (Weinhardt et al., 2003; Weinhardt and Gimpel, 2007; Gimpel et al., 2008), we aim to provide a unified guideline to evaluate past and consciously structure future blockchain research. In contrast to (Glaser, 2017), whose primary focus is on technological aspects, we suggest a theoretical foundation framework for the blockchain as an IT-artifact in the field of economic applications. In doing so, we support the identification of applications and areas, in which blockchain-based economic systems offer effective and efficient solutions. We furthermore build on the descriptive frameworks of Glaser and Bezzenberger (2015), and Brenig et al. (2016) (i.e. a taxonomy system, knowledge bases for common concepts, and use case analyses on a global level). We extend these approaches by going beyond the provision of pure classification schemes and instead suggest a means to actively support the construction of blockchain-based infrastructures on the micro and macro level.

In Figure 2 we introduce the Blockchain Market Engineering Framework, which provides an integrated, holistic view of interconnected and pivotal elements of blockchain-based platforms and surrounding factors. To account for the openness of the technology and its capability to pervade multiple elements of the Market Engineering Framework, we follow Glaser (2017) and add a multi-layer perspective. As the basic macro layer, the environment layer captures legal, social and economic constraints determined by the field of application, legal requirements, the transaction object, and other external contingencies. It is important to note that the transaction object is not limited to a physical object but rather is an abstraction and includes any form of information or object that is transacted over the blockchain network. Building on the environment layer, the infrastructure layer implements the blockchain protocol, and thus specifies the characteristics of the virtual machine eventually running the application logic. Within the infrastructure layer, we differentiate between the protocol layer and the hardware layer. The hardware layer comprises a heterogeneous crowd of interconnected devices that provides the computational power to run the virtual machine that constitutes the runtime environment of the decentralized system. The protocol layer, also known as fabric layer (Glaser, 2017), implements the actual code of the blockchain protocol and thus facilitates the communication between the nodes, enforces agreements, and determines the level of security. In short, the protocol layer defines the basic elements of the IT-artifact, i.e. the distributed database, the consensus algorithm, and the cryptographic protocol, that enable the tokenization of economic value and the implementation of decentralized applications on a micro level. Together, the hardware and the software layer form the backbone of the distributed system and provide the foundation of the microeconomic design, i.e. the micro- and business structure, of potential applications in the application layer. Based on these realized applications, the characteristics and behavior of the interacting economic agents – human and artificial - within the created ecosystem can be analyzed. In combination with the environment layer, which defines the foundation, the agent layer allows the analyses of market outcomes, application performance, or other system properties from a macroeconomic perspective. In addition, the agent layer allows the study of the individual's behavior from a microeconomic perspective. One aspect for instance, is the agent's incentive to participate in the process of truth revelation, which can range from monetary incentives, like in the Bitcoin system, over asymmetrically distributed information or conflicts of interest, such as in the "Market for Lemons" (Akerlof, 1970), to simply decreasing transaction costs (Davidson et al., 2016).

