DISRUPTING INDUSTRIES WITH BLOCKCHAIN: THE INDUSTRY, VENTURE CAPITAL FUNDING, AND REGIONAL DISTRIBUTION OF BLOCKCHAIN VENTURES

Research paper

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Abstract

The blockchain (i.e., a decentralized and encrypted digital ledger) has the potential to disrupt many traditional business models. This study investigates the emerging blockchain business-application landscape by analysing its industry, venture capital funding, and regional distribution. By matching four venture databases on blockchain-based startups we create a unique database in order to analyse the technology from a diffusion of innovation theoretical perspective. First, our results show that blockchain startups are present across all industry segments and are most prominently represented in the Finance & Insurance and Information & Communication industries. A fine-grained analysis of financial services yields increasing novel applications in existing service offerings – especially in payment networks and processing. Second, consistent with the first result, we find that mainly Finance & Insurance and Information & Communication industries are funded by venture capital, but that blockchain startups are present across all industries. Third, our regional distribution analysis of the emerging ventures identifies two leading geographical blockchain clusters (i.e., the US and UK). Overall, our study contributes to the literature by providing one of the first empirical analyses of blockchain-based business applications.

Keywords: blockchain, business models, bitcoin, disruptive innovation.

1   Introduction

The blockchain (i.e., a decentralized and encrypted digital ledger) was recently acknowledged as one of the top 10 emerging technologies by the World Economic Forum 2016 (Cann, 2016). Prior to this notable acknowledgement, The Economist published several articles in its print edition about "the trust machine" (The Economist, 2015b, The Economist, 2015a) and therefore introduced this remarkable new technology to a broader public audience. Prior to these developments, information science and business practice already started to explore the vast potential of blockchain technology with numerous proofs of concepts apart from its origin - developing cryptocurrencies (e.g., Bitcoin (Nakamoto, 2008)). The decentralized and tamperproof ledger technology is expected to have far more use cases than digital currencies with bitcoin as its most prominent application (Tapscott and Tapscott, 2016).

Whereas the blockchain's cross-industry potential may be considered huge (Moody's, 2016), it is unclear how blockchain startups are operating across industries and product/service categories. Moreover, there does not exist a comprehensive overview of neither the actual distribution of venture capital (VC) funding across the industries nor the location of blockchain startups. However, for understanding the advancement of blockchain technology and its current state, investigating these underresearched aspects of blockchain technology operations is crucial. In this vein, it is important to differentiate between theoretical blockchain applications and their business implementation to gauge the disruption potential of extant business models by blockchain technology. By mapping the existing blockchain activities and analyzing how it is used across industries and regions, we can gain an understanding of the disruptive potential of blockchain technology apart from purely conceptual considerations and can evaluate the technology from a diffusion of innovation theoretical perspective (cf. Rogers, 2003).

Hence, the aim of this study in answering these research questions is threefold. First, this study investigates the state of the blockchain landscape by examining the distribution of blockchain-based startups across industries, and, in particular, the occurrence of product/service categories in financial services. Taking into account the distribution of the identified startups across industries, we analyze how entrepreneurs evaluate possible applications across industries and service categories. Second, we match the distribution of startups with the allocation of venture capital investment by analyzing how funding is allocated across industries up until today. Third, we analyze to what extent blockchain technology is a global phenomenon and identify startup clusters by investigating where blockchain activity is concentrated. We do so by merging four different startup databases ("Blockchain Ecosystem Database", "VentureRadar", "Coindesk" and "Crunchbase"). Thus, we build the most comprehensive overview of the current blockchain landscape to provide a profound deep dive into blockchain business applications.

The paper is organized as follows. In section two, we discuss the theoretical framework for the current blockchain landscape. Subsequently, we present the empirical setting with its data set and describe the results in section four. We are concluding the paper with a discussion of the findings and their theoretical and practical implications.

2   Theoretical Framework

In the following sections, we set the theoretical background by introducing basic principles of blockchain technology and perceptions of it being a trust machine. In Section 2, we give an overview on essential principles of disruptive innovation, whereas Section 3 defines the attributes of the diffusion of innovation theory. The section concludes with a theoretical overview of research on business model applications for blockchain technology.

2.1   The trust machine

Digital currencies have been suffering two evident problems until the introduction of bitcoin. So far, central institutions (i.e., a central bank for currencies) have provided trust to the system with time-

stamped transactions and, thus, assured the integrity of the system. The absence of a central source of trust raises the issue of system integrity with two important issues. First, there needs to be a guarantee that nobody can spend the same money twice. This issue is known as the double-spending problem (Karame et al., 2015). On the other hand, the decentralized system needs to operate within an environment where participants cannot be sure of the trustworthiness of other participants. This issue takes the name the Byzantine's generals problem (Lamport et al., 1982). Nakamoto's bitcoin protocol solves this problem with its consensus protocol. It provides trust even without a central intermediary and works on a peer-to-peer network; hence, it is fully decentralized. The protocol builds on three basic pillars in order to provide neutral trust within the system: decentralization, consensus, and cryptography.

