Perceived usefulness, ease of use and user acceptance of blockchain technology for digital transactions–insights from user-generated content on Twitter

Grover, Purva; Kar, Arpan Kumar; Janssen, Marijn; Ilavarasan, P. Vigneswara

Important note
To cite this publication, please use the final published version (if applicable).
Please check the document version above.

Perceived usefulness, ease of use and user acceptance of blockchain technology for digital transactions - Insights from user-generated content on Twitter [1]

Grover, Purva – Indian Institute of Technology Delhi, New Delhi, India

Kar, Arpan Kumar – Indian Institute of Technology Delhi, New Delhi, India

Janssen, Marijn – Delft University of Technology, The Netherlands

Ilavarasan, P. Vigneswara - – Indian Institute of Technology Delhi, New Delhi, India

Although blockchain has attracted a great deal of attention from academia and industry there is a lack of studies on acceptance drivers. This study explores blockchain acceptance among users by mining the collective intelligence of users on Twitter. It maps blockchain user acceptance drivers to technology acceptance constructs. The analysis shows that users are attracted by the security, privacy, transparency, trust, and traceability provided by blockchain. Twitter features more discussions on blockchain benefits than on its drawbacks. Initial coin offering (ICO) is extensively discussed blockchain use case on Twitter. The study provides guidelines for general and IT-managers; and concludes by presenting the limitations of the study along with future research directions.

Keywords: blockchain; collective intelligence; acceptance; user generated content; social media analytics; technology adoption.

1.   Introduction

Blockchain technology is seen as an emergent disruptive technology by both academia and industry. Academics believe that blockchain will lead changes driven by information and communication technology for the next generation (Kogure et al.,

---

2017). Industry leaders such as the CEO of IBM, Ginni Rometty predict that "What the internet did for communications, blockchain will do for trusted transactions" (September 2017). A report by Cognizant, a large multinational IT firm argues that sustaining competitive advantage has been the top driver for blockchain adoption among companies and organisations (Cognizant, 2017).

Blockchain is a distributed transaction ledger in a peer-to-peer network (Nakamoto, 2008) where each block contains transaction information and a cryptographic hash of the previous block. Each block is duplicated at multiple nodes within a network (Magazzeni et al., 2017). The cryptography is used to ensure secure, tamper resistance, authenticated and verifiable transactions (Huckle and White, 2016; Nordrum, 2017; Lu and Xu, 2017; Tai et al., 2016). Each transaction in the network becomes valid only when verified by the participants in the network and when consensus is reached according to the algorithm used. Blockchain was introduced by Satoshi Nakamoto in 2008 in the white paper "Bitcoin: a peer-to-peer electronic cash system" (Nakamoto, 2008). Bitcoin was the first application of blockchain. Blockchain innovated new ways of data storage and sharing (Cuccuru, 2017), transaction management (Cuccuru, 2017) and digital asset transfers (Kiviat, 2015). Applications based on blockchain have the potential for transforming fields such as agriculture (Manski, 2017); banking (Dai and Vasarhelyi, 2017); business and management (White, 2017); finance (Dai and Vasarhelyi, 2017; Manski, 2017; Scott et al., 2017; Tang et al., 2017); capital markets (Tang et al., 2017); insurance (Dai and Vasarhelyi, 2017); services (Dai and Vasarhelyi, 2017; Manski, 2017); governments (Manski, 2017; Tang et al., 2017); logistics (Van Engelenburg et al. 2018), high-tech enterprises (Tang et al., 2017); and the energy internet (Tai et al., 2016).

Blockchain has gained lot of attention from both academia as well industry and is seen as being just as revolutionary as internet (Dai and Vasarhelyi, 2017). However, evidence to back up such statements has not yet been published. This study addresses this literature gap by exploring blockchain acceptance among users. The empirical methods such as surveys cannot be used for exploring blockchain acceptance among users because of the following reasons: firstly, as stated above, blockchain is an upcoming technology and at present inadequate expertise exists and it is difficult to find a representative sample of the collective understanding worldwide. Secondly, blockchain discussion may involve different actors (i.e., users, regulators, developers, operators and many more) and to the best of our knowledge there is no extensive list showing the contact details of these actors. Thirdly, for such emergent technology, respondents would have biases based on limited exposure in ongoing projects at individual level (Hong and Page, 2004) and thus the survey method would ignore diversity in opinion and the multiple perspectives of the different actors, leading to inaccurate observations (Choi and Pak, 2005).

Therefore to explore this research objective there is a need to mine collective intelligence for the following reasons. Firstly, when dealing with an emergent technology like blockchain, there are only a few people who have a detailed understanding of the technology, so we needed to study a larger pool of people who know at least something about the technology. Secondly, since the applications built on blockchain involve different actors such as users, regulators, developers, operators and many more, we needed to include *diverse users* in terms of experiences, training and preferences. Diverse perspectives improve understanding, as shown by the *diversity trumps ability theorem* (Hong and Page, 2004), and help us to make accurate predictions as shown by the *diversity prediction theorem* (Page, 2007). Collective intelligence of

the users on blockchain technology acceptance can be mined through sociotechnical platforms.

Sociotechnical system supports the interaction of humans (social component) through machines (technology) (Cooper and Foster, 1971). Sociotechnical systems is the perfect example where both man and machine complement each other. Sociotechnical system includes three elements, (a) operations by individual; (b) operation by machines; and (c) operations on materials. Cooper and Foster (1971) had presented the input-conversion-output model of a sociotechnical system. In this model input is given by the humans, which depends on individual preferences, psychological requirements and social interactions. Work relationship structure in sociotechnical system composed of human inputs and technical characteristics. Technical characteristics includes level of mechanization, spatio-temporal displacement of technology and nature of processed material. Cooper and Foster (1971) had indicated sociotechnical system generates social-psychological outcomes also. As indicated by Grover, Kar and Davies (2018), data captured on sociotechnical web platforms (STWP) can help in understanding the society, nature and technology together. Technology discussions on sociotechnical web platform influences, controls and shapes users technology acceptance levels. In this digital era, sociotechnical web platform is an integral part of understanding the human society at large. Popular sociotechnical web platforms may include Facebook, Twitter, Linkedin, and Researchgate. These platforms provides a similar environment to all individuals across the globe. Stimulates the thinking process among users. These platforms are interactive in nature which engages users and leads to subsequent usage.

Facebook is the largest social networking platform, worldwide with the largest number of the users (Kim and Cha, 2017). LinkedIn is the world's largest professional

networking site. Twitter is the microblogging platform. ResearchGate is used in academics by scientists and researchers for sharing research articles (Van Noorden, 2014).

Different STWP focus on enabling different functionalities. Facebook is used more for self-presentation, while LinkedIn is used more for self-promotion (Chae, 2018). Similarly people use Twitter for news and updates rather than presenting themselves. Twitter provides high-paced dialogue and escalates information dissemination process (Opitz et al., 2018). Entertainment had been the primary motivations in using Facebook (Kim and Cha, 2017). For using LinkedIn among users, professional advancement and self-presentation had been the primary motivation. Literature indicates Facebook use has ritualistic orientations, whereas LinkedIn use has more instrumental orientations (Kim and Cha, 2017) whereas Twitter satisfies both instrumental and ritualistic needs of the users.

Restrictions on content access on Twitter is very less as compared to Facebook and LinkedIn (Sundararajan et al., 2013). Messages posted on Twitter are publicly available. Twitter had been stated as a social broadcasting tool in literature (Sundararajan et al., 2013). This study is looking for the technology acceptance by diverse users, regulators, developers, operators and users. Therefore according to the authors there is a high probability that these diverse users may not be present on ResearchGate. On basis of the orientation (i.e., instrumental and ritualistic) and restriction on content access, Facebook and LinkedIn cannot be used for mining collective intelligence on blockchain technology.

Therefore Twitter had been used to examine user acceptance of blockchain technology. Twitter satisfies the condition required for collective intelligence stated above. Firstly, in this digital era, Twitter is able to aggregate millions of disparate ideas

(Brabham, 2008) through hashtags (Chae, 2015). Where users on Twitter add content by tagging hashtags, this infers that they have some level of interest and expertise on the concept. This satisfies requirement one, the need for collective intelligence. Secondly, Twitter has evolved as a tool for information sharing and dissemination purposes over a span of time (Hughes and Palen, 2009). Thirdly, Twitter content has been used for examining public opinions related to technology (Runge et al., 2013). Fourthly, it allows geographically dispersed experts in academia and industry to communicate with each other (Runge et al., 2013). Fifthly, the online medium helps us present the big picture of emerging technologies by focusing on applications, policy, and social implications (Cacciatore et al., 2012). And finally, social media data give us a glimpse of unbiased spontaneous communication (Runge et al., 2013). Taken together these reasons satisfy requirement two of collective intelligence surrounding an emergent technology.

