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Insights from academic literature and social media analytics

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Abstract

Purpose – Although blockchain is often discussed, its actual diffusion seems to be varying for different industries. The purpose of this paper is to explore the blockchain technology diffusion in different industries through a combination of academic literature and social media (Twitter).

Design/methodology/approach – The insights derived from the academic literature and social media have been used to classify industries into five stages of the innovation-decision process, namely, knowledge, persuasion, decision, implementation and confirmation (Rogers, 1995).

Findings – Blockchain is found to be diffused in almost all industries, but the level of diffusion varies. The analysis highlights that manufacturing industry is at the knowledge stage. Further public administration is at persuasion stage. Subsequently, transportation, communications, electric, gas and sanitary services and trading industry had reached to the decision stage. Then, services industries have reached to implementation stage while finance, insurance and real estate industries are the innovators of blockchain technologies and have reached the confirmation stage of innovation-decision process.

Practical implications – Actual implementations of blockchain technology are still in its infancy stage for most of the industries. The findings suggest that specific industries are developing specific blockchain applications.

Originality/value – To the best of the authors' knowledge this is the first study which is using social media data for investigating the diffusion of blockchain in industries. The results show that the combination of Twitter and academic literature analysis gives better insights into diffusion than a single data source.

Keywords Technology adoption, Systematic literature review, Blockchain, Diffusion of innovation, Social media analytics

Paper type Research paper

1. Introduction

A blockchain is an open, distributed, peer-validated, transparent, write-only and time-stamped ledger (Aste *et al.*, 2017; Di Pierro, 2017). Blockchain does not provide administrator rights for editing or deleting of data, instead the change of transactions is based on a consensus making protocol (Nakamoto, 2008). Blockchain supports public, private, permissioned and permisionless models of blockchains (Dai and Vasarhelyi, 2017; Huckle and White, 2016). Permission blockchain are the best way to protect client privacy (Nordrum, 2017) and for satisfying regulation standards (Yeoh, 2017). The technical structure of blockchain has been highlighted in the literature (Aste *et al.*, 2017; Ying *et al.*, 2018), where every new entry gets appended to the end of the ledger, by linking to the previous block through a hash value. If something is changed in the block, the hash value of the block changes resulting in breakage of the chain (Aste *et al.*, 2017; Magazzeni *et al.*, 2017). Also, every node has a copy of the ledger which prevents the tampering of a single node (Nakamoto, 2008). The transaction can be a trade or a legal contract.

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The latter are created by using smart contracts (Buterin, 2014). Blockchain has the potential of bringing a major transformation in economic (Kshetri, 2017a; Manski, 2017; Seidel, 2018; Umarovich *et al.*, 2017), political (Kshetri, 2017a) and social context (Kshetri, 2017a; Scott *et al.*, 2017).

Blockchain was first introduced by Satoshi Nakamoto in October 2008, for Bitcoin, a peer-to-peer software for transfer of digital cash without any financial intermediaries. It is surprising to note that first software based on the blockchain, Bitcoin came out in 2009 and first journal research paper based on blockchain came out in 2015 (for the search of the article refer to Section 3.1). Blockchain has gained a lot of attention, but its main application field and largest diffusion seem to be limited to the finance industry (Cuccuru, 2017; Yli-Huumo *et al.*, 2016), although there is much discussion about the potential of blockchain in other industries, its benefits and disruptive effects (Cognizant, 2017; Sharma, Moon and Park, 2017; Shermin, 2017; White, 2017; Ølnes *et al.*, 2017).

Diffusion is a process of an innovation adoption by individuals, society or organizations over the span of time (Rogers, 1995). In this study, the diffusion of blockchain technology in various industries will be determined. To address blockchain diffusion in different industries we attempt to explore the following four research questions (RQs):

RQ1. Which industries are exploring blockchain technology applications?

RQ2. How has blockchain been adopted in different industries?

RQ3. How can blockchain contribute to different industries in the future?

RQ4. Have people posting about blockchain on social media, also have blockchain expertise?

Typical methods which can be used for determining the diffusion of technology in different industry are: empirical research like surveys, focus groups interviews and qualitative case studies; academic literature review; and social media analytics (Fan and Gordon, 2014; Grover and Kar, 2018; Joseph *et al.*, 2017). Rogers (1995) highlighted interpersonal channels are more important at persuasion stage. Surveys, focus groups interviews and qualitative case studies are interpersonal channels in which respondents have to be identified. Therefore, among these methods, academic literature review and social media analytics methods had been used in this study for determining the diffusion stage of blockchain across various industries. The systematic literature review (Hart, 1998) help us in: tracing technology progress from its birth; identifying the main subjects and themes; presents the big picture of the technology in terms of benefits, challenges and characteristics; derives useful information from already available resources; and identifies practical implementation and conceptual frameworks from the literature.

Social media (Twitter) was considered as a second source for the study because: Twitter is a valuable source of voluntary information disclosure (Lischke and Fabian, 2016); online conversations are easy and cost effective way for measuring word of mouth (Godes and Mayzlin, 2004); previous studies shows that Twitter data can be used for predicting value in all phases of a technology lifecycle (Fan and Gordon, 2014; Tempini, 2017); and Rogers (1995) highlighted that mass media channels are more important at the knowledge stage. In today's internet age, social media platforms are considered as mass media channels. Therefore, Twitter analytics were used for determining the blockchain diffusion in industries. In this study systematic literature review depicts the evolution trajectory of the technology whereas social media help us in showing and presenting technological frame of the users.

The remaining sections are organized as follows. Section 2 is dedicated to theoretical basis of each of the RQs. Section 3 explains the research methodology adopted for the study. Section 4 presents the insights from the literature review and social media analytics. Section 5 explains and illustrates discussions of blockchain diffusion in different industries on the basis of academic literature and social media analysis along with discussion on method followed and theoretical contributions of the study. Subsequently, this is followed by a conclusion section which discusses the limitations of the study along with future research directions.

2. Theoretical basis and research questions (RQ)

Diffusion is a process which alters the structure and functioning of social systems by introducing an innovation within a system (Rogers, 1995). An innovation can be an idea, object or practice which is new to the members of the society. According to Rogers (1995), adoption of innovation is determined by five attributes: relative advantage; compatibility; complexity; trialability; and observability. Relative advantage refers to the perceived degree of the betterment of an innovation to the idea replaced by it. Relative advantage can be measured in economic terms, social prestige, convenience and satisfaction. Compatibility is a significant predictor of using a service (Carter and Bélanger, 2005) whereas complexity had been negatively related to using a service (Lean *et al.*, 2009). Trialability refers to a degree of an innovation experimentation on a limited basis. Observability is related to outcome visibility of an innovation implementation. Trialability and observability are positively related to the rate of adoption. This study tries to map diffusion of blockchain among different industries. In short, *RQ1* investigates the industries which are considering blockchain at present in their ecosystem:

RQ1. Which industries are exploring blockchain technology applications?