Decentralization means that the database is distributed with participants in the system. In the case of the bitcoin database, everyone has the possibility to possess a full copy (i.e., act as a node (Wright and De Filippi, 2015)). This has in a big advantage: Hackers would need to get through not just one central institution or central server in order to manipulate the whole system, but various copies of that. Hackers are facing a peer-to-peer network where there is no server, centralized service, or hierarchy in the network (Antonopoulos, 2014). This makes the database less vulnerable to attacks. But it also enables nodes that have gone offline for some time to update their database and reintegrate into the system.

Nevertheless, it might be possible that more versions of the database exist. Participants have to agree on the correct source of truth, with some kind of voting rights, in order to agree on one specific blockchain (Mattila, 2016). This process of agreeing on one correct source of truth is a consensus and it is the second pillar of blockchain technology. Nakamoto's (2008) consensus builds upon the Proof of Work concept introduced by Back (2002). It relies on computational power and its inherent costs: Once a mathematical problem is solved by brute-forcing it—hence using computational power and energy—the node (or miner) has the right to add a block to the blockchain. Participating nodes subsequently can rapidly verify the correctness and add the block onto their database. The longest chain within the system represents the actual single source of truth within the bitcoin blockchain system (Nakamoto, 2008).

However, for understanding the mechanisms of blockchain technology, the third pillar, "cryptography," is crucial. In the bitcoin blockchain and the Proof of Work , some cryptographic technologies are necessary for digital signatures and data integrity—i.e., public/private keys and secure hash algorithms (Federal Information Processing Standards, 2015). First, by applying the concept of public and private keys, the bitcoin blockchain assures the authenticity of participants sending transactions within the system. Public keys, first introduced by Diffie and Hellman (1976), are used to correctly identify accounts (i.e., bitcoin accounts) and private keys to authenticate the user or possessor of bitcoins, respectively. This concept also finds use in encrypted website communications such as HTTPS (Böhme et al., 2015). The private key in the bitcoin protocol is used to sign the instruction to transfer bitcoins from the owner's account to another account; therefore, it gives an assurance that the transaction originally came from the initial bitcoin owner (Böhme et al., 2015). While the public key itself refers to publicly available data of a bitcoin account, it helps to verify the initiation of transactions (Figure 1).

This implies that the bitcoin is not a coin but rather a chain of digital signatures (Nakamoto, 2008). Nakamoto's protocol uses private keys to sign transactions that contain the new owner's public key and the previous transaction history of the electronic coin (i.e., bitcoin). Hence, participants in the system can assess the transaction history of every single electronic coin.

In addition to public and private keys, the SHA-256 cryptography is applied within the bitcoin blockchain (Nakamoto, 2008). This algorithm generates hash values that have certain characteristics, which, in combination with all three pillars, make the bitcoin protocol unique. SHA-256 (Federal Information Processing Standards, 2015) generates a one-way unique hash value (Dang, 2012). A one-way hash signifies that the input data always derives a specific hash value, but it is economically unfeasible to reconvert the hash value to its original data input. Once the data input becomes (just slightly) altered, a completely uncorrelated new hash value results from SHA-256 encryption. These properties ensure that SHA-256 and its resulting hash values find use in various applications such as digital signatures and data integrity (Dang, 2012). Especially data integrity is one of blockchain technology's key features.

For every transaction, a unique hash value is calculated (see Figure 1). Numerous transactions are then bundled in a Merkle tree (Merkle, 1988), i.e. resulting in one unique aggregated hash value for all transactions combined. Together with the hash of the previous block, the time stamp, and a nonce, they form the block itself. The nonce represents the mathematical problem of the Proof of Work concept developed by Nakamoto. Overall, the chaining of blocks ensures than no one can manipulate data without first needing to redo the work to find solutions to the mathematical problems.

Hence, the three pillars of blockchain technology—namely decentralization, consensus, and cryptography—build the foundation for the tamperproof ledger that is the focus of attention these days. To describe the different pillars, the bitcoin blockchain, as the first and largest blockchain, presents an explanatory example. Various different approaches, however, exist for specific parts of decentralization, consensus, and/or cryptography in other blockchain solutions. Nonetheless, the above-described features of blockchain technology generally result in the perception that blockchains serve as trust machines (The Economist, 2015b).

2.2 Diffusion of innovation theory

Rogers (2003) defines five attributes for the diffusion of innovation: relative advantage, compatibility, complexibility, trialability, observability. The higher the degree of these attributes, the higher the possibility of a high rate of adoption. The only exception represents the degree of complexibility, where a lower complexibility is supporting adoption while higher degree hinders a faster adoption of an innovation. A more detailed definition of Rogers'(2003) attributes is presented below:

Relative advantage	The degree to which an innovation is perceived as being better than the idea it supersedes
Compatibility	The degree to which an innovation is perceived as consistent with the existing values, past experiences, and needs of potential adopters
Complexibility	The degree to which an innovation is perceived as relatively difficult to understand and use
Trialability	The degree to which an innovation may be experimented with on a limited basis
Observability	The degree to which the results of an innovation are visible to others

2.3 Revolution or evolution: Essentials of disruptive innovations

The digital transformation of business models makes it necessary for companies to elaborate a strategy to manage (radical) changes in value creations (Hess et al., 2016, Veit et al., 2014). Matt et al. (2015, p. 340) formulate four different dimensions for such digital transformation strategies: use of technologies, changes in value creation, structural changes, and financial aspects. Blockchain technology, however, affects the first two of their dimensions as the technology can be utilized to bypass middlemen in the process of value creations and reduce frictions within systems. It therefore has the potential to be disruptive.