Ma and McGroarty (2017) had pointed out Twitter harness the crowd thinking about market price by engaging disparate individuals which subsequently can be used for improving decision making capabilities related to high frequency trading. Tweets posted by beef consumers across the globe had been used for proposing waste minimization strategies for the products in the literature (Mishra and Singh, 2018). Tang (2018) had suggested user generated content on Twitter related to products and brands can be used for predicting the sales at the firm level and pointed out the predictive power depends on the wisdom of the crowd. Literature indicates user's participation on Twitter during disaster management can acts as the human sensors (Ogie et al., 2018). They had categorised human sensors into four types on the basis of the reliability, these were super active human sensors, very active human sensors, active human sensors and

rarely active human sensors. Twitter contains the aggregated multi-angled social, cultural and organisational views (Ma and McGroarty, 2017).

Therefore, this study explores blockchain acceptance among users by mining collective intelligence of user generated content on Twitter. The study focuses on three interrelated research questions (RQ):

RQ1 - What are the primary characteristics of blockchain? How have these characteristics been discussed on Twitter?

RQ2 - What are the primary use cases of blockchain? How have these use cases been discussed on Twitter?

RQ3 - What are the dominant benefits and drawbacks of blockchain technology? How have these benefits and drawbacks been discussed on Twitter?

For the first part of RQ1, RQ2 and RQ3, academic literature was consulted in order to list the primary characteristics, primary use cases, benefits and drawbacks of blockchain. The academic literature was considered as suggested by previous scholars (for instance, Glenn, 2015). Subsequently these lists were used for building the hypotheses H1, H2 and H3 within the Twitter ecosystem.

Tweets containing the term "#blockchain" were extracted for two months between 1 January 2018 and the end of February 2018. This period has been chosen for data extraction because various organization had indicated the blockchain will be significant for their domain in 2018, for instance health domain (Johnmar, 2017). Secondly if you observe Gartner hype cycle for emerging technologies in July 2016 blockchain was between innovation trigger and peak of inflated expectation, but in July 2017 blockchain peak of inflated expectation and trough of disillusionment and remained their only in July 2018.

The study assumed that tweets tagged with "#blockchain" had been posted by the humans only and not by bots. We were able to extract 4,000 to 6,000 tweets per day. The discussions on use cases, benefits and drawbacks were tracked on a daily basis, while characteristics were tracked in the top 80% shareable tweets according to the Pareto principle (i.e. 80/20).

The remaining sections are organised as follows: Section 2 focuses on the theoretical basis and hypothesis development. Section 3 illustrates the research approach used for the study. Section 4 gives an analysis of tweets surrounding blockchain technology. Section 5 illustrates discussions of blockchain concerning perceived usefulness (blockchain characteristics), perceived ease of use (blockchain use cases), attitude towards use (blockchain benefits) and external variables (blockchain drawbacks) affecting blockchain usage. The paper concludes by presenting the limitations of the study along with future research directions. It also includes implications for practice.

2.   Theoretical Basis and Hypothesis Development

Subsection 2.1 gives a brief presentation of the concept of collective intelligence and crowd wisdom on Twitter. Subsections 2.2, 2.3 and 2.4 discuss the characteristics, use cases, benefits and drawbacks of blockchain as shown in academic literature. Subsection 2.5 presents the technology acceptance model for blockchain technology.

2.1 Collective intelligence and crowd wisdom

Twitter has the potential of capturing collective intelligence from a large pool of users. Collective intelligence has been defined as the meeting of the minds on the internet for validating the ideas of the individuals (Gregg, 2010; Kapetanios, 2008). Glenn (2015) pointed out that collective intelligence could be the next big thing in the information

technology ecosystem. Collective intelligence can facilitate better decision making (Kornrumpf and Baumöl, 2013). The literature also indicates that the combined knowledge of thousands of individuals made independently is more robust and accurate, especially when the domain is new and evolving (Page, 2007). The biggest example of the collective intelligence of the people is when they collectively choose their government representatives for their nations (Grover et al., 2017a).

Collective intelligence relies on user participation and connectionism. Users can be knowledge creators, knowledge consumers, software creators, problem solvers and learners (Kapetanios, 2008). To facilitate and connect users across the globe, a platform is needed (Glenn, 2015) such as Twitter. The way in which blockchain users add their collective intelligence to Twitter is shown in Figure 1. Connections among and between users help in learning, discussing and sharing and thus add to the knowledge surrounding blockchain (Cachia et al., 2007; Senadheera et al., 2017), thereby pushing the frontiers of knowledge on this emerging technology and impacting the practice.

[Figure 1 near here]

The biggest advantage of collective intelligence is that social consensus mitigates conflicts and biases, so that a clear picture of how users perceive the technology emerges. The literature indicates collective intelligence has been used by both academia and industry (Gregg, 2010; Kapetanios, 2008; Zhao and Zhu, 2014, Joseph et al., 2017).

The wisdom of the crowd has been defined in the literature as the process of taking collective opinion on an idea by a group of individuals rather than a single expert (Yi et al., 2012). The crowd as a whole has access to far more data than a single expert (Ma et al., 2015). Crowd wisdom helps to generate feasible, robust and accurate solutions (Heiko et al., 2016). Collective intelligence of the users on blockchain is

present on Twitter, and there is a need to extract crowd wisdom from this. Figure 2 illustrates the process of extracting crowd wisdom on blockchain characteristics, use case, benefits and drawbacks from the intelligence present on Twitter. We used the 'four stages' research approach – capture, analyse, visualise and comprehend – to extract the crowd wisdom from the collective intelligence present on Twitter described in Section 3.

[Figure 2 near here]

2.2 Blockchain Characteristics

Perceived usefulness is about a person's belief that job performance can be enhanced by using a particular technology (Davis et al., 1989). The technology considered in this study is blockchain and the job in question is the digital transaction. Perceived usefulness focuses on the following items: (a) the efficiency, performance, effectiveness, quality, ease and productivity of digital transaction; and (b) the need and usefulness of blockchain compared to existing technologies. Perceived usefulness is significantly correlated to usage (Davis, 1989). In RQ1 we investigate the perceived usefulness of blockchain in terms of characteristics and the way these characteristics have been discussed within a virtual community of users.

RQ1: What are the primary characteristics of blockchain? How have these characteristics been discussed on Twitter?

The key characteristics of blockchain are discussed extensively in the literature; a brief explanation of these characteristics is shown in Table 1. However, the literature does not indicate which characteristics are perceived as more useful for digital transactions, and it is this gap in the literature that the present study is investigating using the collective intelligence of Twitter users.

[Table 1 near here]

An earlier literature study attempted to map blockchain characteristics to potential benefits in different domains such as strategic, organisational, economic, informational and technological categories (Ølnes et al., 2017). The strategic category focused on transparency, fraud, and corruption. The organisational category focused on accountability, traceability, trust, and auditability. The economic category focused on cost and resilience. The informational category focused on distributed or decentralised, no intermediaries (reducing human errors), availability, sharing or reproducibility, reliability, privacy, scalability, data integrity, and quality and the technological category focused on security, authentication, immutability or tamper-resistance, efficiency, and reduced energy consumption.

We can ask whether the users' perceived usefulness regarding blockchain is due to strategic, organisational, economical, informational and technological benefits. If the answer is yes, does the perceived usefulness of users lean more towards either of the strategic, organisational, economical, informational and technological categories or is it equal for all aspects? We put forward the following hypothesis for this:

H1: All potential benefits of blockchain (clustered under strategic, organisational, economic, informational and technological characteristics) are discussed equally on Twitter.

$$\mu_{strategic} = \mu_{\text{organisational}} = \mu_{\text{economic}} = \mu_{informational} = \mu_{technological}$$

2.3   Blockchain Use Cases

The perceived ease of use refers to the degree to which a person believes that using the technology will be effortless. The easier the system, the greater the likelihood of it being adopted by the users (Davis, 1989). The perceived ease of use includes the

following items: (a) physical and mental effort needed; (b) understandability of the use cases; (c) ease of learning for operating various usages; (d) operational efficiency of the use case in terms of error-proneness, controllability, unexpected behaviour; and (e) user-friendliness in terms of ease of remembering and guidance. The perceived ease of use is regarded as a secondary determinant in the technology acceptance (Davis, 1989). RQ2 investigates perceived ease of use of use cases of blockchain technology.