Diffusion of innovation theory had been used in the literature for determining diffusion and adoption of information technology such as cloud computing (Oliveira *et al.*, 2014), green IT (Bose and Luo, 2011), virtual technology (Fuller *et al.*, 2007) and Web 2.0 services (Corrocher, 2011). Diffusion theory suggests that technology can have different levels of diffusion in a different industry (Zhu *et al.*, 2012). Furthermore, industries can cross-fertilize each other.

The innovation-decision process is the process through which an individual acquires the knowledge about the innovation leading to forming of an attitude toward the innovation (persuasion), followed by a decision whether to accept or reject the innovation, followed by implementing the innovation and whether to continue using innovation or not (confirmation) (Rogers, 1995). The literature suggests that during the knowledge phase people build their technological frame about the new technology and that social context plays a significant role in influencing the people throughout the process (Karsten and Laine, 2007). Therefore, *RQ2* tries to investigate the depth of blockchain diffusion across industries:

RQ2. How has blockchain been adopted in different industries?

Innovativeness refers to the degree to which an individual, group or organization is relatively quick in adopting new innovation as compared to others in the society. On the basis of the innovativeness, adopters can be classified into five categories such as innovators, early adopters, early majority, late majority and laggards (Rogers, 1995). People had used a particular system more when other in the neighborhood had used it (Kraut *et al.*, 1998). Diffusion process can be accelerated or decelerated in early and later parts of the diffusion curve by the influential and imitators (Van den Bulte and Joshi, 2007). Therefore, *RQ3* tries to investigate which industries might adopt blockchain in future:

RQ3. How can blockchain contribute to different industries in the future?

Using this study we want to showcase the diffusion of blockchain technology among different industries through academic literature and social media analytics by exploring the answers to *RQ1–RQ3*. The study assumes that the authors writing research papers are experts in blockchain area, but this assumption does not hold for social media users, who are tweeting about blockchain. The literature suggests information on Twitter is of low quality (Lee *et al.*, 2016; Wang *et al.*, 2013). Therefore, there is a need to check the quality of tweets posted on Twitter regarding blockchain. *RQ4* investigates the expertise of the users tweeting on Twitter related to the blockchain. *RQ4* was only applicable to social media data:

RQ4. Have people posting about blockchain on social media, also have blockchain expertise?

Users' expertise in blockchain network on social media cannot be validated. In our approach we will assume that if users are posting about blockchain extensively than if his/her post are valid when other users will follow up posts by having further queries. Therefore to test this, *H1* states that users posting on blockchain (activity) have got visibility on the blockchain topic leading to queries of other users. So, if the users which are tweeting about blockchain are experts than there will be strong association between their activity and visibility. Expertise of users on social media is directly proportional to association between activity and visibility on the "#blockchain":

H1. There is (monotonic) association between activity and visibility on "#blockchain."

3. Research methodology

The study tries to give an overview of diffusion of blockchain in different industries by investigating academic literature and content on Twitter. Both systematic literature review and social media analytics are complementary approaches. Figure 1 briefly outlines the research methodology. The systematic literature review will explain the need for the technology, features, challenges, conceptual frameworks and practical implementation whereas social media analytics tries to showcase the technological frame of the users regarding innovation along with popular players in the field and conceptual concepts which can be taken forward in future. Scopus was used to study the diffusion of blockchain from the academic literature.

Scopus is the most extensive database for engineering and management focused literature. The relevant research studies were searched on January 8, 2018. For searching the articles, the search term "blockchain" had been searched for in "Article Title," "Keywords" and "Abstract."

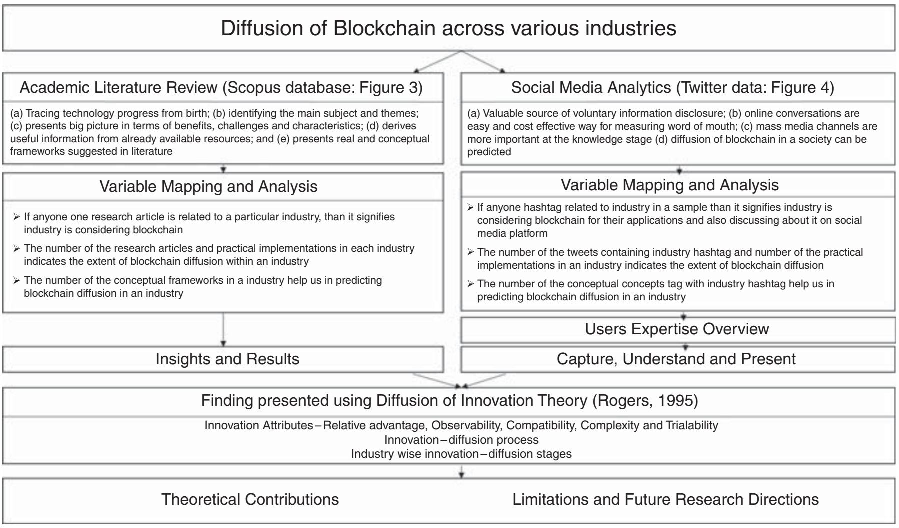


Figure 1.
Research approach followed for blockchain diffusion in different industries

The query resulted in 770 articles. Given the volume of publications we decided to investigate journal publications only. The second round had fetched around 193 studies. The distribution of research articles across different subject area is shown in Figure 2. Among all subject areas business, management and accounting had occupied the third position with 42 articles. Out of 193 research studies, 116 research studies were selected on the basis of the abstract. Among 116 studies, 54 studies included the industry applications. The "Strategic Change" journal published the most research articles, 10 in total from 54 research articles. Among authors Kshetri, N. had published four articles (highest in number) followed by Nordrum, A., Wang, F. Y. and Yuan, Y. from which each had published three articles. Figure 3 explains the selection process followed for selecting research articles for the systematic literature review. These 54 research articles had been divided into the various industries. Industries include consumer discretionary, financials, healthcare, industrials, information technology, management of companies and enterprises, transportation, supply chain, energy sector and public administration. These industries had been defined in various industry classification reports such as Global Industry Classification Standard (MSCI, Inc., Standard & Poor's Financial