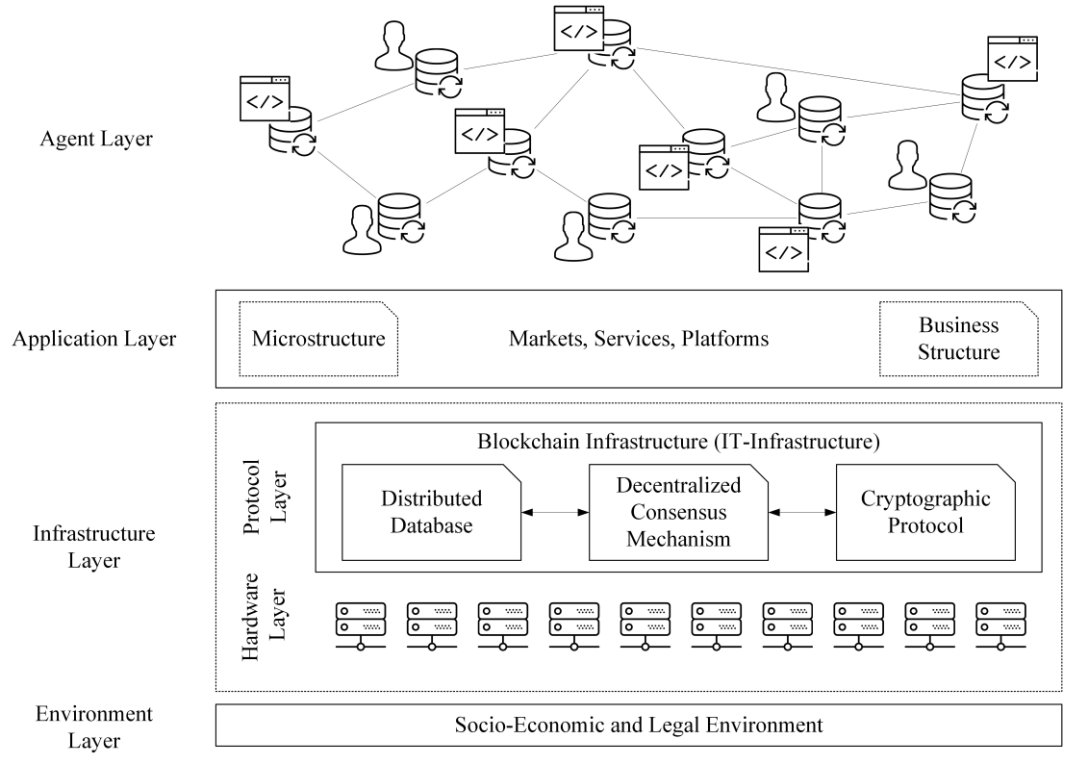

Figure 2. ***Blockchain Market Engineering Framework****: This figure shows the Blockchain Market Engineering Framework and its pivotal elements and layers.*

7 Future Research Directions

Overall, we perceive the blockchain as a decentralized infrastructure that not only supports markets, but also other forms of platform-based applications, such as customer-oriented financial service platforms (Puschmann et al., 2012; Alt and Puschmann, 2016) crowdfunding and -investing (Glaser, 2017), or multi-sided markets in the realm of the sharing economy (Puschmann and Alt, 2016) – potentially reshaping the issue of trust (Hawlitschek et al., 2016a; Hawlitschek et al., 2016b). Within this scope, the Blockchain Market Engineering Framework provides a guideline, to direct future research in the field of IS and supports researchers and practitioners to identify key concepts of blockchain-based economic systems in their endeavors. However, these key concepts should not be limited to specific elements of our framework but also take dependencies, interactions, and reciprocal relationships among the respective elements into account. Moreover, we encourage the blockchain community to go beyond a pure engineering perspective and include all stakeholders, such as users, regulatory bodies, and other third parties in their interdisciplinary analyses. In addition, IS researchers should go beyond the known use cases and adopt blockchain as an IT-artifact to connect human and artificial agents on a decentralized level. In consequence, future research directions include but are not limited to design science approaches to explore the technological capabilities of blockchain-based economic systems, experimental approaches to analyze users' behavior and their perception of trust-free economic systems, as well as survey-based approaches to evaluate usage intentions and acceptance. In addition, theoretical and empirical models and simulation-based analyses allow the assessment of economic system properties, overall system characteristics, the applications' microstructure, and outcomes in (financial) market setups.

8 Conclusion

The blockchain is a truly fascinating technology with a set of characteristics that have the potential to transform and disrupt a variety of different industries, such as financial markets (Fanning and Centers, 2016), transaction and asset management systems (Ruault, 2016) , or the Sharing Economy (Sundararajan, 2016). However, in order to transition from a buzzword at the top of the Gartner Hype Cycle (Gartner, 2016) to an established technological basis for real-world market applications, blockchain technology still has a long way to go. As we demonstrated in our literature review, IS research can play a leading role in facilitating and shaping this transition and the growing base of IS research articles addressing blockchain-related issues will help both researchers and practitioners to address distributed ledger technology from an interdisciplinary point of view. However, in order to make a valuable contribution to the field of creating blockchain-based markets, IS researchers may profit from a common language and approach to structure their research efforts, put them into perspective with respect to the elements blockchain systems and position their work in relation to other contributions. In order to help and guide IS researchers in doing so, we introduced the Blockchain Market Engineering Framework, comprising the layers and corresponding elements of blockchain-based applications. With this framework, we hope to make a valuable contribution to both research and practice and to create the basis for future research in the context of engineering blockchain-based markets.