RQ2: What are the primary blockchain use cases? How have these use cases been discussed on Twitter?

The three use cases highlighted in literature are: (a) initial coin offering (ICO); (b) smart contract; and (c) distributed ledger. The literature evidences along with their impacts are shown in Table 2. The subsequent subsection gives a brief overview of blockchain use cases.

[Table 2 near here]

2.3.1 Initial Coin Offering

In 2008, Satoshi Nakamoto introduced the idea of electronic cash transfer within a peer-to-peer online network without intermediaries by generating timestamp and immutable transactions records (Nakamoto, 2008). Bitcoin is an electronic digital currency which can be traded in the peer-to-peer network through open source software, built on blockchain technology (Savelyev, 2017). It is the first and most popular crypto-currency (Hayes, 2016). Using Bitcoin enables criminal activities such as money laundering, terrorism financing, digital ransomware, weapons trafficking, and tax evasion to be easily tracked (Ducas and Wilner, 2017).

The key features of Bitcoin are: (a) anonymity (Bailis et al., 2017); (b) algorithm based computation of value; (c) absence of single administrator of transactions; and (d) resilience to data manipulations from outside (Huckle and White, 2016; Nordrum, 2017;

Lu and Xu, 2017; Tai et al.; 2016; Savelyev, 2017). The value of the crypto-currency is dependent on: competition level among producers within a network; production rate; and algorithm complexity (Hayes, 2016). The Bitcoin exchange rate depends on the following : (a) technology factors such as public recognition and mining; (b) economic factors such as money supply, GDP, interest rate and inflation; (c) Bitcoin economy such as supply, number of transactions and their value; and (d) market activity such as trading volume and volatility (Li and Wang, 2017). The digital currency can be used for collecting donation and crowd-sourced funds (Kshetri, 2017a).

2.3.2   Smart contract

A smart contract is a self-executing digital transaction (Werbach and Cornell, 2017). It stores predetermined criteria and rules for a contract and automatically verifies the same, resulting in subsequent execution of the terms (Cuccuru, 2017). This is done within a decentralised ecosystem using a cryptographic mechanism (Werbach and Cornell, 2017). Some characteristics of the smart contract (Savelyev, 2017) are: (a) electronic in nature; (b) software implemented; (c) provides increase certainty; (d) conditional in nature; and (e) self-performing and self-sufficient. Smart contracts as a way to automate performance may open new business areas in the future (Püttgen and Kaulartz, 2017). Using smart contracts will minimise: (a) online fraud risk; (b) uncertainty; and (c) monitoring expenses (Cuccuru, 2017). It will also keep an exhaustive record of transaction history. The main challenges are understandability, rigidity by code and decentralisation (Cuccuru, 2017).

The smart contract has the potential for (a) replacing legal contracts (Magazzeni et al., 2017); (b) automatic monitoring of the accounting process (Dai and Vasarhelyi, 2017); (c) accelerating insurance processes (Püttgen and Kaulartz, 2017); (d) making patient consent workflow easier and flexible (Benchoufi et al., 2017); and (e) solving

principal-agent issues (Shermin, 2017). There are challenges in replacing contract law by smart contracts (Savelyev, 2017). An example of a leading smart contract platform (Bailis et al., 2017) is Ethereum, developed by ConsenSys. The financial sector has been the most dynamic area for smart contract experimentation (Cuccuru, 2017). More than 80 global financial institutions have partnered with the R3 consortium for a smart contract conceptual framework, Corda (Magazzeni et al., 2017).

2.3.3   Distributed ledger

Distributed ledgers allow content to be written to the blocks if – and only if – the data gets consensus from other users present in the network. Blockchain supports various consensus algorithms, such as proof of work; proof of stake; proof of activity; proof of burn; proof of capacity; and proof of elapsed time (Coindesk, 2017). Cryptographic methods can be used for encrypting, authorising and linking blocks (Magazzeni et al., 2017). The shared ledger is stored locally on each of the participants' machines (Tai et al., 2016). Changes in the block require consensus in a distributed multi–stakeholder network for updating. Once a record is written in the database it is impossible to erase (tamper resistant).

The Blockchain will evolve in future as a distributed computing platform (Anjum et al., 2017; McConaghy et al., 2017) and can be used in many domains. A validated, real-time shipment tracking system can be built using a set of private distributed ledgers along with a public blockchain ledger. This can be used by the supply chain industry to support data flow across various distribution phases (Wu et al., 2017). Blockchain can be used for owning a digital artwork and subsequently using it for tracking, characterising, and exchanging value (McConaghy et al., 2017). Blockchain technology can act as an information system within a peer-to-peer energy

market (Mengelkamp et al., 2018) along with dynamic pricing (Peck and Wagman, 2017).

In the light of the above, Hypothesis 2 investigates the distribution of discussions on blockchain use cases among users on Twitter, including how they feel about the technology through sentiment scoring. Ma and McGroarty (2017) had pointed out classifying the message on the sentiment scores enables us to predict the market for the use cases.

H2: The distribution of discussion on blockchain use cases, initial coin offering, smart contract, and distributed ledger is similar on Twitter in the study time frame.

2.4   *Blockchain benefits and drawbacks*

Earlier, Davis (1989) highlighted the following points with respect to the adoption of information and communication technology (ICT): (a) users are willing to face operational difficulty of a system that provides them needed functionality; (b) cost-benefit paradigm is relevant to both perceived usefulness and ease of use; and (c) decision makers can alter their strategies as task complexity changes. Acceptance of the technology depends on three factors, perceived usefulness, perceived ease of use and attitude toward use (Taherdoost, 2018). Perceived usefulness and perceived ease of use have considerable impact on attitude toward use. In technology acceptance sometimes other factors such as external variables had been considered. External variables includes user training, system characteristics, user participation in design and the implementation process nature (Taherdoost, 2018). RQ3 investigates benefits and drawbacks of blockchain technology and how benefits and drawbacks were discussed within a virtual community of users.

RQ3: What are the benefits and drawbacks of blockchain technology? How have these benefits and drawbacks been discussed on Twitter?

Blockchain can transform the ICT field by: (a) reducing overhead expenditure for each transaction (Cohen et al., 2017; Kshetri, 2017; Shermin, 2017); (b) supporting speedy transactions completion time (Cohen et al., 2017); and (c) providing security and trust (Kogure et al., 2017). The security and trust provided by the blockchain architecture help the systems in reducing corruption, fraud and bureaucracy within their ecosystems (Kshetri, 2017; Shermin, 2017).

Blockchain provides these benefits but the implementation of blockchain in real time is not without challenges: (a) power consumption (Cocco et al., 2017; Fairley, 2017); (b) hardware costs (Cocco et al., 2017; Fairley, 2017); (c) disintermediation of central authority / middleman / intermediary (Adams et al., 2017; Kshetri, 2017a); (d) multiple identities (Alabi, 2017); and (e) ransomware risk (Kshetri and Voas, 2017). Power consumption and hardware costs can be included under system characteristics in external variables. Disintermediation of users and multiple identities can be included under user participation in external variables. Researchers have raised concerns regarding cost, time, security, trust, power, hardware, intermediaries and identity while working on blockchain applications.

There is no evidence in the literature whether prospective users are discussing the benefits or drawbacks related to blockchain. Therefore hypothesis H3 proposes that there is no statistically significant difference between the discussions of benefits and drawbacks of blockchain implementation among Twitter users.

H3: The distribution of discussions on blockchain benefits and blockchain drawbacks are similar on Twitter across the time frame of the study.

2.5 Technology acceptance model for blockchain

The user adoption of a system depends on its functionality performance and operational complexity (Davis, 1989). Therefore to develop the hypothesis, concepts from the technology acceptance model (TAM, Davis et al., 1989) like perceived usefulness, perceived ease of use, attitude towards use and external variables have been used as the guiding theoretical lens (Taherdoost, 2018). Davis (1989) highlighted that perceived usefulness and perceived ease of use are two determinants of use of ICT. Perceived usefulness measures the belief of a person that using a system will help him/ her to perform their job better (Corkindale et al., 2018), whereas perceived ease of use measures belief of a person that using a system will be free from effort. The attitude towards use tries to take into the account the person's attitude and internal beliefs regarding the technology. The external variable takes individual differences, situational constraints and managerially controllable interventions into consideration.