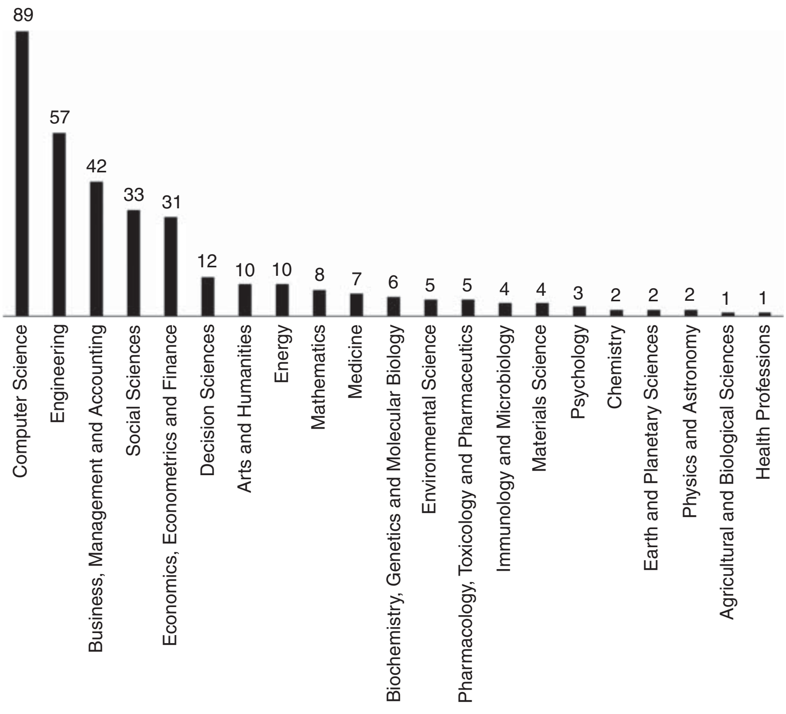


Figure 2.
Distribution of blockchain articles per subject area

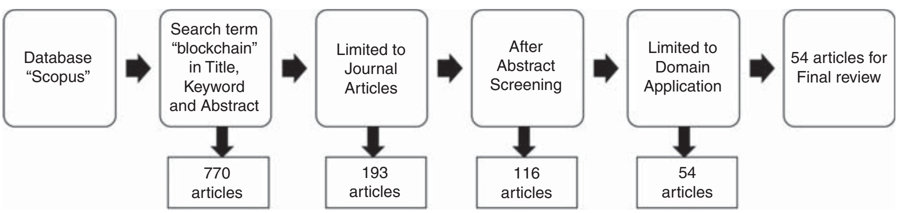


Figure 3.
Stages for selection of the articles for a literature review

Services LLC (S&P), 2016) and North American Industry Classification System. For this study, North American Industry Classification System had been used. For this study the assumption was made that if an academic article mentions an industry then it signifies particular industry is considering blockchain at present. The number of the studies and practical implementations in each industry was used as an indicator for determining the extent of blockchain adoption within an industry. The number of conceptual frameworks with respect to various industries helps us in predicting blockchain adoption in an industry in near future.

Social media analytics is an interdisciplinary research field which can help in decision making by reviewing computer-mediated communication on social media platforms (Al-Yafi *et al.*, 2018; Hamouda, 2018; Odoom *et al.*, 2017; Rathore *et al.*, 2016; Sunday, 2018). Social media had been used for various purposes such as: for identifying the reasons for the customer dissatisfaction (Fan and Gordon, 2014; He *et al.*, 2015); for capturing spatial patterns across the city (Brandt *et al.*, 2017); for modeling and predicting dynamic user interests (Feng *et al.*, 2015); and learning and knowledge sharing (Leonardi, 2017).

To the best of our knowledge this is the first study which is using social media data for investigating the diffusion of blockchain in different industries. Social media analytics is a three-stage process of capturing social media data, understanding the extracted data and presenting the insights using the CUP framework (Fan and Gordon, 2014). For deriving the insights from Twitter data for blockchain diffusion within industries CUP framework had been adopted, elaborated in Figure 4. Step 1 extracts the data from Twitter using search API, by searching the term "#blockchain." The data had been extracted on daily basis for two months starting from January 1 2018 to February 28, 2018. After extraction is over, extracted data had been prepared for further analysis by performing data cleaning, stemming, tagging and classifying. Step 2 tries to examine the data through descriptive analysis (Chae, 2015), where ever found necessary the descriptive statistics had been noted. For finding the top 100 dominant hashtags descriptive analysis was used. The activity and visibility of each user in a sample were computed using descriptive analysis. The information flow within the network had been mapped for network analysis (for *RQ4*). The content of the tweets had been analyzed through content analysis (Kassarjian, 1977) using word clouds and hashtag analysis (Chae, 2015). Word clouds help in visualizing the popular words within the tweets. For mapping, the hashtags to industries lexicon based analysis were used. Content analysis was used for identifying the practical implementations and conceptual concepts related to industries. The statistical test Spearman's rank-order correlation was applied to the activity and visibility of the user for testing the authenticity and credibility of the information tweeted on social media platform. Step 3 presents the results. In the study results had been presented using dominant hashtags, practical implementation, conceptual concepts, activity, visibility and information flow diagram.

4. Results and analysis

This section is divided into the three subsections. The first subsection presents the insights from the literature review. The second subsection presents insights from social

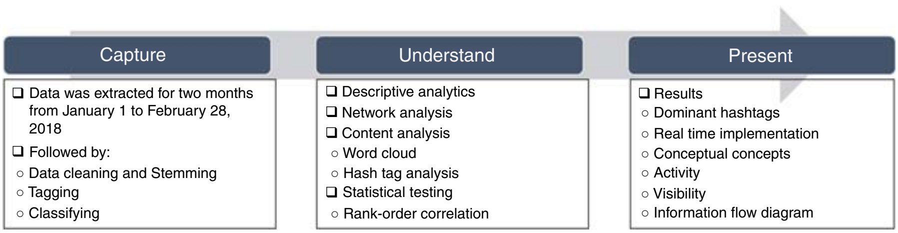


Figure 4.
CUP framework (Fan and Gordon, 2014) for deriving insights from Twitter

media analytics, whereas the third section presents an overview of Twitter users. For this study, North American Industry Classification System had been used for classifying the industries.

4.1 Insights from the literature review

The brief overview of blockchain industry applications had been presented in academic literature in Table I. Each is represented using first four letters, manufacturing (MANU); transportation, communications, electric, gas and sanitary service (TRAN); finance, insurance and real estate (FINA); services (SERV); public administration (PUBL); trading (TRAD); the first column of table contains the industry name followed by the practical implementation and conceptual evidence from the literature. In the industry classification, wholesale and retail had been considered under one industry, trading:

RQ1. Which industries are exploring blockchain technology applications?

Table I depicts industries like MANU, TRAN, FINA, SERV and PUBL is considering blockchain for various applications. Among 54 studies only one study had talked about retail trade. The industries like agriculture, forestry, fishing, mining and construction do not