In its initial context, disruption describes a development where a smaller company—initially focused on the lower and least profitable end of the market—rises toward a challenging competitor of incumbents (Christensen, 1997) in the highly profitable customer segments. Over the past 20 years, the academic discussion about a general definition of disruption was and is still ongoing (Yu and Hang, 2010, Christensen, 2006, Schmidt and Druehl, 2008, Markides, 2006, Garcia and Calantone, 2002). While most literature follows Christensen's proposition of disruption (Yu and Hang, 2010), his theory does not allow clearly differentiating between low-performing technologies and initially inferior technology (Tellis, 2006, Wörner et al., 2016), nor does it offer a solution to the measurability of its degree of disruptiveness (Govindarajan and Kopalle, 2006). It is possible to determine only in retrospect whether a technology really was disruptive.

In contrast to disruptive innovation, sustainable innovation represents improvements that are either incremental or major but that still enhance the service offering for the most profitable customers (Christensen et al., 2015). This is normally reflected in product and process innovations but also in innovating entire business models (Bucherer et al., 2012), where business models can be defined as "the rationale how an organization creates, delivers and captures value" (Osterwalder and Pigneur, 2010). Furthermore, technology shifts are not only a problem of technology innovation, but also have a close relation to the core of business models (Tongur and Engwall, 2014). If technological innovation develops a new technology, then this affects business models as well. It could totally change how companies, or in this case incumbents, create, deliver, and capture value (Tongur and Engwall, 2014). If managers of incumbents overlook the rise of a new technology with lower costs, higher performance, and/or better fit to customer needs, then they face a huge risk of disruption and eventually becoming insignificant. Blockchain technology could represent one of such.

2.4   Business models and services across industries

The three-pillar basis of the blockchain protocol emerged in 2008 (Nakamoto, 2008). The nature of blockchain protocols relies on three main principles: decentralization, cryptography, and consensus. The combination of these principles allows creating a tamperproof database (also referred to as a ledger (European Central Bank, 2016)) that had its first use case with cryptocurrencies, such as the bitcoin. Since the blockchain protocol is applicable to a variety of transaction ledgers beyond cryptocurrency applications, it is now being considered for applications in other business segments within the financial services industry (Peters and Panayi, 2015).

Blockchain technology serves as a ledger for fast transactions (Moody's, 2016), providing trust (Deloitte, 2016) within a system of unknown users. Even though some dispute the cost-efficiency of the bitcoin protocol (O'Dwyer and Malone, 2013, Moody's, 2016), the World Economic Forum recently emphasized the potential in the banking industry with its report on the future of the financial infrastructure (WEF, 2016). The UniCredit bank published its view on the impact of blockchain technology in the banking industry (UniCredit, 2016), stating its impact on payments, know-your-customer processes, trade finance, and post-trading (as well: DTCC, 2016). The SWIFT Institute also expects "substantial reductions in both cost and risk" within certain business areas of financial services (Mainelli and Milne, 2016). In capital markets, blockchains could affect, among other business models, clearing houses, exchanges, brokers, or remittances (McKinsey, 2015). A similar result comes from Deutsche Bank Research, which sees the highest potential in real-time money transfer, cryptocurrencies, and settlement (Dapp, 2016). Insurance, another part of financial services, also holds potential for blockchain technology applications. In a recent study, McKinsey identifies the following applications: among others, automation by smart contracts, easier fraud detection, and reduction of administrative costs (McKinsey, 2016). Hence, in financial services, there are many possibilities for applying blockchain technology. This could allow entrepreneurs to harness this potential.

Apart from financial applications, a distributed ledger has potential for use in other industries as well. In their book *The Blockchain Revolution*, D. Tapscott and A. Tapscott evaluate a large number of further applications beyond the financial services industry, creating a "Blockchain Utopia" by predicting[1] a pure peer-to-peer economy and the return of data ownership to users (Tapscott and Tapscott, 2016). They identify application potential especially in public services, another prominent industry with regard to ledgers. The UK Government Office for Science published a recent report on the potential of blockchain technology in governmental services (Walport, 2016). The report identifies use cases in protecting critical infrastructure, departments for work and pensions, as well as possibilities in the improvement of international aid systems, and potential within the area of taxation. Moreover, Moody's predicts its potential for use in voting systems and identity management (Moody's, 2016).

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[1] Or, as they would personally state, the achieved rather than predicted future.