On the basis of the literature (Davis, 1989; Davis et al., 1989), we mapped (a) the perceived usefulness of the blockchain to the characteristics of blockchain; (b) the perceived ease of use to the sentiment score of use cases among users on Twitter; (c) the attitude toward use to the benefits of blockchain; and (d) the external variables to drawbacks of blockchain. The external variables consider factors influencing the users' or organisations' adoption of blockchain technology.

Given the above, we proposed the technology acceptance model (Davis et al., 1989) for blockchain, with four factors - perceived usefulness, perceived ease of use, attitude towards use and external variables. To answer RQ1, RQ2, and RQ3, we examined tweets using social media analytics (Chae, 2015; Fan and Gordon, 2014) along with data mining and statistical approaches (see Section 3).

[Figure 3 near here]

3   Research Approach

Sociotechnical platform has been used for different purposes in society such as: (a) investigating word of mouth in online communities (Cho and Chan, 2017; Senadheera et al., 2017; Song et al., 2018; Shan and Lin, 2017; Tse et al., 2018; Wang and Guo, 2017); (b) opinion mining (Moe and Schweidel, 2012; Grover et al., 2018a; Ravi and Ravi, 2015); (c) information gathering (Grover et al., 2018b; Senadheera et al., 2017); and (d) communication purposes (Corkindale et al., 2018; Shan et al., 2017). User-generated content exhibits a stronger impact than market-generated content on user behaviour (Goh et al., 2013) and gives less biased, deeper and better understanding by presenting the true state of technology acceptance (Poria et al., 2014). For this reason we used Twitter data to summarise user acceptance of blockchain technology.

The social media analytics framework is suggested by Fan and Gordon (2014) for analysing social web data. The framework tries to explain how data can be extracted and analysed in three stages: capture, understand and present. However, the framework lacks a provision for showcasing what the outcome of the analysis indicates and signifies. Therefore, this study proposes a new four-stage research approach for working with data - capture; analyse; visualise; and comprehend, for analysing and deriving insights and discussing the implications and significance (Figure 4).

For RQ1 and to validate H1, we mapped the characteristics within tweets using manual content analysis (Kassarjian, 1977). The bar chart demonstrates the frequency of the characteristics within the tweets. These characteristics are clustered into categories of benefits (Ølnes et al., 2017). Analysis of Variance (ANOVA) was applied over the frequency of the characteristics to statistically validate the discussions on blockchain. The information flow network is used to visually depict the information flow of

blockchain benefits across the network. The results of blockchain characteristics are presented in Section 4.1.

For RQ2 and validating H2, we identified the tweets containing use cases hashtags. The use cases hashtags that occurred in the top 100 dominant hashtags were selected for further analysis. The frequency of the tweets related to use cases hashtags was computed on a daily basis and the results presented in bar and pie charts. As the distribution of discussions on use cases did not satisfy normality and homogeneity tests, a non-parametric test, the Kruskal-Wallis H test was applied. We made a sentiment analysis of the use cases tweets can provide an overview of users' perception, opinion and attitudes (Mishra and Singh, 2018) concerning blockchain use cases and their associated features. For sentiment analysis, we took a list of positive and negative words from the literature (Hu and Liu, 2004; Liu et al., 2005). The list of the positive and negative words was carefully examined. The list is the extensive collection of the positive and negative words and also includes all the positive and negative words related to blockchain technology, to best of our knowledge.

A sentiment score for each tweet based on the number of positive and negative words in the tweet was computed. Initially for all the tweets sentiment score had been initially assigned to zero. For each positive word in a tweet +1 had been added to the sentiment score. For each negative word in a tweet -1 had been added to the sentiment score. For each neutral word in a tweet 0 had been added to sentiment score. For each word in a tweet +1, 0 or -1 had been added to sentiment score on the basis of the word polarity (i.e., positive or negative). This same process had been adopted in literature (Mishra and Singh, 2018). This process help us in examining the aspect level categorisation of tweet towards the use case. If the sentiment score of a tweet was less than 0, this indicates a negative tweet (more number of negative words for a use case in

the tweet); for a value greater than 0, the tweet is positive (more number of positive words for a use case in the tweet); and for a value equal to 0, the tweet is neutral (no positive and no negative word just a query relating to use case; or equal number of positive and negative words, presenting the ambiguous scenario of the users towards the use case). The results are presented in Section 4.2.

For RQ3 and to validate H3, we used lexicon-based extraction to locate tweets related to benefits and drawbacks. The frequency of tweets related to benefits and drawbacks is presented using bar charts. To statistically validate the distribution of discussion on blockchain benefits and drawbacks, we used the Mann Whitney test. The results of this are presented in Section 4.3.

Out of the four stages, in the first stage (capture), we extracted data on a daily basis from Twitter. A mean daily average of 5,784 tweets was extracted. In total, 341,309 tweets were extracted with 35 parameters which included both user and tweet attributes. The user attributes include information for the user such as name, location, description, joining date, followers, following, like, lists and moment count. The tweet attributes contain information related to tweets such as creation time, content, language, location (geo-coordinates), retweet, like and reply attributes.

As a tweet is an informal unstructured content consisting of text, images, hyperlinks, hashtags and other media, cleaning was required. Firstly, anything other than English letters was removed. Secondly, all the extra white spaces were removed. Thirdly, all the URLs were removed. Fourthly, references to other screen names in the tweets were removed.

In the second stage (analyse), we applied descriptive analytics, content analysis (Chae, 2015) and statistical testing to the tweets to derive useful information. The

descriptive analysis focused on descriptive statistics, such as the number and types of tweets, number of unique users, hashtags and @mention in the tweets.

We used content analysis to extract the semantic intelligence from the text data. This uses natural language processing and text mining (Kayser and Blind, 2017) to retrieve the information from text data (Kassarjian, 1977). The content analysis includes such methodology as lexicon-based extraction, hashtag analysis, topic modelling and content analysis.

In the third stage (visualise), we visually depicted the connection among users on Twitter using the networks (Stieglitz et al., 2014). The flow of information across the network was visualised using the network diagram. The networks analysis helped us identify communities in a network. The users were clustered on the basis of their opinions (Abascal-Mena et al., 2015). In addition to network charts, information is shown in bar and pie charts.

In the fourth stage (comprehend), the findings of the social media analytics were mapped and presented using technology acceptance theory (Davis et al., 1989). On the basis of the mapping, the discussion was made for blockchain perceived usefulness, perceived ease of use, attitude towards use and external variables.

[Figure 4 near here]

4   Analysis

This section highlights the characteristics of blockchain and goes on to discuss popular blockchain use cases on Twitter, followed by the benefits and drawbacks of blockchain.

4.1 Blockchain Characteristics

This section presents the analysis for RQ1. In the extracted sample, 5918 unique tweets had been retweeted 80% times. The blockchain characteristics were mapped within

5,918 tweets using manual content analysis techniques. Content analysis (Kassarjian, 1977) is a technique which converts qualitative data into quantitative data for statistical analysis. The reliability of the process is improved by allowing more than one judge to map the tweets to characteristics, such that consensus is achieved.

In manual content analysis, there were 136,114 decision points, i.e. for 5918 unique tweets were mapped to 23 characteristics. Two independent judges agreed on 119,685 decisions and disagreed on 16,429 decisions resulting in higher coefficient of reliability, 87.93 percent. The literature suggests that 85% and above coefficients of reliability for the studies is sufficient (Kassarjian, 1977). The choices of the categories enhance or diminish the likelihood of the valid inferences (Berelson, 1952). Therefore a close check was done on the mapping by both the judges. The top characteristics of blockchain discussed on Twitter are presented in Figure 5.

[Figure 5 near here]

The literature mapped these characteristics to potential benefits in strategic, organisational, economic, informational and technological categories (Ølnes et al., 2017). Hypothesis H1 investigates the mean discussion regarding blockchain technology on Twitter.

H1: All potential benefits of blockchain (clustered under strategic, organisational, economic, informational and technological characteristics) are discussed equally on Twitter.

$$\mu_{strategic} = \mu_{\text{organisational}} = \mu_{\text{economic}} = \mu_{informational} = \mu_{technological}$$

Let α=0.05 (assumption), the degree of freedom is (k-1, n-k), where k is the number of samples (k=5; strategic, organisational, economic, informational and technological) and n is the total number of observation (n=23; blockchain characteristics identify from literature). The degree of freedom for this is equal to (4,

18). The decision rule states, if the calculated value of F is greater than the table value of F, reject H1. The table value of F at 5% level of significance for degrees of freedom (4, 18) is 2.93. The F- statistic is the ratio of the variability between groups to the variability within groups.