References

Ahangama, S., and Poo, D.C.C. (2016). "Credibility of Algorithm Based Decentralized Computer Networks Governing Personal Finances: The Case of Cryptocurrency." In: *HCI in Business, Government, and Organizations: eCommerce and Innovation: Third International Conference, HCIBGO 2016, Held as Part of HCI International 2016.* Springer International Publishing, pp. 165–176.

Akerlof, G.A. (1970). "The Market for "Lemons". "Quality Uncertainty and the Market Mechanism". *The Quarterly Journal of Economics,* 84 (3), pp. 488.

Alt, R., and Puschmann, T. (2016). *Digitalisierung der Finanzindustrie. Grundlagen der Fintech-Evolution*. Berlin, Heidelberg: Springer Gabler.

Baek, C., and Elbeck, M. (2014). "Bitcoins as an investment or speculative vehicle? "A first look". *Applied Economics Letters,* 22 (1), pp. 30–34.

Baiyere, A., and Salmela, H. (2015). "Wicked yet Empowering - When IT Innovations are also Disruptive Innovations." In: *ICIS 2015 Proceedings.*

Barratt, M.J. (2015). "Drugs on the Dark Net. "How Cryptomarkets Are Transforming the Global Trade in Illicit Drugs by James Martin Hampshire, UK: Palgrave Pivot, Palgrave Macmillan, 2014 ISBN 9781137399045, 92 pp. Hardback. Price: £45.00". *Drug and Alcohol Review,* 34 (4), pp. 458–459.

Beck, R., *et al. (*2016). "Blockchain - The Gateway to Trust-Free Cryptographic Transactions." In: *ECIS 2016 Proceedings.* AIS Electronic Library: Association for Information Systems (AIS).

Bellare, M., Namprempre, C., and Neven, G. (2009). "Security Proofs for Identity-Based Identification and Signature Schemes". *Journal of Cryptology,* 22 (1), pp. 1–61.

Benbasat, I., and Zmud, R.W. (2003). "The Identity Crisis within the Is Discipline: Defining and Communicating the Discipline's Core Properties". *MIS Quarterly,* 27 (2), pp. 183–194.

Bouri, E., *et al. (*2016). "On the hedge and safe haven properties of Bitcoin. "Is it really more than a diversifier?". *Finance Research Letters*.

Brenig, C., Accorsi, R., and Müller, G. (2015). "Economic Analysis of Cryptocurrency Backed Money Laundering." In: *ECIS 2015 Proceedings.* AIS Electronic Library: Association for Information Systems (AIS).

Brenig, C., Schwarz, J., and Rückeshäuser, N. (2016). "Value of Decentralized Consensus Systems - Evaluation Framework." In: *ECIS 2016 Proceedings.* AIS Electronic Library: Association for Information Systems (AIS).

Brière, M., Oosterlinck, K., and Szafarz, A. (2015). "Virtual currency, tangible return. "Portfolio diversification with bitcoin". *Journal of Asset Management,* 16 (6), pp. 365–373.

Bundesbank (2016). *Joint Deutsche Bundesbank and Deutsche Börse blockchain prototype.* URL: https://www.bundesbank.de/Redaktion/EN/Pressemitteilungen/BBK/2016/2016_11_28_blockchain_prototype.html (visited on 12/02/2016).

Burleson, J. (2013). "Bitcoin: The Legal Implications of a Novel Currency". *Review of Banking & Financial Law,* 33 (1), pp. 99–105.

Connolly, A., and Kick, A. (2015). "What Differentiates Early Organization Adopters of Bitcoin From Non-Adopters?" In: *AMCIS 2015 Proceedings.* AIS Electronic Library: Association for Information Systems (AIS).