An unresolved issue of blockchain technology as of today is the missing technology standards. The competition between the different concepts of public/private and permissionless/permissioned block-chains is still ongoing. Different solutions and forms of the technology are still being assessed (Hyperledger, 2016, Buterin, 2014, Brown, 2016). In addition, there is still a need for an appropriate solution for the energy-consuming concept (O'Dwyer and Malone, 2013) and for avoiding the pitfalls of competing concepts. This competition has the potential to lead to a high penetration of blockchain startups in the information and communications sector.

When building a peer-to-peer economy, however, concepts such as the prosumer and the retail customer (for instance, as extant in the energy sector) become important. In these cases, the self-supplying con-sumer produces more energy than necessary and sells the surplus. With blockchain technology, this consumer could reach the retail energy consumer and get a retail energy price rather than a wholesale price from the big intermediary. A recent study by the Verbraucherzentrale Nordrhein-Westfalen (NRW) and PricewaterhouseCoopers (2016) assesses the potential of blockchain technology within the energy sector. A de-central controlled transaction and energy delivery system could be one possible use case. In addition, smart contracts could find application in further contract and document management (Verbraucherzentrale NRW and PricewaterhouseCoopers AG, 2016).

Overall, the extensive potential of blockchain applications across industries and product or service of-ferings is evident. Our research assesses this potential and its use based on a comprehensive data set of blockchain startups to map out the current blockchain landscape from different perspectives. On the one hand, this is from an "entrepreneur's perspective," when analyzing the evaluation of entrepreneurs of possible blockchain applications by taking into account the distribution of startups across industries. On the other hand, it is from a "venture capitalist's perspective," by analyzing the amount of venture capital funding allocated across industries up until today.

3   Data set and Methodology

We use four data sets from different databases to derive a comprehensive overview of existing block-chain startups. We created and analyzed the final data set as of June 15, 2016. It contains 1,140 startups that use blockchain technology as part of their business models. In order to provide a holistic view of the current blockchain landscape, we use four different databases (for detailed information, see Appen-dix A). First, the open-source Blockchain Ecosystem Database (Blockchain Ecosystem Database, 2016) helped generate an initial list of blockchain startups. The Blockchain Ecosystem Database (Blockchain Ecosystem Database, 2016) classifies the different ecosystems into their sector and product or service category. At the time of the data collection, it contained 923 ecosystems. This initial list was extended with three additional databases: VentureRadar (VentureRadar, 2016), CoinDesk (CoinDesk, 2016), and Crunchbase (Crunchbase, 2016b). From VentureRadar (VentureRadar, 2016), we identified 336 startups with the search query "blockchain." The news and insights company CoinDesk (CoinDesk, 2016) pro-vided a further selection of bitcoin and blockchain startups. Using their database helped to identify an-other 137 startups. Finally, we searched the venture capital database Crunchbase (Crunchbase, 2016b) for further startups. By searching the short description section of the database with the queries "block-chain" and "bitcoin," we were able to merge another set of 267 startups with the existing data set. In total, we derived a list of 1,663 startups. After correcting for double listings and updated company names, all startups were analyzed and categorized in industries and product or service classes (when it has not been classified in the databases already). Existing classifications were revised and adjusted where a more intuitive denomination was necessary. We removed from the dataset any ecosystems clas-sified as cryptocurrencies or digital currencies, as they are not pure blockchain startups but rather dif-ferent blockchain protocols with little market capitalization and, by nature of blockchain protocols, are not startups.

Understanding the current expectations of the market potential of blockchain technology requires deriv-ing a financial distribution within blockchain-related investments. Thus, the next step was to merge the

list of 1,140 categorized startups with venture capital funding data extracted from the Crunchbase database (Crunchbase, 2016a).

4 Results

This section first gives an overview from the entrepreneur's perspective, and subsequently provides the venture capitalist's perspective. The regional distribution of the blockchain landscape completes the three-dimensional analysis approach outlined above.

4.1 The blockchain landscape from an entrepreneur's perspective

Figure 1 presents the entrepreneur's view on blockchain technology applications. The 1,140 startups show the distribution of blockchain startups across industry sectors in which entrepreneurs harness the potential for blockchain application.

With a 42.4% share, the Finance & Insurance sector represents the largest share of blockchain applications. The second-largest group of startups operates in the Information & Communication industry with a 36.5% share, emphasizing the origin of the technology in the area of data and information.