The calculated value of the F- statistic for the blockchain discussions surrounding characteristics is 0.503 which is less than the threshold value of 2.93. Therefore, H1 is not rejected. Hence there is no significant difference between means of discussions surrounding blockchain characteristics. This indicates Twitter had been used equally for discussions related to strategic, organisational, economic, informational and technological characteristics.

Figure 6 presents the flow of information regarding blockchain characteristics in the top 80% retweets with the following colour coding: purple - technological characteristics; light green - informational characteristics; blue - organisational characteristics; red - strategic characteristics; and dark green - economic characteristics. Some of the network parameters (Shan et al., 2017) are listed below: number of nodes - 449; number of edges-676; average degree-3.011; average weighted degree-10.367; network diameter- 7; graph density-0.007; connected components-178; average clustering coefficient-0.131; and average path length-3.403. The graph shown in Figure 6 has a graph density equal to 0.007 and average clustering coefficient equal to 0.131 which indicates that graph is weakly connected and the users are dispersed in the network. There are 178 connected components in a network of 449 users, which indicates on average 2 or 3 users in one connected component which indicates a loosely coupled network.

Figure 6, presents the flow of blockchain characteristics information within Twitter users. The node size indicates the tweeting frequency of the user with

"#blockchain". The larger the size of the node indicates the more the users had tweeted compared to others. For the technological and organisational characteristics, some users tweet more heavily whereas for the informational and strategic characteristics use is distributed more evenly across the users. The weights of the edges depict the frequency of communication between the users. Figure 6 shows that some users are frequently discussing the economic characteristics together. In terms of percentage, informational characteristics (44.49%) are discussed most among users, followed by technological (34.38%); organisational (12.82%); strategic (6.64%); and economic (1.66%) characteristics. The informational and technological characteristics were discussed and shared more compared to other characteristics.

[Figure 6 near here]

4.2 Use cases

The popular use cases related to blockchain are ICO, smart contract and distributed ledger as shown in the literature (Table 2). From 341,309 tweets collected for the study, the top 100 hashtags were identified. From these, those related to blockchain use cases such as #cryptocurrency or #coin or #money; #smartcontracts; #data or #datascience or #dlt; were selected. Figure 7 shows the number of tweets in the sample associated with dominant use cases hashtags. The counts of the tweets for #coin, #money, #smartcontracts, #data, #datascience, and #dlt were between 2 and 382 and for #cryptocurrency the count was between 133 and 1721.

[Figure 7 near here]

To statistically validate significant differences in the distribution of discussion surrounding blockchain use cases on Twitter, we proposed hypothesis H2.

H2: The distribution of discussion on blockchain use cases (initial coin offering, smart contract, and distributed ledger) is similar on Twitter in the study time frame.

The distribution of the discussion on use case on daily basis did not satisfy normality and homogeneity conditions, so we applied the non-parametric test Kruskal-Wallis H test. The test showed a statistically significant difference in discussions between different blockchain use cases discussions, $\chi^2(2) = 148.082$, $p < .001$, with a mean rank discussion of 147.45 for ICO, 32.71 for smart contracts and 86.84 for distributed ledgers.

The perceived ease of use for the application on blockchain was measured using users' sentiment analysis. The sentiment analysis (Liu, 2010) of the use cases tweets helped us to determine Twitter users' opinions regarding blockchain use cases. We computed the sentiment analysis of the tweets on the basis of the words' polarity in the tweets. A list of positive and negative words was taken from the literature (Hu and Liu, 2004; Liu et al., 2005). On the basis of the number of positive and negative words in the tweet, the sentiment score was computed for each tweet. Figure 8 presents the sentiment analysis for blockchain use cases.

[Figure 8 near here]

Besides #cryptocurrency or #coin or #money hashtags, ICO hashtags, #bitcoin or #btc, #xrp, #altcoin, #digibyte, #trx or #tron, #litecoin or #ltc, #edinarcoin and #dash also occurred in the top 100 hashtags. Bitcoin is the most popular currency among all coin offerings. Bitcoin tweets are the most liked and retweeted by users on Twitter. The use cases related to ICO are more frequently discussed compared to smart contracts and the distributed databases.

4.3 Benefits and Drawbacks

The literature indicates that transaction cost, transaction time, security and trust are the perceived benefits (Cohen et al., 2017; Kogure et al., 2017; Kshetri, 2017; Shermin, 2017) whereas power consumption and hardware cost are some of the challenges faced when implementing blockchain technology (Cocco et al., 2017; Fairley, 2017). According to the literature, the perceived risks in using blockchain technology include disintermediation of intermediaries (Adams et al., 2017; Kshetri, 2017a) and multiple identities of users (Alabi, 2017). We searched these benefits and drawbacks in the sample, using the lexicon-based method.

To identify the tweets related to transaction cost, we searched the lexicon "cost" in the sample. Once identified, the semantics of the tweets were checked, whether the tweet was talking about transaction cost or some other cost. Once the tweet semantic was checked and found relevant, we considered the tweet for further analysis. The same process was repeated for other benefits and drawbacks. The lexicons used for other benefits and drawbacks are given in brackets as follows: transaction time (time), security (security), trust (trust), power consumption (power), hardware cost (hardware), disintermediation of intermediaries (intermediary / intermediaries) and multiple identities of users (identity and identities).

Figure 9 shows the distribution of the discussion on benefits and drawbacks of the study across the time frame of the study. The sample counted the following benefits in decreasing order of popularity: security, transaction completion time, transaction cost and trust. The sample counted the following drawbacks in decreasing order of popularity: power consumption; users multiple identities; hardware cost and disintermediation.

[Figure 9(a) and 9(b) near here]

Hypothesis H3 is an attempt to statistically validate the distribution of discussions on blockchain benefits and drawbacks.

H3: The distribution of discussions on blockchain benefits and drawbacks are similar on social media across the time frame of the study.

The mean benefits of discussions is 344.01 and for drawback-related discussions, it is 178.61. The benefits discussions distribution appeared to be significantly normal D (59) = 0.066, p<.05 but drawbacks discussions distribution was not normal D(59) = 0.001. The assumption of homogeneity is met, F(1,116)= 0.175. The distribution was not normal but homogeneous, so we applied a non-parametric test, the Mann Whitney test. The Twitter users were significantly discussing the benefits of blockchain more U=278, z = -7.872, p<.001, than the drawbacks.

5   Discussion

This section presents the insights derived from the Twitter data for the three research questions. The literature sees blockchain as an upcoming disruptive technology in many sectors (Kogure et al., 2017), but there is no clear evidence for blockchain acceptance by user. This paper uses technology acceptance constructs (Davis, 1989; Davis et al., 1989) for blockchain technology, as presented in Figure 3, along with four constructs: perceived usefulness, perceived ease of use, attitude to use and external variables.

RQ1: What are the primary characteristics of blockchain? How have these characteristics been discussed on Twitter?

The primary characteristics of the blockchain are shown in Table 1. The study shows that digital transactions on blockchain are beneficial regarding security, decentralisation, shareability, privacy, traceability, trust and transparency (the three Ts).

Users demand the three Ts in their tweets for digital transactions along with speedy and secure (the two Ss) transactions over the internet with reduced overhead cost.

The analysis of Twitter discussions shows: (a) the security provided by blockchain with regard to digital transactions is in line with the literature (Cuccuru, 2017; Kogure et al., 2017); (b) blockchain supports trustworthy digital transactions within decentralised networks and will transform the boundaries of the organisations in future; and (c) blockchain as a data storage medium enables the transparent traceability of goods across all stages of the supply chain; The discussions indicate that blockchain characteristics are disrupting the ways financial, banking, health and supply chain sector perform, since blockchain characteristics are extensively discussed on Twitter.

The literature indicates that blockchain benefits are not supported by empirical evidence (Ølnes et al., 2017). The study statistically validated blockchain primary characteristics discussions on Twitter by mapping them into strategic, organisational, economic, informational and technological benefits (Ølnes et al., 2017). We used the frequency occurrences of the characteristics in the tweets to statistically test H1 and our results indicate that Twitter is used for discussions related to strategic, organisational, economic, informational and technological characteristics in equal proportions. In numbers, informational characteristics of blockchain are the most discussed, followed by the technological, organisational, strategic and economic characteristics of blockchain, which is in line with literature (Ølnes et al., 2017) and indicates that informational characteristics, (data integrity and higher data quality) can lead to organisational characteristics (transparency).