Industry (research articles in number)	Practical implementation	Conceptual framework
MANU (1)	Machine-to-machine communications (Yin *et al.*, 2017)	An application of cotton spinning production process was highlighted touching utilization, information security, network design and solution architecture
TRAN (13)	Smart meter – for tracking electricity production (Kshetri, 2017b; Peck and Wagman, 2017)	Emission Trading Scheme model for Industry 4.0 integration (Khaqqi *et al.*, 2018) Online shipment tracking framework (Wu *et al.*, 2017) Intelligent distributed electrical energy systems (Zhang *et al.*, 2017) OriginChain (Lu and Xu, 2017) Energy trading (Cai *et al.*, 2017; Shi *et al.*, 2017) Firmware update for embedded devices (Lee and Lee, 2017) Blockchain-enabled M2M electricity market (Sikorski *et al.*, 2017) Vehicle network architecture for transport management system within the smart city (Sharma, Moon and Park, 2017)
FINA (12)	None presented	Automatic assurance system (Dai and Vasarhelyi, 2017) Transparent accounting ecosystem (Dai and Vasarhelyi, 2017) CoinParty (Ziegeldorf *et al.*, 2018)
SERV (17)	Digital Art Identification, Authentication and Usage rights (McConaghy *et al.*, 2017) HNA E-Commerce platform (Ying *et al.*, 2018)	Advert reporting system – for determining the authenticity of ad-reports (Mamais and Theodorakopoulos, 2017) Medical data sharing model (Roehrs *et al.*, 2017; Xia *et al.*, 2017; Xue *et al.*, 2017) Online taxi-hailing – with personal privacy protection (Zhang *et al.*, 2017) Patient consent workflow (Benchoufi *et al.*, 2017) DistBlockNet model – for detecting attacks in IoT network (Sharma, Singh, Jeong and Park, 2017) FairAccess – authorization management framework (Ouaddah *et al.*, 2016) Pervasive social network-based healthcare (Zhang *et al.*, 2016) Healthcare Data Gateway App (Yue *et al.*, 2016)
PUBL (10)	E-residency (Sullivan and Burger, 2017)	Backfeed (Pazaitis *et al.*, 2017) OfferCoin (Goertzel *et al.*, 2017) Property rights (Ishmaev, 2017)

Table I. Industry-specific practical implementation and conceptual framework on blockchain technology insights from literature review contain any pieces of literature evidences of conceptual and practical implementation of blockchain technology, therefore these industries not included in Table I. However, there are studies in the literature which signals blockchain can create disruptive innovation in the agriculture field (Manski, 2017):

RQ2. How has blockchain been adopted in different industries?

The extent of the blockchain adoption in industries had been estimated using the practical implementation in an industry. One by one we will elaborate the practical implementation existing within industries. Let us first summarize for MANU, using blockchain expansion of machines is possible through secure inter-communication among machines (Yin *et al.*, 2017). Machine-to-machine communication had been used for: for checking and validating firmware updates (Lee and Lee, 2017); for establishing electricity markets for trading (Sikorski *et al.*, 2017). Popular characteristics of blockchain in TRAN pointed out in the literature: data transparency (Cai *et al.*, 2017; Lu and Xu, 2017); data sharing (Lu and Xu, 2017); distributed or decentralization (Cai *et al.*, 2017); user-centricity (Cai *et al.*, 2017); and trustworthy and secure (Shi *et al.*, 2017). Blockchain is suitable for smart meters (Tai *et al.*, 2016) and energy internet trading (Cai *et al.*, 2017; Mengelkamp *et al.*, 2018; Shi *et al.*, 2017); product traceability (Lu and Xu, 2017; Wu *et al.*, 2017); managing public transport system (Sharma, Moon and Park, 2017). OriginChain (Lu and Xu, 2017) software had been suggested in the literature which improves product traceability.

Blockchain features making it popular in SERV industry: elimination of intermediaries (Seidel, 2018; Ying *et al.*, 2018); distributed trust (Seidel, 2018); user anonymity (Mamais and Theodorakopoulos, 2017); user privacy (Mamais and Theodorakopoulos, 2017; Ouaddah *et al.*, 2016; Xia *et al.*, 2017; Zhang *et al.*, 2017); user mobility (Hong *et al.*, 2017; Yue *et al.*, 2016; Zhang *et al.*, 2016); time-stamped record creation and ownership (Hoy, 2017; O'Dair and Beaven, 2017); reproducibility (Benchoufi *et al.*, 2017; McConaghy *et al.*, 2017; O'Dair and Beaven, 2017); security (Benchoufi *et al.*, 2017; Sharma, Singh, Jeong and Park, 2017; Ouaddah *et al.*, 2016). Hainan Airlines (HNA) group had implemented a blockchain-enabled E-commerce platform for offering flexible benefit plans to their employees through digital coins (Ying *et al.*, 2018). Blockchain can provide an asset ownership layer over the internet for digital properties (McConaghy *et al.*, 2017).

Blockchain features making it popular in PUBL industry are: immutability (Kewell *et al.*, 2017; Nordrum, 2017); transparency (Nordrum, 2017) and decentralization (Pazaitis *et al.*, 2017). E-residency (Sullivan and Burger, 2017) is the first application of the blockchain in PUBL by Estonia Government. The application provides a human being, living anywhere in the world with e-residency using which a human can run businesses in Estonia. E-residency is basically a commercial initiative of Estonia Government:

RQ3. How can blockchain contribute to different industries in the future?

The prediction whether blockchain will be used in the future by the particular industry or not had done on the basis of the conceptual framework that had been suggested in academic literature. Table I depicts for MANU industry none had been presented in academic literature related to conceptual framework. Therefore, lets us consider the conceptual framework that has been presented in academic literature related to TRAN. Intelligent, large-scale, distributed electrical energy systems (Zhang *et al.*, 2017) and transportation systems are feasible to build using blockchain technology (Sharma, Moon and Park, 2017). Blockchain features such as transparency and immutability had been used in emission trading scheme for improving efficiency and management (Khaqqi *et al.*, 2018). The industry is facing problems in integrating blockchain technology due to the learning curve of the workers and cost of integration in present systems (Lu and Xu, 2017).

Blockchain features making it popular in FINA: tamper resistance (Dai and Vasarhelyi, 2017; Püttgen and Kaulartz, 2017); strong authentication (Dai and Vasarhelyi, 2017); disintermediation (Cohen *et al.*, 2017; Larios-Hernández, 2017; Nordrum, 2017); reliability (Khan *et al.*, 2017; Püttgen and Kaulartz, 2017); reduction in risk (Eyal, 2017; Khan *et al.*, 2017; Umarovich *et al.*, 2017). The literature suggests methodologies and products for FINA industry based on blockchain technology for achieving: financial privacy and user anonymity (Ziegeldorf *et al.*, 2018); accounting information disclosure and automated assurance (Dai and Vasarhelyi, 2017); financial inclusion (Larios-Hernández, 2017). There are around 2bn citizens in developing economies that have limited or no access to formal financial services. These citizens can find new opportunities in financial services building on blockchain which supports disintermediation (Larios-Hernández, 2017). Investors can track their financial assets performance on the blockchain, which can later result in disintermediation of credit rating agencies (Cohen *et al.*, 2017). FinTech industries can use blockchain technology for capital markets and corporate banks which will facilitate in reducing transaction latency and operational risk (Eyal, 2017).

The literature predicts that in near future blockchain technology will be used for everything from medical records to library checkouts (Hoy, 2017) within SERV industry. Medical data sharing model based on blockchain guarantees high security, tamper resistance and collective maintenance (Roehrs *et al.*, 2017; Xia *et al.*, 2017; Xue *et al.*, 2017). Blockchain technology in the recorded music industry can provide various benefits (O'Dair and Beaven, 2017) such as accuracy and availability of copyright data; near-instant micropayments for royalties; and high transparency. Platforms such as Uber, Airbnb, Google, Facebook, Kickstarter and Indiegogo had been between two parties for building trust, as the blockchain evolves it will establish distributed trust (Seidel, 2018) among users.