Professional services (e.g., business consulting, lawyers, coaching, audit) take the third-largest share of 4%. As blockchain technology is a complex new technology, the provision of professional services is necessary for companies that have little to no involvement in the technology so far, in order to assess potential implications for their business model(s). The media industry takes 2.6% of the total share, with startups covering expert opinions as well as legal, regulatory, and general developments within the blockchain industry.
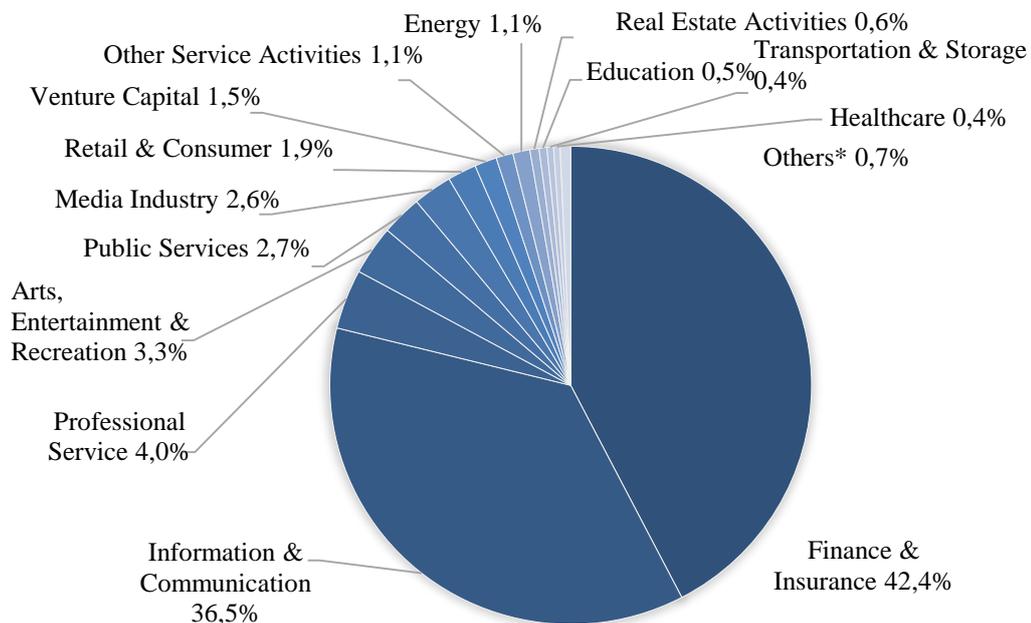

Figure 1.   Percentage of startups operating in each industry sector.

Not only do traditional blockchain industries appear in the data set but so do industries that have not been associated with blockchain technology right from the beginning. The Arts, Entertainment & Recreation sector represents 3.3% of blockchain startups. Next come Public Services (2.7%), Retail & Consumer (1.9%), Energy (1.1%), and Healthcare (0.4%).

4.2   Product or service categories in Finance & Insurance

In total, we identified 23 different product and service offerings in the data set for the Finance & Insurance sector (Figure 2). One can clearly see the influence of bitcoin and cryptocurrencies—the origin of blockchain technology—when looking at the leading service category of Figure 3, Financial Exchanges & Trading. With 181 of 483 startups in the Finance and Insurance sector, Exchanges and Trading services still constitute the center of blockchain technology. However, different business models have already started to evolve apart from the basic trading of cryptocurrencies. Nevertheless, on combining all pure bitcoin- and cryptocurrency-related business models, Financial Exchanges & Trading (181), Wallet (29), ATM (20) account for 47.6% of blockchain startups in the Finance and Insurance sector.

On the other hand, Payment Processing (63 startups) as well as Payment & Asset Networks (40 startups), together with general Financial Services (59 startups), make up nearly as big a portion of business models as Financial Exchanges & Trading itself. Crowdfunding Platforms with 16 startups, represent another application of blockchain technology within the Finance and Insurance sector. In the lower third of the figure, the representation of different business models is very fragmented. It reduces to single-figure representations.
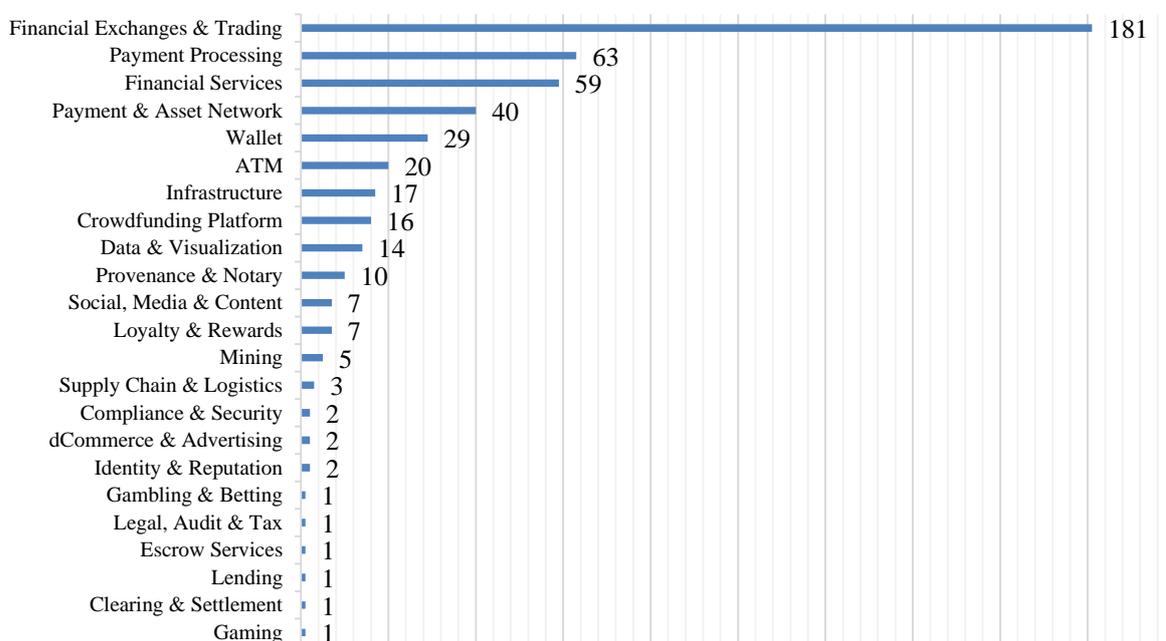

Figure 2.   Number of startups by products and services in Finance & Insurance sector.