Figure 6, shows the flow of information related to blockchain characteristics. The informational characteristics are more frequently discussed and shared compared to technological characteristics, but the influence of the technological characteristics is

greater compared to the informational characteristics (Figure 6). This may be due to the higher need for cyber security (Shackelford, 2016; Tehrani et al., 2013) for digital transactions which can be provided by the immutability of the records (Huckle and White, 2016; Nordrum, 2017; Lu and Xu, 2017; Tai et al., 2016).

The Twitter analysis indicates that security, privacy, the three Ts, speed, reduced costs, authentication, and removal of intermediaries are perceived as the usefulness of the blockchain for digital transactions. The security and the three Ts provided by blockchain can help the systems to reduce corruption, fraud and bureaucracy, which can subsequently improve the efficiency, performance, effectiveness, and quality of digital transactions.

RQ2: What are the primary use cases of blockchain? How have these use cases been discussed on Twitter?

The primary use cases of blockchain shown in Table 2 are: ICO, smart contracts and distributed ledgers. The frequency of the hashtags related to blockchain use cases was mapped on a day-by-basis, but due to limited page width, it is presented on an alternative day basis (Figure 7) and these values are used to statistically validate H2. The results of H2 indicate that there is a statistically significant difference in discussions of blockchain use cases.

ICO was extensively discussed on Twitter, followed by distributed ledgers and smart contracts. The sample indicates users also discussed other ICOs than Bitcoin using the hashtags #xrp, #altcoin, #digibyte, #trx or #tron, #litecoin or #ltc, #edinarcoin and #dash. The literature opines that Bitcoin has attracted a billion dollar economy (Tschorsch and Scheuermann, 2016) which explains why Bitcoin tweets are the most liked and retweeted by users.

The perceived ease of use of ICO, smart contract and distributed ledger was measured using sentiment analysis. For all the use cases, the neutral sentiment is greater than the positive and negative sentiments. This is obvious as blockchain is an upcoming technology and its use cases are considerably new, therefore actors are using Twitter for enquiries. If the neutral tweets are removed, then the majority of the tweets are positive tweets, inferring a positive outlook of users towards blockchain technology. Figure 8 shows that smart contracts have the highest percentage of positive tweets followed by similar percentages for distributed ledger and ICO. As the literature indicates that easier systems are most likely to be adopted by the users (Davis, 1989). Literature had predicted market by classifying the internet messages on the basis of sentiment analysis (Ma and McGroarty, 2017; Zhang et al., 2011) and had indicated sentiment score enables the researchers to evaluate users' perception, opinion and attitudes towards the new use cases of the technology. Therefore on these evidences the next upcoming application of blockchain appears to be smart contract.

The analysis indicates that smart contract is seen positively by users, in line with the literature which indicates the urgency of smart contract deployment in the financial and banking sectors (Cuccuru, 2017), medical data storage and sharing (Roehrs et al., 2017; Xia et al., 2017; Benchoufi et al., 2017); and land regulations (Herian, 2017; Zhang and Wen, 2017). Instances of all these use cases were discussed on Twitter. The tweets indicate that smart contract (a) minimises uncertainty in transactions; (b) reduces monitoring expenses; and (c) is self-enforceable, triggering conditions that can open new business areas.

RQ3 - What are the dominant benefits and drawbacks of blockchain technology? How have these benefits and drawbacks been discussed on Twitter?

Blockchain has many benefits for digital transactions: it reduces transaction cost and time and subsequently increases security and trust in online transactions. However, to implement blockchain requires heavy infrastructure and high power consumption and involves the risks of multiple user identities and disintermediation of intermediaries. To statistically validate H3, whether users are discussing more about benefits or drawbacks, we tracked blockchain benefits and drawbacks on a daily basis. The results of H3, indicate that Twitter users discuss blockchain benefits significantly more often than they do the drawbacks. The most discussed benefit of blockchain is security with 9213 tweets followed by the transaction completion time with 5517 tweets. The most discussed drawback of blockchain is power consumption with 8607 tweets followed by the users multiple identities with 1445 tweets.

6   Conclusion

This study investigates the acceptance drivers of blockchain by extracting the wisdom from collective intelligence of the users present on Twitter. On the basis of the literature (Davis, 1989; Davis et al., 1989) the (a) the perceived usefulness of the blockchain was mapped to the characteristics of blockchain; (b) the perceived ease of use was mapped to use cases sentiment score among users on Twitter; (c) the attitude toward use was mapped to the benefits of the blockchain; and (d) the external variables were mapped to drawbacks of the blockchain.

The study indicates that blockchain is gathering attention because of the characteristics and benefits offered by the technology. The findings show that blockchain can transform digital transactions by: (a) reducing transaction overhead cost; (b) providing secure and speedy (2Ss) transactions; and (c) providing security, privacy, transparency, trust and traceability (3Ts) in the digital transactions. The literature indicates that in today's digital world, security is greatly needed (Shackelford, 2016;

Tehrani et al., 2013). Our analysis shows that users feel that blockchain may provide security to digital transactions. Whether this is so is beyond the scope of this present study and is something to be explored by future researchers. Twitter was used for analysing discussions related to strategic, organisational, economic, informational and technological benefits of blockchain technology. The informational characteristics were discussed on Twitter and these are shown to be shared more often compared to the technological characteristics, however, the influence of the technological characteristics is more frequent compared to the informational characteristics.

The study found that ICO was extensively discussed on Twitter as compared to other blockchain use cases, smart contract and distributed ledger. Bitcoin is the most popular among all ICOs. The study indicates that prospective users are more inclined towards blockchain benefits than the drawbacks. This may be seen as a signal that users are open to accepting blockchain technology for digital transactions. The authors of the study confirm that the argument made by the earlier studies that "blockchain will be as revolutionary as internet" (Dai and Vasarhelyi, 2017) and "blockchain will lead ICT for the next generation" was found on Twitter. Subsection 6.1 shows the implications for practice along with guidelines for IT and general managers and researcher and academia for further development in blockchain, and Subsection 6.2 lists the limitations of the study, along with the future scope.

6.1   *Implications for practice*

The study proposes a new research approach of extracting collective intelligence of users from Twitter and subsequently using it to present the characteristics, use cases, benefits and drawbacks of the technology. The research approach used in the study is comprised of four stages: capture, analyse, visualise, and comprehend for extracting insights from the social web (Twitter). Future researchers can use this research approach

for mining collective intelligence of the users for different purposes such as technology evolution, technology acceptance, trend analysing, and many more. To the best of our knowledge, this study is the first to demonstrate a technology acceptance model for blockchain technology. The study also shows users within the virtual world discussing blockchain benefits (attitude towards use) more often compared to drawbacks (external variable), which highlights the positive outlook of users towards blockchain and indicates a bright future for this technology. Blockchain applications can offer new commercialisation opportunities (White, 2017). The study highlights blockchain use cases, such as ICO, that can provide faster transactions, disintermediate financial intermediaries, support cross border transactions and create an open economy. Smart contracts can provide trusted networks; self-enforceability; and control and easy access. Distributed databases can provide sharing economy, immutability, high availability; and the absence of single administrator. On the basis of the results of the study, the authors provide guidelines for using blockchain technology in Subsection 6.1.1 to IT managers and general manager and in Subsection 6.1.2 to researcher and academia for further development in blockchain.

6.1.1   Guidelines for IT managers and general managers

The study suggests the following guidelines for IT managers and general managers who are working in the domain of transferring value over the internet (digital transactions) and who are planning to use blockchain technology:

(a)   The blockchain can provide two Ss and three Ts in transferring value through internet which can enhance efficiency, performance, effectiveness, quality, and ease of digital transactions.

(b)   Twitter has been used for discussions related to strategic, organisational, economic, informational and technological benefits. IT managers and general managers

working in blockchain can use Twitter profiles for gathering news and updates related to these benefits and subsequently can use blockchain for the same.

(c)   This analysis suggests that blockchain will lead ICT in the next generation, and manpower is needed at different levels of implementation of blockchain solutions such as designers, developers, operators, regulators and many more.

d)   The literature shows that for the most part, academics and the industry have built their own platforms for gaining collective intelligence. The study suggests extracting collective intelligence and crowd wisdom from the social web. This has two advantages over building a platform: firstly, the cost for building the platform will be saved; and secondly, it enables larger and more diverse group perspectives to be analysed.

6.1.2   Guidelines for researcher and academia for further development

The study suggests the following guidelines for researcher and academia for further development in blockchain and regulation of the application built on blockchain:

(a)   Users are attracted towards the blockchain due to security and speedy transaction. Therefore researcher for further development in blockchain should try to optimize it, to the extent it is possible.