Literature indicates that blockchain can be used in public administration for the following purposes: tackling corruption (Nicholson, 2017; Nordrum, 2017); security (Kshetri, 2017c); empowering women (Nicholson, 2017); property rights (Ishmaev, 2017; Herian, 2017); e-residency (Sullivan and Burger, 2017); and open and sharing economy (Goertzel *et al.*, 2017; Pazaitis *et al.*, 2017). Literature indicates using blockchain technology United Nation's 2030 sustainable development goals can be transformed into reality (Kewell *et al.*, 2017). Backfeed presents a conceptual model for governance for decentralized value creation (Pazaitis *et al.*, 2017). Blockchain technology can empower individuals for entrepreneurship having limited or no access to financial services (Larios-Hernández, 2017). Relationship between the law and technology can be represented through the four distinct phases (De Filippi and Hassan, 2016) such as digitizing of information; bringing automation to decision-making processes; incorporation of legal rules into code and emergence of regulation by code; code-ification of law; the fourth phase code-ification of law is just beginning and smart contract is leveraging the growth of the fourth phase (De Filippi and Hassan, 2016). Some of the countries using or in trial phase of blockchain applications in public administration are: USA, Illinois (Nordrum, 2017); United Arab Emirates, Dubai (Nordrum, 2017); Africa (Kshetri, 2017a); Europe (Peck and Wagman, 2017) and Canada (Ducas and Wilner, 2017). In Dubai, a blockchain-enabled pilot project regarding sale purchase of real estate is going on. In Illinois, five blockchain projects are under trial for handling property, academic transcripts, records, energy market credits and licenses to healthcare providers.

Overall among 54 articles 1.85 percent of academic articles talk about MANU industry; 24.07 percent of academic articles talk about TRAN industry; 22.22 percent of academic articles talk about FINA industry; 31.48 percent of academic articles talk about SERV industry; 18.52 percent of academic articles talk about PUBL industry; and 1.85 percent of academic articles talk about TRAD industry.

4.2 Insights from social media analytics

In total, 341,309 tweets were extracted on the search term "#blockchain" from Twitter starting from January 1, 2018 to February 28, 2018. The information quality of blockchain on Twitter was very low only small portion of tweets had contained useful information regarding blockchain rest of the tweets were exacerbating the benefits related to blockchain without giving any useful information. Only one-fifth of the sample tweets were tagged with industry hashtag. The overview of Twitter users profile is presented in Section 4.3:

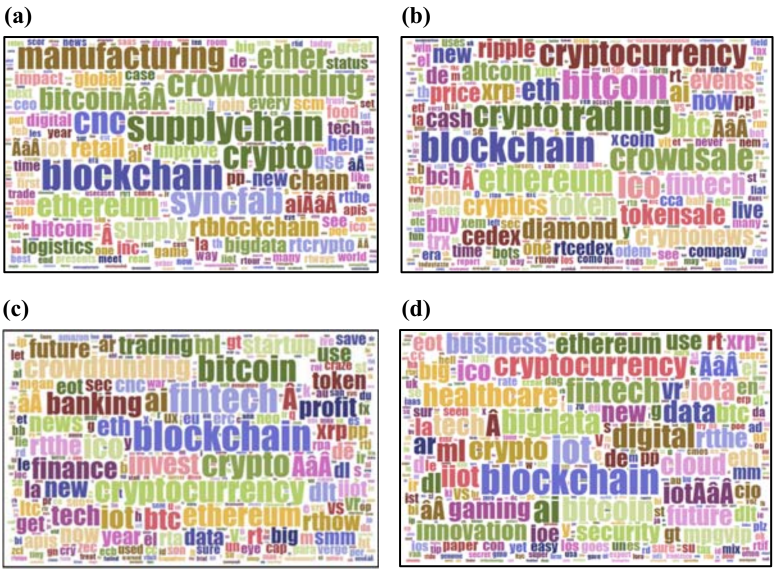
RQ1. Which industries are exploring blockchain technology applications?

Within top 100 hashtags, there were no single hashtags found related to the industries like agriculture, forestry and fishing; mining; construction; and public administration. Figure 5 presents the industry-specific word cloud of hashtags related to TRAN, TRAD, FINA and SERV. Figure 5 depicts the following information regarding the blockchain technology: Ripple and Neo are the organizations working in blockchain; popular digital currencies bitcoin, xrp, altcoin, digibyte, tron, litecoin and edinarcoin; blockchain impacts on security, privacy, decentralized, immutability and trust; and popular blockchain platforms are Ethereum, Aelf, IZX, Vestarin and Experty on Twitter:

RQ2. How has blockchain been adopted in different industries?

The tweets were screened according to the industries. The application which had been used by the user, and the users are sharing their experience on Twitter, such an application had been considered as practical implementation. The dominant hashtags for each industry are listed in column 2 of Table II. The practical implementation based on blockchain that had been discussed on Twitter and listed in Table II.

Table II depicts Twitter users had experienced decentralized logistics platform; decentralized education marketplace; trading of soybeans, diamonds and natural assets; authentic access to digital and musical contents; self-flying drone; and multilingual



Notes: (a) TRAN; (b) TRAD; (c) FINA; and (d) SERV

Figure 5.
Industry-specific word cloud of hashtags

Industry (number of tweets captured)	Top 100 hashtags with "#blockchain"	Practical implementation	Conceptual concepts
TRAN (1,421)	#supplychain (1,421)	Self-flying drone enabled by blockchain Decentralized logistics platform	Green energy production Autonomous transportation Minerals traceability
FINA (37,246)	#fintech(21,973) #invest (6,210) #crowdfunding (2,917) #insurtech (2,396) #finance (1,366) #banking (2,384)	Bill payments Initial coin offering Securities	Financial inclusion Instant international payments National cryptocurrency Better home-sharing economy Smart financial bonds
SERV (24,978)	#iot (13,660) #digital (5,453) #gaming (2,520) #cloud (1,744) #healthcare (1,601)	Multilingual crypto networking Authenticated access to digital and musical contents Enhancing patient care Medical training Decentralized education marketplace	Digital signatures Answering medical dilemmas Social network Net neutrality Improve health data benefits
TRAD (8,610)	#crowdsale (3,562) #trading (2,672) #diamond (1,202) #cedex (1,174)	Trading soybeans to China Jewelry business network Natural asset exchange Crowd sale	Global trading Digitization of trading Paperless trading
PUBL	Not a single hashtag in top 100 dominant hashtags of a sample	Blockchain-enabled passports Blockchain Id for travelers Blockchain task force Data sharing	Digital identity Crypto tax Voting platform Fraud-free #elections Land records

Table II. Industry-specific practical implementation and conceptual concepts of blockchain technology – insights from social media analytics

crypto networking. There is no mechanism to validate these evidence but these had been stated by users on Twitter.