4.3   The blockchain landscape from a venture capitalist's perspective

As a comparison to the entrepreneur's perspective, we add a venture capitalist's perspective to the assessment of the blockchain landscape. Table 1 shows the distribution of venture capital funding across sectors. Investments in startups of the data set sums up to USD 1,547 million. The biggest industries in terms of having received funding are Finance & Insurance as well as Information & Communication. Both industries together received nearly USD 1,500 million of venture capital investment, representing approximately 97% of the overall funds. While the Finance & Insurance industry received USD 805.6 million in investments from risk-seeking investors, Information & Communication received USD 694.33 million. When comparing the average funding of startups within the data set, both industries show the same average funding per startup of USD 1.67 million.

The table shows a huge difference between the two sectors and the remaining industries from the data set. While Finance & Insurance, and Information & Communication are the only two sectors with more than USD 500 million as investment, eight out of 19 industries have not received any funding at all. It is notable that the Energy sector, with 13 startups in the data set, does not show any investment in their blockchain applications at all. The same holds for e.g. Healthcare (five startups), Education (six startups), and Transportation & Storage (five startups).

Nonetheless, similar to the entrepreneur's perspective, Professional Services startups are the third-largest industry in terms of venture capital investment. Until mid-2016, this sector received USD 20.11 million in investment, with, on average, USD 0.44 million invested per startup. This positions the Professional Services sector as the only one in the double-digit space.

The Arts, Entertainment & Recreation sector ranks fourth in terms of absolute startup numbers and remains on the same position in terms of absolute venture capital funding. But its average investment of USD 0.26 million per startup is smaller than the comparable sectors: Retail & Consumer with USD 0.35 million investment per startup and Venture Capital with USD 0.37 million funding per startup. Although positioned seventh in terms of numbers of startups, Retail & Consumer received USD 7.62 million; therefore, it ranks fourth by venture capital funds as one industry with bigger potential of blockchain technology.

Sector	VC funding, in million USD	Number of startups	Avg. VC funding in million USD
Agriculture, Forestry & Fishing	-	2	-
Arts, Entertainment & Recreation	9.80	38	0.26
Education	-	6	-
Finance & Insurance	805.60	483	1.67
Food & Beverages	-	1	-
Healthcare	-	5	-
Information & Communication	694.33	416	1.67
Other Service Activities	0.18	13	0.01
Professional Service	20.11	46	0.44
Public Services	1.11	31	0.04
Real Estate Activities	1.30	7	0.19
Telecommunications	-	1	-
Transportation & Storage	-	5	-
Venture Capital	6.30	17	0.37
Media Industry	0.55	30	0.02
Energy	-	13	-
Tourism Industry	0.18	3	0.06
Aviation & Space	-	1	-
Retail & Consumer	7.62	22	0.35
Grand Total	**1,547.08**	**1,140**	**1.36**

Table 1.   Venture capital funding of blockchain startups in total.

4.4   Regional distribution of blockchain landscape

In this section, we examine the geographical distribution of the blockchain landscape. As evident from Figure 4, the distribution of blockchain startups across the globe nearly covers the biggest regions. Figure 4 shows that the US hosts the largest group of startups—a total of 365 (32.02%). The UK ranks second with regard to the assembly of startups in the blockchain landscape, with 127 startups (11.14%) and startup headquarters. Nevertheless, startups in the US outnumber the second largest cluster in UK by three times. Table 2 shows the absolute and relative distribution of startups across the globe. The 29 countries represent 90.79% of the total distribution of 68 different countries in the data set. North America is the most penetrated region hosting 397 startups, including the US with 365 startups and Canada
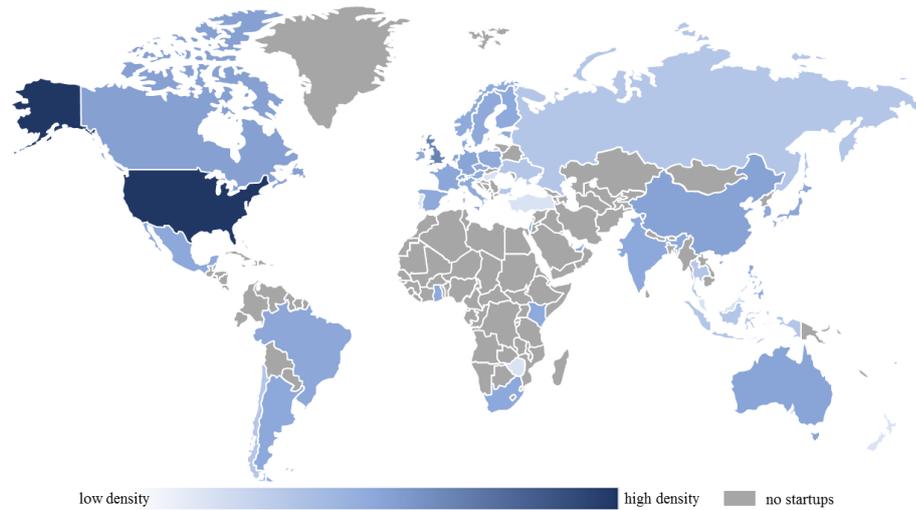
Figure 3.   Color-coded world map of blockchain startup density.