Consultancy.uk (2016). *Two thirds of European FinTech startups eye strong revenue growth.* URL: http://www.consultancy.uk/news/12840/two-thirds-of-european-fintech-startups-eye-strong-revenue-growth (visited on 12/03/2016).

Cooper, H.M. (1988). "Organizing knowledge syntheses. "A taxonomy of literature reviews". *Knowledge in Society,* 1 (1), pp. 104–126.

Dahlberg, T., *et al. (*2015). "M-Payment - How Disruptive Technologies Could Change The Payment Ecosystem." In: *ECIS 2015 Proceedings.* AIS Electronic Library: Association for Information Systems (AIS).

Davidson, S., Filippi, P. de, and Potts, J. (2016). "Economics of Blockchain". *SSRN Electronic Journal*.

Dev, J.A. (2014). "Bitcoin mining acceleration and performance quantification." In: *Canadian Conference on Electrical and Computer Engineering (CCECE).* IEEE, pp. 1–6.

Dhillon, G. (2016). "Money Laundering and Technology Enabled Crime: a cultural analysis." In: *AMCIS 2016 Proceedings.*

Dinger, J., and Hartenstein, H. (2006). "Defending the Sybil attack in P2P networks: taxonomy, challenges, and a proposal for self-registration." In: *First International Conference on Availability, Reliability and Security (ARES'06).* Los Alamitos, Calif.: IEEE Computer Society, pp. 8 pp-763.

Dyhrberg, A.H. (2016a). "Bitcoin, gold and the dollar – A GARCH volatility analysis". *Finance Research Letters,* 16, pp. 85–92.

Dyhrberg, A.H. (2016b). "Hedging capabilities of bitcoin. Is it the virtual gold?". *Finance Research Letters,* 16, pp. 139–144.

Economist (2015). *The trust machine. The promise of the blockchain.* URL: http://www.economist.com/news/leaders/21677198-technology-behind-bitcoin-could-transform-how-economy-works-trust-machine (visited on 11/29/2016).

Ethereum (2016). *Proof of Stake FAQ.* Etherum Wiki. URL: https://github.com/ethereum/wiki/wiki/Proof-of-Stake-FAQ (visited on 11/29/2016).

Eyal, I. (2015). "The Miner's Dilemma." In: *IEEE Symposium on Security and Privacy (SP).* IEEE, pp. 89–103.

Fanning, K., and Centers, D.P. (2016). "Blockchain and Its Coming Impact on Financial Services". *Journal of Corporate Accounting & Finance,* 27 (5), pp. 53–57.

Farmer, P. (2014). "Speculative Tech: The Bitcoin Legal Quagmire & the Need for Legal Innovation". *Journal of Business & Technology Law,* 9 (1), pp. 85. URL: http://digitalcommons.law.umaryland.edu/jbtl/vol9/iss1/6.

Frey, R., Wörner, D., and Ilic, A. (2016). "Collaborative Filtering on the Blockchain: A Secure Recommender System for e-Commerce." In: *AMCIS 2016 Proceedings.*

Fry, J., and Cheah, E.-T. (2016). "Negative bubbles and shocks in cryptocurrency markets". *International Review of Financial Analysis,* 47, pp. 343–352.

Fürstenau, D., and Kliewer, N. (2014). "Standards Diffusion in Growing Networks: Modelling Interaction Patterns." In: *ECIS 2014 proceedings.* AIS Electronic Library: Association for Information Systems (AIS).

Gartner (2016). *3 Trends Appear in the Gartner Hype Cycle for Emerging Technologies.* URL: http://www.gartner.com/smarterwithgartner/3-trends-appear-in-the-gartner-hype-cycle-for-emerging-technologies-2016/ (visited on 12/02/2016).

Geng, D. (2016). "Data Analytics on Consumer Behavior in Omni-Channel, Retail Banking, Card and Payment Services." In: *PACIS 2016 Proceedings.*

Gervais, A., *et al. (*2016). "On the Security and Performance of Proof of Work Blockchains." In: *Proceedings of the 2016 ACM SIGSAC Conference on Computer and Communications Security - CCS'16.* New York, New York, USA: ACM Press, pp. 3–16.