Self-flying drone had been tagged with #supplychain in the tweets. The FINA industry hashtags #fintech, #invest, #crowdfunding, #insurtech, #finance and #banking were containing experiences and feedbacks for the applications facilitating users in bill payments and managing securities. Applications build on blockchain, decentralized education marketplace and authentic access to digital and music content is popular in SERV industry on Twitter. TRAD industry is having dominant hashtags such as #crowdsale, #trading, #diamond #cedex. The CEDEX is a certified blockchain based diamond exchange which facilitates global exchange and focuses on bridging the gap between traditional diamond industry and financial markets. Trading diamond through blockchain is very popular use-case on Twitter. For PUBL industry no dominant hashtag had been captured, but users are talking about blockchain-enabled identities and passports.

"#blockchain" had been frequently used with other hashtags focusing on impacts, use cases, companies, platforms, computing algorithms, start-ups and innovations. A blockchain platform, Ethereum, developed by ConsenSys, is the most discussed platform on Twitter:

RQ3. How can blockchain contribute to different industries in the future?

Conceptual concepts (potential applications which are not yet implemented) based on blockchain that had been discussed on Twitter are listed in Table II, column 4. A tweet is a message limited to 140 characters only, therefore users on Twitter were only mentioning potential application names in their tweets. The application which had been purposed within virtual community for the betterment of society was considered under conceptual concepts. The practical implementation of conceptual concepts was not discussed on Twitter.

Using Twitter, users had suggested some conceptual concepts based on blockchain technology related to various industries given in Table II, such as implementing green energy production, automatic transportation system and minerals traceability within TRAN industry; implementing instant international payments and national cryptocurrency within FINA industry; and implementing net neutrality, paperless trading, digital identity, crypto tax and voting platforms within PUBL. Literature suggests information from a group of users is mostly results in the better decision as compared to a single user (Guo *et al.*, 2015) and indicates crowd intelligence had attracted a lot of attention from industry and researchers (Gleasure and Feller, 2016; Li *et al.*, 2017). These conceptual concepts can be considered as the collective intelligent efforts of Twitter users for taking blockchain technology to next level. These conceptual concepts can be taken forward in future by industry and researchers for further research and implementation.

TRAN had captured 1.97 percent of industry-related post on Twitter. FINA had captured 51.55 percent of industry-related post on Twitter. SERV had captured 34.57 percent of industry-related post on Twitter. TRAD had captured 11.92 percent of industry-related post having dominant hashtags such as #crowdsale, #trading, #diamond #cedex. No dominant hashtag in top 100 belongs to PUBL, MANU and other industries.

4.3 Twitter users overview

There were around 96,497 unique users. The sample had accounted: 37,372 tweets from top 100 active users; 1,997 tweets from top 100 visible users; and 16,928 tweets from top 100 users which are present in the list of active users and visible users. Top 10 users having highest activity, visibility and both highest activity and visibility are listed in Figure 6.

Twitter handles operated by bloggers (@Remi_Vladuceanu and @insidestat) are high in their number of Tweets including blockchain. Twitter mention such as @startupcrunch and @earnbtcwork are sharing latest opportunities related to digital currency. From the visibility count, it is evident users on Twitter are querying organizations working on blockchain such as @ceek, @fortknoxster, @aelfblockchain, @izx, @vestarin and @digibytecoin. Some of Twitter handles having high activity and visibility includes news channels focusing on cryptocurrency such as @cryptocurrent, @coinspectator, @bitcoinagile and @dumbwire; and influencers such as @kuriharan, @evankirstel, @bourseettrading, @sachinlulla and @mclynd:

RQ4. Have people posting about blockchain on social media, also have blockchain expertise?

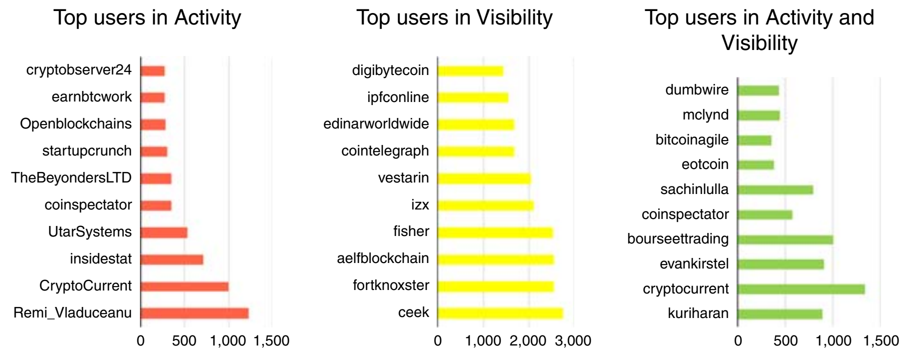


Figure 6.
Top users in activity, visibility and both

To test *H1*, the Spearman's rank-order correlation (Page, 1963) was applied. There were around 96,497 unique users were identified in the sample. For all the 96,497 users were rank according to activity on Twitter. There were around 32,800 users who had been queried on Twitter using @mention facility on Twitter. For all 32,800 users were ranked according to a number of the times they had been queried on Twitter. Thereafter, the users which are present in both lists were selected. There were around 9,937 users were present in both activity and visibility list. These users were re-ranked according to their position in the combined list for applying Spearman's rank-order correlation $n = 9{,}937$:

H1. There is (monotonic) association between activity and visibility on "#blockchain."

d_i is the difference in paired ranks. In this case, d^2 equals to 96,854,464,442. When all the values applied to Spearman's rank-order correlation, $r_s = 0.407$ was computed. The r_s value indicates there is a very weak association between activity and visibility on blockchain discussions. Expertise of users on social media is directly proportional to association between activity and visibility on "#blockchain." Therefore from $r_s = 0.407$ it can be concluded users are not posting valid tweets, if they had association between activity and visibility on "#blockchain" had been greater. This signifies more of speculation on blockchain rather than based on expertise which is in line with the literature that indicates information on Twitter is of low quality (Lee *et al.*, 2016; Wang *et al.*, 2013).

To study the impact of high activity and visibility in a social network on blockchain discussions, the affiliation networks among the users were drawn. The network is shown in Figure 7. The red nodes indicate users having high activity. The yellow nodes indicate users having high visibility. The green users indicate high activity and visibility. The size of a node represents the frequency of user's participation in discussion. The edge weight indicates the frequency of interaction between the users. The color of the edge is based on their source node color.

From the affiliation network of Figure 7, it is evident that posts posted by high active users are impacting users more (red edges are more in terms of number and weight both) within a virtual community. Users who are ranking high in activity and visibility (green nodes) are potential cues for the discussion on blockchain technology but the speculation around the blockchain is introduced in the network by high active users.

5. Discussion and implications

First, we will discuss the difference in the findings of the systematic literature review and social media analytics, followed by a discussion of the research approach.

5.1 Comparing systematic literature review and social media analytics insights

The blockchain is a new form of technology that has the potential of transforming commerce operations by making it more transparent, accountable, responsible and safer (Lee and Pilkington, 2017). Diffusion is a process which alters the structure and functioning of social system by introducing an innovation within a system (Rogers, 1995), let us examine to what extent blockchain had altered the various industry by referring to the results presented in Sections 4.1 and 4.2. Industry-specific insights on blockchain from academic literature and social media had been contrasted in Table III.