(b)   Users are concern about power consumption and multiple user's identities with blockchain technology. Therefore the developers and researcher of blockchain technology should come up with blockchain implementation model where these concerns can be taken care of.

(c)   The use cases built on blockchain, ICO and smart contract has the potential of disrupting the way digital transactions used to take place in business, finance, services, governments, logistics, and the energy internet. Therefore academia

should take steps in to promote and educate the public for these use cases (Gomber et al., 2018).

(d)   On the basis of the result of the study it can be concluded users are open to accept blockchain for digital transactions. Therefore there is need for researchers and academician to list down the operational regulation for these applications and to highlight the ethical and legal rules violated by the applications, if any (Dierksmeier and Seele, 2018).

6.2   *Limitation and future research*

The study does have some limitations. Firstly, sentiment analysis on the basis of the number of positive and negative words in the tweet was used to calculate the sentiment score to each tweet. A positive sentiment score indicated a positive tweet, a negative sentiment score indicated a negative tweet and a zero sentiment score indicated a neutral tweet. This way of computing the sentiment score is not always very accurate as it focuses on individual words and does not consider the semantic of the tweet. A second limitation is that there was no mechanism in the study for differentiating between ad-like tweets and non-ad-like tweets. The Twitter Search API was used for tweet extraction.

In future research the blockchain acceptance model could be empirically validated. More research is needed to understand the perceived usefulness and perceived ease of use for blockchain technology over other technologies. This study is the first and initial step in this direction. Researchers could focus on each feature of the blockchain and examine how blockchain can open new opportunities for businesses and organisations. The study could be also used as evidence of extracting wisdom from the collective intelligence of Twitter users in the context of technology acceptance.

References

Abascal-Mena, R., Lema, R., and Sèdes, F. 2015. "Detecting sociosemantic communities by applying social network analysis in tweets." *Social Network Analysis and Mining* 5(1): 1-17.

Adams, R., Parry, G., Godsiff, P., and Ward, P. 2017. "The future of money and further applications of the blockchain." *Strategic Change* 26(5): 417-422.

Alabi, K. 2017. "Digital blockchain networks appear to be following Metcalfe's Law." *Electronic Commerce Research and Applications* 24: 23-29.

Anjum, A., Sporny, M., and Sill, A. 2017. "Blockchain standards for compliance and trust." *IEEE Cloud Computing* 4(4): 84-90.

Bailis, P., Narayanan, A., Miller, A., and Han, S. 2017. "Research for practice: cryptocurrencies, blockchains, and smart contracts; hardware for deep learning." *Communications of the ACM*, 60(5): 48-51.

Benchoufi, M., Porcher, R., and Ravaud, P. 2017. "Blockchain protocols in clinical trials: Transparency and traceability of consent." *F1000Research* 6. Doi: 10.12688/f1000research.10531.4

Brabham, D. C. 2008. "Crowdsourcing as a model for problem solving: An introduction and cases." *Convergence* 14(1): 75-90.

Bradbury, D. 2015. "In blocks [security bitcoin]." *Engineering & Technology* 10(2): 68-71.

Cacciatore, M. A., Anderson, A. A., Choi, D. H., Brossard, D., Scheufele, D. A., Liang, X., Ladwig,P.J. and Xenos, M. 2012. "Coverage of emerging technologies: A comparison between print and online media." *New Media & Society* 14(6): 1039-1059.

Cachia, R., Compañó, R., and Da Costa, O. 2007. "Grasping the potential of online social networks for foresight." *Technological Forecasting and Social Change* 74(8): 1179-1203.

Chae, B. K. 2015. "Insights from hashtag# supplychain and Twitter analytics: Considering Twitter and Twitter data for supply chain practice and research." *International Journal of Production Economics* 165: 247–259.

Chae, J. 2018. "Reexamining the relationship between social media and happiness: The effects of various social media platforms on reconceptualized happiness." *Telematics and Informatics*. DOI: 10.1016/j.tele.2018.04.011

Cho, V. and Chan, A. 2017. "A study on the influence of eWOM using content analysis: how do comments on value for money, product sophistication and experiential feeling affect our choices?." *Enterprise Information Systems* 11(6): 927-948.

Choi, B. C., and Pak, A. W. 2005. Peer reviewed: a catalog of biases in questionnaires. *Preventing chronic disease* 2(1): A13.

Cocco, L., Pinna, A., and Marchesi, M. 2017. "Banking on Blockchain: Costs Savings Thanks to the Blockchain Technology." *Future Internet* 9(3): 25. DOI: 10.3390/fi9030025

Cognizant. 2017. "Blockchain in Europe: Closing the Strategy Gap." accessed April 12, 2018, https://www.cognizant.com/whitepapers/blockchain-in-europe-closing-the-strategy-gap-codex3320.pdf

Cohen, L. R., Samuelson, L. and Katz, H. 2017. "How Securitization Can Benefit from Blockchain Technology." *Journal of Structured Finance* 23(2): 51-54.

Coindesk. 2017. "A (Short) Guide to Blockchain Consensus Protocols" accessed March 28, 2018, https://www.coindesk.com/short-guide-blockchain-consensus-protocols/

Cooper, R., and Foster, M. 1971. "Sociotechnical systems". *American Psychologist*, 26(5):467.

Corkindale, D., Ram, J., and Chen, H. 2018. "The adoption of Firm-Hosted Online Communities: an empirical investigation into the role of service quality and social interactions." *Enterprise Information Systems* 12(2): 173-195.

Cuccuru, P. 2017. "Beyond bitcoin: an early overview on smart contracts." *International Journal of Law and Information*. Doi: 10.1093/ijlit/eax003

Dai, J., and Vasarhelyi, M. A. 2017. "Toward Blockchain-Based Accounting and Assurance." *Journal of Information Systems* 31(3): 5-21.

Davis, F. D. 1989. "Perceived usefulness, perceived ease of use, and user acceptance of information technology." *MIS quarterly* 13(3): 319-340.

Davis, F. D., Bagozzi, R. P., and Warshaw, P. R. 1989. "User acceptance of computer technology: a comparison of two theoretical models." *Management science* 35(8): 982-1003.

Dierksmeier, C., and Seele, P. 2018. "Cryptocurrencies and business ethics." *Journal of Business Ethics* 152(1):1-14.

Ducas, E., and Wilner, A. 2017. "The security and financial implications of blockchain technologies: Regulating emerging technologies in Canada." *International Journal: Canada's Journal of Global Policy Analysis* 72(4): 538-562.

Fairley, P. 2017. "Blockchain world-Feeding the blockchain beast if bitcoin ever does go mainstream, the electricity needed to sustain it will be enormous." *IEEE Spectrum* 54(10): 36-59.

Fan, W., and Gordon, M. D. 2014. "The power of social media analytics." *Communications of the ACM* 57(6): 74-81.

Glenn, J. C. 2015. "Collective intelligence systems and an application by The Millennium Project for the Egyptian Academy of Scientific Research and Technology." *Technological Forecasting and Social Change*, 97: 7-14.

Goertzel, B., Goertzel, T., and Goertzel, Z. 2017. "The global brain and the emerging economy of abundance: Mutualism, open collaboration, exchange networks and the automated commons." *Technological Forecasting and Social Change* 114: 65-73.

Goh, K. Y., Heng, C. S., and Lin, Z. 2013. "Social media brand community and consumer behavior: Quantifying the relative impact of user-and marketer-generated content." *Information Systems Research* 24(1): 88-107.

Gomber, P., Kauffman, R. J., Parker, C., and Weber, B. W. 2018. "On the Fintech Revolution: Interpreting the Forces of Innovation, Disruption, and Transformation in Financial Services." *Journal of Management Information Systems* 35(1): 220-265.

Gregg, D. G. 2010. "Designing for collective intelligence." *Communications of the ACM* 53(4): 134-138.

Grover, P., Kar, A. K., Dwivedi, Y. K., and Janssen, M. 2018a. "Polarization and acculturation in US Election 2016 outcomes–Can twitter analytics predict changes in voting preferences." *Technological Forecasting and Social Change*. DOI: https://doi.org/10.1016/j.techfore.2018.09.009

Grover, P., Kar, A. K., and Davies, G. 2018b. "Technology enabled Health–Insights from twitter analytics with a socio-technical perspective." *International Journal of Information Management* 43:85-97.

Hayes, A. S. (2016). "Cryptocurrency value formation: An empirical study leading to a cost of production model for valuing bitcoin." *Telematics and Informatics* 34: 1308-1321.