Giaglis, G.M., and Kypriotaki, K.N. (2014. "Towards an Agenda for Information Systems Research on Digital Currencies and Bitcoin. Ed. by . *Business Information Systems Workshops. BIS 2014 International Workshops*Springer International Publishing, pp. 3–13.

Gimpel, H., *et al. (*2008. "Market Engineering: A Research Agenda. Ed. by H. Gimpel, *et al., eds. Negotiation, Auctions, and Market Engineering. International Seminar, Dagstuhl Castle, Germany, November 12-17, 2006, Revised Selected Papers*Berlin, Heidelberg: Springer-Verlag Berlin Heidelberg, pp. 1–15.

Gimpel, H., Rau, D., and Röglinger, M. (2016). "Fintech-Geschäftsmodelle im Visier". *Wirtschaftsinformatik & Management,* 8 (3), pp. 38–47. URL: http://link.springer.com/content/pdf/10.1007%2Fs35764-016-0057-z.pdf.

Gipp, B., Meuschke, N., and Gernandt, A. (2015). "Decentralized trusted timestamping using the crypto currency bitcoin". *arXiv preprint arXiv:1502.04015*.

Glaser, F., *et al. (*2014). "Bitcoin-Asset or Currency? Revealing Users' Hidden Intentions." In: *ECIS 2014 proceedings.* AIS Electronic Library: Association for Information Systems (AIS).

Glaser, F. (2017). "Pervasive Decentralisation of Digital Infrastructures: A Framework for Blockchain enabled System and Use Case Analysis." In: *Hawaii International Conference on System Sciences (HICSS) 2017.* IEEE.

Glaser, F., and Bezzenberger, L. (2015). "Beyond Cryptocurrencies - A Taxonomy of Decentralized Consensus Systems." In: *ECIS 2015 Proceedings.* AIS Electronic Library: Association for Information Systems (AIS).

Gomber, P., Kauffman, R.J., and Weber, B.W. (2016). *FINANCIAL IS, UNDERLYING TECHNOLOGIES, AND THE FINTECH REVOLUTION. A Call for Papers: Special Issue of the Journal of Management Information Systems.* URL: http://www.jmis-web.org/cfps/JMIS_SI_Fintech.pdf (visited on 12/03/2016).

Greiner, M., and Hui, W. (2015). "Trust-free Systems - a New Research and Design Direction to Handle Trust-Issues in P2P Systems: The Case of Bitcoin." In: *AMCIS 2015 Proceedings.* AIS Electronic Library: Association for Information Systems (AIS).

Gump, A., and Leonard, C. (2016). "Blockchain: regulating the future of finance". *International Financial Law Review, pp.* 1.

Hari, A., and Lakshman, T.V. "The Internet Blockchain." In: *Proceedings of the 15th ACM Workshop on Hot Topics in Networks - HotNets '16.* New York, New York, USA: ACM Press, pp. 204–210.

Hawlitschek, F., *et al. (*2016a). "Trust in the Sharing Economy: An Experimental Framework." In: *ICIS 2016 Proceedings.*

Hawlitschek, F., Teubner, T., and Weinhardt, C. (2016b). "Trust in the Sharing Economy". *Die Unternehmung - Swiss Journal of Business Research and Practice,* 70 (1), pp. 26–44.

Hjelholt, M., and Damsgaard, J. (2012). "The Genesis and Evolution of Digital Payment Platforms." In: *ECIS 2012 Proceedings.* AIS Electronic Library: Association for Information Systems (AIS).

Hur, Y., Jeon, S., and Yoo, B. (2015). "Is Bitcoin a Viable E-Business?: Empirical Analysis of the Digital Currency's Speculative Nature." In: *ICIS 2015 Proceedings.*

Ingram, C., and Morisse, M. (2016). "Almost an MNC: Bitcoin Entrepreneurs' Use of Collective Resources and Decoupling to Build Legitimacy." In: *Hawaii International Conference on System Sciences (HICSS) 2016.* IEEE, pp. 4083–4092.