with 32. Europe is close behind North America, with 300 startups. The European countries in Table 2 with the highest count of blockchain startups are led by the UK with 127 startups, and followed by the Netherlands (28), Germany (22), Switzerland (18), France (14), Spain, Poland, Sweden, and Estonia (seven each). Asia follows as the third-biggest region in the data sample with 140 startups, representing 12.28%.

Of the startups, 19.39% either explicitly specified operating in a fully decentralized manner or did not publish any information about the location of their headquarters' destination. Making it into the top three leading categories from a geographical perspective and together with the US and UK counting more than one hundred blockchain ventures. The distribution of blockchain startups is spread all around the world and is increasing steadily, with some primary clusters in North America (US) and Europe (UK).

Country	#	%	Country	#	%
United States	365	32.02%	Japan	13	1.14%
No HQ*	221	19.39%	Hong Kong	13	1.14%
United Kingdom	127	11.14%	Mexico	9	0.79%
Canada	32	2.81%	Argentina	8	0.70%
Netherlands	28	2.46%	South Africa	8	0.70%
China	27	2.37%	India	8	0.70%
Singapore	27	2.37%	Republic of Korea	8	0.70%
Germany	22	1.93%	Spain	7	0.61%
Australia	20	1.75%	Poland	7	0.61%
Israel	19	1.67%	Sweden	7	0.61%
Switzerland	18	1.58%	Philippines	7	0.61%
France	14	1.23%	Estonia	7	0.61%
Brazil	13	1.14%	…	…	….
	Total startups			**1,140**	
N. America (N.A.)	397	34.82%	Asia	140	12.28%
Americas w/o N.A.	42	3.68%	Oceania	22	1.93%
Europe	300	26.32%	Africa	18	1.58%
*Set if companies do not specify their headquarters' location or if they operate in a decentralized manner.					

Table 2.   Table 1.Venture capital funding of blockchain startups in total.

4.5   Venture capital investment across countries

When analyzing the regional distribution of blockchain ventures, it is interesting to see where venture capital firms invest. For the analysis of this part, we match the five highest-funded industries from the data set with the regional distribution of the 20 highest-funded industries (see Table 3). Here, the US shows the highest investment of all countries, with roughly USD 772 million invested. Apart from Finance & Insurance and Information & Communication, the invested funds for all remaining industries are mainly allocated in the US. The UK, despite the high representation of startups, only shows an investment of USD 39 million. On the other hand, Ireland (USD 136 million) and Canada (USD 110 million) show high investments compared to their absolute numbers of startups.

The venture capital investment in Finance & Insurance as well as Information & Communication has clear clusters within the US, but the distribution is better across other countries. However, "No HQ" with a sole investment of USD 160 million in Information & Communication is noteworthy, as it represents the second-highest category in comparison to the presented countries.

4.6   Diffusion of innovation for blockchain technology

With the distributions of blockchain ventures across industries, VC funding and regions the different perceived attributes of innovation according to Rogers (2003). Table 4 shows the deduction of the four attributes of Rogers' diffusion of innovation theory.

Perceived attributes of innovation	Deduction for blockchain technology
Relative advantage	Blockchain technology offers the possibility for (data related) products and/or services that are cheaper, faster and more secure than existing technologies.
Compatibility	With blockchain technology current market frictions can be overcome by creating peer-to-peer networks in many senses. Results show that mainly current business models and industries are prone to this innovation.
Complexibility	Blockchain technology relies on three pillars: decentralization, consensus, and cryptography. This unique combination a priori makes it rather difficult to understand.
Trialability	The current distribution of applications of blockchain technology across industries and products/services shows its high degree of trialability
Observability	Results of innovation for blockchain technology at this early stage are visible mostly to experts.

Table 4.   Blockchain technology's perceived attributes of innovation (cf. Rogers, 2003).