Now let us examine the insights presented in Table III on the adoption of innovations attributes: relative advantage; compatibility; complexity; trialability; and observability. The relative advantage of blockchain depends on application laid on the technology. Blockchain applications had been highlighted in the literature (Table I) and on Twitter (Table II). The analysis indicates blockchain is beneficial for industries and many industries are considering blockchain for various applications. The insights show that

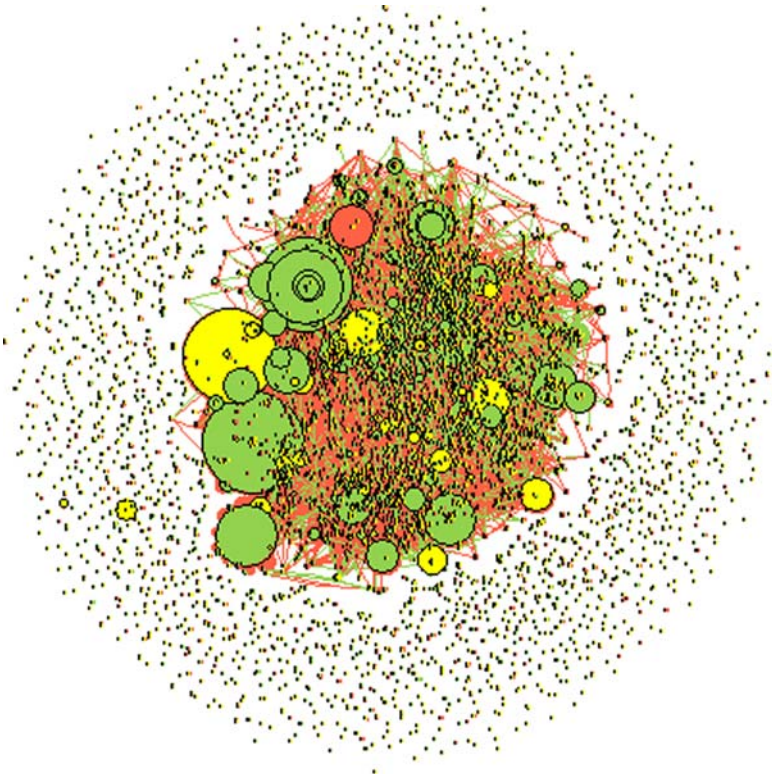


Figure 7.
Affiliation network between users having high activity (red nodes), high visibility (yellow nodes) and both high activity and visibility (green nodes)

Notes: Node size indicates the occurrence of users in blockchain discussions; edge weight indicates the frequency of interaction between the users. Edge color is based on source node color

blockchain implementation is complex because of the mining process and knowledge scarcity among IT and general managers. Blockchain innovation had been led by start-ups like Ripple, Neo, R3 and ConsenSys, whereas the activity of the multinational corporations in blockchain experimentation seems to be limited. Government and dominant software players are observing start-ups. Governments of developed countries are collaborating with start-ups for blockchain experimentation. Now let us summarize at which stage of innovation-decision process (Rogers, 1995) each industry had reached on the basis of the results presented in Sections 4.1 and 4.2. The results had been mapped to five levels of innovation-decision process: first stage is the knowledge, which indicates whether an industry has got the initial knowledge related to blockchain. The second stage is the persuasion which indicates whether an industry has a favorable or unfavorable attitude toward blockchain. The third stage is the decision, it occurs when an industry thinks about developing an application with blockchain and an industry decides whether to adopt or reject the technology. The fourth stage is the implementation, when the industry puts an application based on blockchain into use; and the last stage is confirmation, which signals blockchain had replaced the system before in use and working better than previous system. An overview of the comparative analysis of blockchain diffusion is presented in Figure 8.

Industry	Academic literature	Social media analysis
TRAN	24.07% of academic articles talk about TRAN Popular features: Data transparency; Data sharing; Distributed or Decentralization; User-centricity Challenges: Cost of integration; Learning curve of professionals	1.97% of industry-related buzz on Twitter was about TRAN Dominant hashtags: #supplychain Popular features: Digital information; Security; Transparency Challenges: Hardware cost; Trust Popular players: Syncfab; IBM
FINA	22.22% of academic articles talk about FINA Popular features: Tamper resistance; Authentication; Disintermediation; Reliability; Reduce risk Challenges: Hardware cost; Ransomware risk (Kshetri and Voas, 2017); Energy consumption	51.55% of industry-related buzz on Twitter was about FINA Dominant hashtags: #banking; #insurtech; #finance; #fintech; #invest; #crowdfunding; Popular features: Security; Challenges: Power consumption Popular players: Ethereum
SERV	31.48% of academic articles talk about SERV Popular features: Disintermediation; Distributed trust; User anonymity; User privacy; User mobility; Time-stamped record; Ownership; Reproducibility; Security; Challenges: Knowledge is lacking among business managers regarding blockchain technology	34.57% of industry-related buzz on Twitter was about SERV Dominant hashtags: #gaming; #cloud; #digital; #iot; #healthcare Popular features: Security; Efficiency; Digital information; Automation Challenges: Power consumption; Interoperability; Popular players: Ethereum
PUBL	18.52% of academic articles talk about PUBL Popular features: Immutability; Transparency; Decentralization Challenges: Fewer experts	No dominant hashtag in top 100, but practical implementation and conceptual concepts highlighted in Table II
TRAD	1.85% of academic articles talk about TRAD Popular features: Transparent; Accountable	11.92% of industry-related buzz on Twitter was about TRAD Dominant hashtags: #trading; #crowdsale; #cedex; #diamond Popular features: Product history details; Standardization; Transparency Challenges: Not mentioned Popular players: Ripple; Ethereum
MANU	1.85% of academic articles talk about MANU Popular features: Sandwiched between the public network areas and private areas for sending and receiving query packets	No dominant hashtag in top 100

Table III. Industry-specific insights on blockchain from systematic literature review and social media analytics

This comparative analysis provides industry-specific insights about the nature of diffusion across these industries:

(1) 22.22 percent of academic articles talk about FINA industry and FINA had captured 51.55 percent of industry-related post on Twitter. Therefore, it seems from the insights that FINA is at the confirmation stage of the innovation-decision process.

(2) 31.48 percent of academic articles talk about SERV industry and SERV had captured 34.57 percent of industry-related post on Twitter. Therefore, it seems from the insights that SERV is at the implementation stage of the innovation-decision process.