Ingram, C., Morisse, M., and Teigland, R. (2015). "'A Bad Apple Went Away': Exploring Resilience Among Bitcoin Entrepreneurs." In: *ECIS 2015 Proceedings.* AIS Electronic Library: Association for Information Systems (AIS).

Irwin, A.S.M., and Milad, G. (2016). "The use of crypto-currencies in funding violent jihad". *Journal of Money Laundering Control,* 19 (4), pp. 407–425.

Karame, G. (2016). "On the Security and Scalability of Bitcoin's Blockchain." In: *Proceedings of the 2016 ACM SIGSAC Conference on Computer and Communications Security - CCS'16.* New York, New York, USA: ACM Press, pp. 1861–1862.

Kassin, I. (2016). *How Fintech Companies Can Capture The Millennial Market.* Forbes. URL: http://www.forbes.com/sites/forbesfinancecouncil/2016/12/01/how-fintech-companies-can-capture-the-millennial-market/#48030a3064d3 (visited on 12/03/2016).

Kazan, E., and Damsgaard, J. (2014). "An Investigation of Digital Payment Platform Designs: a Comparative Study of Four European solutions." In: *ECIS 2014 proceedings.* AIS Electronic Library: Association for Information Systems (AIS).

Kazan, E., Tan, C.-W., and Lim, E.T. (2015). "Value Creation in Cryptocurrency Networks: Towards A Taxonomy of Digital Business Models for Bitcoin Companies." In: *AMCIS 2015 Proceedings.* AIS Electronic Library: Association for Information Systems (AIS).

Kazan, E., Tan, C.-W., and Lim, E.T.K. (2014). "Towards a Framework of Digital Platform Disruption." In: *Australasian Conference on Information Systems (ACIS).* Australasian Association for Information Systems (AAIS).

Kosba, A., *et al. (*2016). "Hawk: The Blockchain Model of Cryptography and Privacy-Preserving Smart Contracts." In: *IEEE Symposium on Security and Privacy (SP).* IEEE, pp. 839–858.

Lamport, L., Shostak, R., and Pease, M. (1982). "The Byzantine Generals Problem". *ACM Transactions on Programming Languages and Systems,* 4 (3), pp. 382–401.

Lee Kuo Chuen, D., ed. (2015. *Handbook of digital currency. Bitcoin, innovation, financial instruments, and big data*. 1st ed. Amsterdam: Academic Press Elsevier.

Levenshtein, V. (1965). "Binary codes capable of correcting spurious insertions and deletions of ones". *Problems of information Transmission,* 1 (1), pp. 8–17.

Li, C.-T., *et al. (*2015). "A Hash Based Remote User Authentication and Authenticated Key Agreement Scheme for the Integrated EPR Information System". *Journal of medical systems,* 39 (11), pp. 144.

Liebenau, J.M., Elaluf-Calderwood, S.M., and Bonina, C.M. (2014). "Modularity and Network Integration: Emergent Business Models in Banking." In: *8th International Symposium on Service-Oriented System Engineering (SOSE).* IEEE, pp. 1183–1192.

Lustig, C., and Nardi, B. (2015). "Algorithmic Authority: The Case of Bitcoin." In: *Hawaii International Conference on System Sciences (HICSS) 2015.* IEEE, pp. 743–752.

Mai, F., *et al. (*2015). "From Bitcoin to Big Coin. "The Impacts of Social Media on Bitcoin Performance." In: *ICIS 2015 Proceedings.*

Malone, D., and O'Dwyer, K.J. (2014). "Bitcoin Mining and its Energy Footprint." In: *25th IET Irish Signals & Systems Conference 2014 and 2014 China-Ireland International Conference on Information and Communities Technologies (ISSC 2014/CIICT 2014).* [Piscataway, N.J.]: [IEEE], pp. 280–285.

Marian, O.Y. (2013). "Are Cryptocurrencies 'Super' Tax Havens?". *Michigan Law Review (*38).