5   Discussion

This quantitative part of the study examines how blockchain technology is disrupting industries from three different angles: First, we analyze the distribution of blockchain startups by determining the allocation of startups across industry sectors. By diving into the Finance & Insurance and Information & Communication sectors, we evaluate different applications of the new technology within existing business models. Subsequently, we consider the allocation of venture capital investment by distinguishing the current funding of blockchain applications across industries. Both analyses combined show the advancements of the disruption caused by blockchain technology across industries. The regional allocation of blockchain startups delivers an additional view of the current landscape, with two rising clusters. Examining the industry distribution of startups, the "home turf" of blockchain technology— applied as a distributed transaction ledger for cryptocurrencies—explains the high density of the Finance & Insurance sector.

Countries	Finance & Insurance	Information & Communication	Professional Service	Arts, Entertainment & Recreation	Retail & Consumer	Venture Capital	Total
United States	449.57	286.12	19.69	9.80	7.15		772.33
No HQ*		165.00					165.00
Ireland	136.00						136.00
Canada	33.94	76.22					110.16
Netherlands	5.53	60.00					65.53
Japan	43.47	2.80					46.27
United Kingdom	18.61	18.51	0.22			1.71	39.05
Luxembourg	30.43	0.57				2.45	33.45
Sweden	1.15	32.00					33.15
Israel	8.40	19.00					27.40
Singapore	5.02	20.92					25.95
China	18.68						18.68
Indonesia	18.05						18.05
Republic of Korea	11.82				0.20		12.02
Germany	2.94	6.25	0.00				9.20
Barbados	5.50						5.50
France	1.12	3.73					4.85
Australia	3.86						3.86
Switzerland	3.79						3.79
Mexico	2.25	1.00					3.25
Total	**800.13**	**692.13**	**19.91**	**9.80**	**7.35**	**4.16**	**1,533.48**

*Set if companies do not specify their headquarters' location or if they operate in a decentralized manner.

Table 3.   Distribution of venture capital investment in blockchain ventures across countries in million USD

As shown in the theoretical framework section, the potential use cases for blockchain technology in financial services make it a crucial industry for further expansion of the fast and tamperproof technology. Even though the competition between different blockchain technology concepts is still ongoing, the key beneficial service offerings provided in this industry receive support from blockchain technology.

A coherent conclusion is possible when evaluating the blockchain landscape from a venture capitalist's perspective. The highest funding is in financial services. It is a result of the already advanced and proven applicability of blockchain technology within the industry. Both views display the potential of blockchain technology within financial services, evaluated by visionary but risky business perspectives.

The second notable industry sector—Information & Communications—highlights the early stage of blockchain technology. The lack of necessary industry standards for blockchains is embodied in the high density of startups within the Information & Communications sector. The absolute startup numbers and venture capital funding are indicators as well. This shows that the competition of different technology concepts is still ongoing and results in risky approaches to establish industry-dominating standards with proprietary solutions. Once those standards are established, competition can take place in different applications of the technology. The high density in the Information & Communication sector is slowing down advancement in further industry applications since it is not clear what kind of blockchain concept—whether public/private and permissionless/permissioned—will be the next standard. A comparison between blockchain technology today and the internet in the 1990s may explain the potential further steps for advancement. Once the basic layer standard is in place (i.e., with the ITP or TCP of the internet), competition may move to the upper layer and may have the potential to disrupt existing business models by harnessing the upside potential of the new technology (i.e., speed, cost-efficiency, tamperproof construction).

This assessment of the two largest industry sectors in the sample may explain the results for other industries. Even though the application potential of blockchain technology may be huge, without basic standards the risk of implementing own solutions within other industries is high. Hence, one sees that entrepreneurs are willing to take that risk at the current state of the technology. But venture capitalists are still investing in more advanced industries such as Financial Services and Information & Communications. In assessing the upside and downside of specific blockchain concepts and further conditions for blockchain applications, further research is necessary to help advance the technology and establish new possibilities for applications implemented in other industries.

Geographically, the blockchain landscape has two emerging clusters in the US and the UK. In terms of investment, however, the US with nearly half of the funds outpaces all other countries in the data sample. The US's trial-and-error culture supports the establishment and growth of startups, and underlines the country's leading position not just for blockchain ventures.

Nevertheless, the high number of uncategorized startups in terms of regional distribution raises an interesting question. With a completely decentralized business model, fully decentralized operating models seem realizable, as seen with the DAO – a decentralized autonomous organization (Jentzsch, 2016). Henceforth, such applications may result in a global peer-to-peer economy, where national borders do not make a difference (cf. Tapscott and Tapscott, 2016). Therefore, further research needs to lay out the legal, regulatory, and political framework for such a pure global technology.

When evaluating blockchain technology from a diffusion of innovation theoretical perspective, its relative advantage compared to existing technologies together with a vast and high degree of triability (as seen in our empirical results) shows high potential for a broad diffusion of blockchain technology across industries. However, the remaining three attributes, namely compatibility, complexibility, and observability are necessary obstacles for ensure a true disruption of blockchain technology. Further research should elaborate solutions to overcome especially the currently low degrees of compatibility and observability. In conclusion, our analysis shows that the blockchain landscape mirrors the still early stage of the technology but concurrently also identifies its huge potential. The development during the upcoming years will reveal its potential as a merely incremental innovation – or a truly disruptive technology.

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