(3) 24.07 percent of academic articles talk about TRAN industry and TRAN had captured 1.97 percent of industry-related post on Twitter. Table I shows many conceptual frameworks and Table II shows very less real-time framework. Therefore

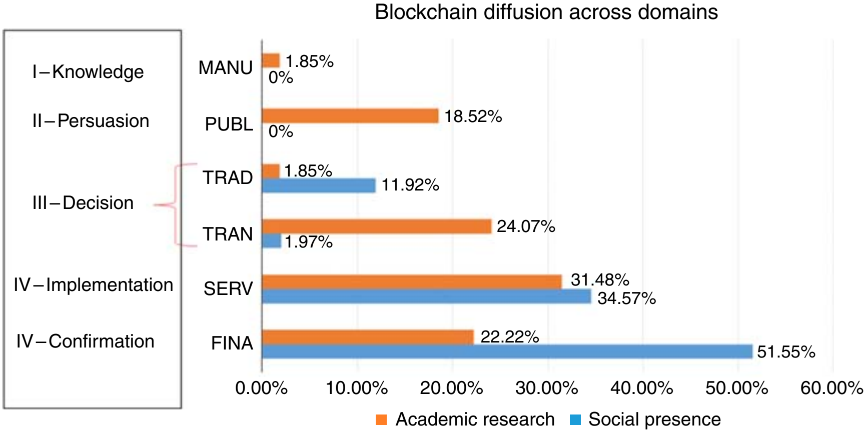


Figure 8.
Comparison of diffusion in social discussions and academic research

from this evidence, it can be concluded TRAN is at the decision stage of the innovation-decision process.

(4) 1.85 percent of academic articles talk about TRAD industry and TRAD had captured 11.92 percent of industry-related post. Therefore from this evidence, it can be concluded TRAD is at the decision stage of the innovation-decision process.

(5) 18.52 percent of academic articles talk about PUBL industry; no dominant hashtag in top 100 belongs to PUBL industry, but real-time implementation and conceptual concepts highlighted in Table II. Therefore from this evidence, it can be concluded PUBL is at the persuasion stage of the innovation-decision process.

(6) 1.85 percent of academic articles talk about MANU industry; no dominant hashtag in top 100 belongs to MANU industry. Therefore, we conclude MANU is at the knowledge of the innovation-decision process.

(7) For other industries there are very fewer evidence in the academic literature and Twitter, therefore other industries may be at knowledge stage of the innovation-decision process or maybe not considering blockchain for their industry. The diffusion in other industry is an open question and can be undertaken in future by other researchers.

As the industries are in different diffusion stages they can learn from each other experiences. Industries lagging behind can avoid the making of mistakes and benefit from the learnings of the frontrunner industries. In the view of the above findings, it seems like FINA and SERV had reached to the critical mass. According to Rogers (1995), critical mass is the point at which enough individuals in an ecosystem have adopted an innovation and further adoption of the innovation is self-sustaining. Therefore, by focusing on people in the FINA and SERV can facilitate the further adoption of blockchain in the domain. Each additional adoption within in FINA and SERV industries will increase the utility of blockchain adoption for all the adopters. For TRAN and PUBL industries, both academic research and social presence had shown the favorable attitudes toward blockchain use. Therefore, academician and start-ups have the potential of becoming lead users within TRAN and PUBL industries. Lead users are the types of users who create the innovation prototypes subsequently convince the company to produce and sell something similar (Rogers, 1995). TRAD is having higher social presence as compared to academic research, therefore industry sponsored project, from organizations such as CEDEX can be beneficial in accelerating blockchain within the domain. For MANU and other industries, there is a need for setting the agenda, in order to find the contexts and scenarios where blockchain can be beneficial in the domain.

5.2 Discussion of the method and theoretical contribution

The study purposes two complementary approaches for determining diffusion of blockchain within industries. The similar methodology can be used by future researchers in exploring diffusion of new technologies. The study points out industry-specific features, challenges and players related to blockchain through the academic literature and social media data (Table III). The study depicts information quality is low on Twitter (Lee *et al.*, 2016; Wang *et al.*, 2013). The study depicts crowd intelligence on Twitter can be used for briefing conceptual concepts (green energy production; autonomous transportation; minerals traceability; home-sharing economy; voting platform; and fraud-free elections) which can be implemented on blockchain in future. This study suggests manpower is needed in blockchain technology. To trace features and challenges industry specific, the literature review is a better approach, whereas for tracing practical implementation social media is a better approach.

6. Conclusion

Blockchain has been defined as an open, distributed, peer-validated, transparent, write-only and time-stamped ledger (Aste *et al.*, 2017; Dai and Vasarhelyi, 2017; Di Pierro, 2017; Huckle and White, 2016; Magazzeni *et al.*, 2017; Nakamoto, 2008; Yeoh, 2017). Blockchain has the potential of transforming society in the economic, political and social contexts and had been used in various applications such as cryptocurrency, smart contracts, machine-to-machine communication, asset management, online identification, public procurement and many more. Blockchain had been considered in various subject areas other than computer science, engineering and business management such as social sciences, decision sciences, arts, energy and many more.

This study had used the literature review and social media analytics complementary methods for exploring the diffusion of blockchain across different industries. Insights signals, finance, insurance and real estate is at confirmation stage of the innovation-decision process; services is at implementation stage of the innovation-decision process; transportation, communications, electric, gas, and sanitary service and trading is at decision stage of the innovation-decision process; public administration is at persuasion stage of the innovation-decision process; manufacturing is at knowledge stage of the innovation-decision process; and for the other industries there were very fewer evidence in the academic literature and Twitter, therefore it can assume other industries may be at knowledge stage of innovation-decision process or may be not considering blockchain for their industry. The diffusion in other industries is open for further research. By understanding the differences in diffusions, industries can use this to learn from other industry experiences at the different stages of diffusion.

Industry-specific features, challenges, conceptual framework (through the literature review insights), conceptual concepts (through social media analytics insights), practical implementation (through the literature review and social media analytics insights) and popular players of blockchain have been highlighted in the study. The benefits of the blockchain technology had not been amplified in the academic literature and had been justified by suggesting conceptual frameworks, whereas on Twitter benefits had been amplified a lot without focusing on real-time implementation and just touching on conceptual concepts. *H1* suggests that on Twitter there is more speculation on blockchain rather than deep expertise. There were only a few tweets which had highlighted industry-specific characteristics and challenges on Twitter. More conceptual frameworks have been suggested in the academic literature, whereas on Twitter more practical use cases have been discussed. The study reveals blockchain can be used for machine-to-machine communications in manufacturing industry. Transportation, communications, electric, gas and sanitary service can use blockchain for energy trading through smart meters. Blockchain can revolutionized finance, insurance and real estate by bringing transparency in financial systems. Service industry look up to blockchain for providing authentication, authorization, disintermediation and traceability to their customers.

7. Limitations and future research directions

The systematic literature review in the study only focused on journal articles; therefore future researchers can consider conferences, white paper and other gray literature for tracing the diffusion of the blockchain. The data from Twitter for determining the diffusion of blockchain in different industries was only collected for two months future researchers can explore the same with larger data set. In future, researchers use the method for visualizing the blockchain or any technology adoption among industries. Blockchain industry-specific analysis can be conducted using social media analytics in future. Future study can be used for mapping user level adoption for various stages in the innovation-decision process. Longitudinal studies can be beneficial for tracing the diffusion of blockchain in various industries. The study list some of the conceptual concepts such as green energy production; autonomous transportation; minerals traceability; home-sharing economy; voting platform; and fraud-free elections; suggested by the crowd on Twitter. The future researchers can investigate whether these conceptual concepts are feasible with blockchain technology or not.

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