Maurer, B., Nelms, T.C., and Swartz, L. (2013). "“When perhaps the real problem is money itself”: the practical materiality of Bitcoin". *Social Semiotics,* 23 (2), pp. 261–277.

Mock, V. (2016). *Investment Plan for Europe: EUR 105 million support for thermal energy in Germany.* URL: http://europa.eu/rapid/press-release_MEX-16-3691_en.htm (visited on 12/02/2016).

Morisse, M. (2015). "Cryptocurrencies and Bitcoin: Charting the Research Landscape." In: *AMCIS 2015 Proceedings.* AIS Electronic Library: Association for Information Systems (AIS).

Moser, M., Bohme, R., and Breuker, D. (2013). "An inquiry into money laundering tools in the Bitcoin ecosystem." In: *ECIS 2012 Proceedings.* IEEE, pp. 1–14.

Nadarajah, S., and Chu, J. (2017). "On the inefficiency of Bitcoin". *Economics Letters,* 150, pp. 6–9.

Nakamoto, S. (2008). "Bitcoin: A Peer-to-Peer Electronic Cash System". *white paper.* URL: https://bitcoin.org/bitcoin.pdf.

Navarro, G. (2001). "A guided tour to approximate string matching". *ACM Computing Surveys,* 33 (1), pp. 31–88.

Puschmann, T., and Alt, R. (2016). "Sharing economy". *Business & Information Systems Engineering,* 58 (1), pp. 93–99.

Puschmann, T., Nueesch, R., and Alt, R. (2012). "Transformation Towards Customer-Oriented Service Architectures in the Financial Industry." In: *ECIS 2012 Proceedings.* AIS Electronic Library: Association for Information Systems (AIS).

Ruault, P. (2016). "Collateral management — Winners or losers in five years' time?". *Journal of Securities Operations & Custody,* 8 (1), pp. 41–45.

Sundararajan, A. (2016). *The Sharing Economy. The End of Employment and the Rise of Crowd-Based Capitalism*. s.l.: The MIT Press.

Szabo, N. (1994. *Smart Contracts.* URL: http://szabo.best.vwh.net/smart.contracts.html.

Varriale, G. (2013). "Market poll: the best way to regulate Bitcoin". *International Financial Law Review, pp.* 39.

Viola, R., and Guersent, O. (2016). *European Commission sets up an internal Task Force on Financial Technology.* URL: https://ec.europa.eu/digital-single-market/en/blog/european-commission-sets-internal-task-force-financial-technology.

Vom Brocke, J., *et al. (*2009). "Reconstructing the Giant: On the Importance of Rigour in Documenting the Literature Search Process." In: *ECIS 2009 Proceedings.* AIS Electronic Library: Association for Information Systems (AIS).

Wattenhofer, R. (2016). *The science of the blockchain*: Inverted Forest Publishing.

Webster, J., and Watson, R.T. (2002). "Analyzing the Past to Prepare for the Future: Writing a Literature Review". *MIS Quarterly,* 26 (2), pp. xiii–xxiii.

Weinhardt, C., and Gimpel, H. (2007. "Market Engineering: An Interdisciplinary Research Challenge. Ed. by . *Dagstuhl Seminar Proceedings*.

Weinhardt, C., Holtmann, C., and Neumann, D. (2003). "Market-Engineering". *WIRTSCHAFTSINFORMATIK,* 45 (6), pp. 635–640.

Wörner, D., *et al. (*2016). "The Bitcoin Ecosystem: Disruption Beyond Financial Services?" In: *ECIS 2016 Proceedings.* AIS Electronic Library: Association for Information Systems (AIS).

Xu, X., *et al. (*2016). "The blockchain as a software connector." In: *Working IEEE/IFIP Conference on Software Architecture (WICSA).* IEEE.

Zyskind, G., Nathan, O., and Pentland, A.'. (2015). "Decentralizing Privacy: Using Blockchain to Protect Personal Data." In: *Security and Privacy Workshops (SPW).* IEEE, pp. 180–184.