Heiko, A., Hommel, U., Prokesch, T., and Wohlenberg, H. 2016. "Testing weighting approaches for forecasting in a Group Wisdom Support System environment." *Journal of Business Research* 69(10): 4081-4094.

Herian, R. 2017. "Blockchain and the (re) imagining of trusts jurisprudence." *Strategic Change* 26(5): 453-460.

Hong, L., & Page, S. E. 2004. "Groups of diverse problem solvers can outperform groups of high-ability problem solvers." *Proceedings of the National Academy of Sciences* 101(46): 16385-16389.

Huang, B., Liu, Z., Chen, J., Liu, A., Liu, Q., and He, Q. 2017. "Behavior pattern clustering in blockchain networks." *Multimedia Tools and Applications* 76(19): 20099–20110.

Huckle, S., and White, M. 2016. "Socialism and the blockchain." Future Internet 8(4): 49. doi:10.3390/fi8040049

Hughes, A. L., and Palen, L. 2009. "Twitter adoption and use in mass convergence and emergency events." *International Journal of Emergency Management* 6(3-4): 248-260.

Ito, J., Narula, N., and Ali, R. 2017. "The Blockchain Will Do to the Financial System What the Internet Did to Media. *Harvard Business Review*." accessed April 10, 2018 from https://hbr.org/2017/03/the-blockchain-will-do-to-banks-and-law-firms-what-the-internet-did-to-media

Kapetanios, E. 2008. "Quo Vadis computer science: From Turing to personal computer, personal content and collective intelligence." *Data & Knowledge Engineering* 67(2): 286-292.

Kassarjian, H. H. 1977. "Content analysis in consumer research." *Journal of Consumer Research* 4(1): 8-18.

Kayser, V., and Blind, K. 2017. "Extending the knowledge base of foresight: The contribution of text mining." *Technological Forecasting and Social Change* 116: 208-215.

Khaqqi, K. N., Sikorski, J. J., Hadinoto, K., and Kraft, M. 2018. "Incorporating seller/buyer reputation-based system in blockchain-enabled emission trading application." *Applied Energy*, 209: 8-19.

Kim, K. J., and Hong, S. P. 2016. "Study on Rule-based Data Protection System Using Blockchain in P2P Distributed Networks." *International Journal of Security and Its Applications* 10(11): 201-210.

Kim, M., and Cha, J. 2017. "A comparison of Facebook, Twitter, and LinkedIn: Examining motivations and network externalities for the use of social networking sites." *First Monday* 22(11). DOI: 10.5210/fm.v22i11.8066

Kiviat, T. I. 2015. "Beyond bitcoin: Issues in regulating blockchain transactions." *Duke Law Journal* 65: 569-608.

Kogure, J., Kamakura, K., Shima, T., and Kubo, T. 2017. "Blockchain Technology for Next Generation ICT." *Fujitsu Scientific and Technical Journal* 53(5): 56-61.

Kornrumpf, A., and Baumöl, U. 2013. "From collective intelligence to collective intelligence systems: Definitions and a semi-structured model." *International Journal of Cooperative Information Systems* 22(3): 1340002.1-1340002.21.

Kshetri, N. 2017a. "Will blockchain emerge as a tool to break the poverty chain in the Global South?." *Third World Quarterly* 38(8): 1710-1732.

Kshetri, N. 2017b. "Can Blockchain Strengthen the Internet of Things?." *IT Professional* 19(4): 68-72.

Kshetri, N. 2017c. "Blockchain's roles in strengthening cybersecurity and protecting privacy." *Telecommunications Policy* 41(10): 1027-1038.

Kshetri, N., and Voas, J. 2017. "Do Crypto-Currencies Fuel Ransomware?." *IT Professional* 19(5): 11-15.

Larios-Hernández, G. J. 2017. "Blockchain entrepreneurship opportunity in the practices of the unbanked." *Business Horizons* 60(6): 865-874.

Li, X., and Wang, C. A. 2017. "The technology and economic determinants of cryptocurrency exchange rates: The case of Bitcoin." *Decision Support Systems* 95: 49-60.

Liu, B. 2010. "Sentiment Analysis and Subjectivity." *Handbook of natural language processing* 2: 627-666.

Liu, B., Hu, M., and Cheng, J. 2005. "Opinion observer: analyzing and comparing opinions on the web." In *Proceedings of the 14th international conference on World Wide Web* (pp. 342-351). ACM.

Lu, Q., and Xu, X. 2017. "Adaptable Blockchain-Based Systems: A Case Study for Product Traceability." IEEE Software 34(6): 21-27.

Ma, J., Zheng, Y., Ning, H., Yang, L. T., Huang, R., Liu, H., Mu, Q., and Yau, S. S. 2015. "Top challenges for smart worlds: A report on the Top10Cs forum." *IEEE Access* 3: 2475-2480.

Ma, T., and McGroarty, F. 2017. "Social Machines: how recent technological advances have aided financialisation." *Journal of Information Technology* 32(3): 234-250.

Magazzeni, D., McBurney, P., and Nash, W. 2017. "Validation and Verification of Smart Contracts: A Research Agenda." *Computer* 50(9): 50-57.

Manski, S. 2017. "Building the blockchain world: Technological commonwealth or just more of the same?." *Strategic Change* 26(5): 511-522.

McConaghy, M., McMullen, G., Parry, G., McConaghy, T., and Holtzman, D. 2017. "Visibility and digital art: Blockchain as an ownership layer on the Internet." *Strategic Change* 26(5): 461-470.

Mengelkamp, E., Gärttner, J., Rock, K., Kessler, S., Orsini, L., and Weinhardt, C. 2018. "Designing microgrid energy markets: A case study: The Brooklyn Microgrid." *Applied Energy* 210: 870-880.

Mishra, N., and Singh, A. 2018. "Use of twitter data for waste minimisation in beef supply chain." *Annals of Operations Research* 270(1-2): 337-359.

Moe, W. W., and Schweidel, D. A. 2012. "Online product opinions: Incidence, evaluation, and evolution." *Marketing Science* 31(3): 372-386.

Nakamoto, S. 2008. "Bitcoin: a peer-to-peer electronic cash system." accessed June 25, 2018, https://bitcoin.org/bitcoin.pdf

Nordrum, A. 2017. "Govern by blockchain dubai wants one platform to rule them all, while Illinois will try anything." IEEE Spectrum 54(10): 54-55.

Ølnes, S., Ubacht, J., and Janssen, M. (2017). "Blockchain in government: Benefits and implications of distributed ledger technology for information sharing." *Government Information Technology* 34: 355-364.

Ogie, R. I., Forehead, H., Clarke, R. J., and Perez, P. 2018. "Participation patterns and reliability of human sensing in crowd-sourced disaster management." *Information Systems Frontiers* 20(4): 713-728.

Opitz, M., Chaudhri, V., and Wang, Y. 2018. "Employee social-mediated crisis communication as opportunity or threat?." *Corporate Communications: An International Journal* 23(1): 66-83.

Ouaddah, A., Abou Elkalam, A., and Ait Ouahman, A. 2016. "FairAccess: a new Blockchain-based access control framework for the Internet of Things." *Security and Communication Networks*, 9(18): 5943-5964.

Page, S.E. 2007. "Making the Difference: Applying a Logic of Diversity." *Academy of Management Perspectives* 21(4): 6-20.

Pazaitis, A., De Filippi, P., and Kostakis, V. 2017. "Blockchain and value systems in the sharing economy: The illustrative case of Backfeed." *Technological Forecasting and Social Change*, 125: 105-115.

Peck, M. E. 2017. "Blockchain world-Do you need a blockchain? This chart will tell you if the technology can solve your problem." IEEE Spectrum 54(10): 38-60.

Peck, M. E., and Wagman, D. 2017. "Energy trading for fun and profit buy your neighbor's rooftop solar power or sell your own-it'll all be on a blockchain." *IEEE Spectrum* 54(10): 56-61.

Poria, S., Cambria, E., Winterstein, G., and Huang, G. B. 2014. "Sentic patterns: Dependency-based rules for concept-level sentiment analysis." *Knowledge-Based Systems* 69: 45-63.

Püttgen, F., and Kaulartz, M. 2017. "Insurance 4.0 - Use of blockchain technology and smart contracts in the insurance sector." *ERA Forum* 18(2): 249-262.

Ravi, K., and Ravi, V. 2015. "A survey on opinion mining and sentiment analysis: tasks, approaches and applications." *Knowledge-Based Systems* 89:14-46.

Roehrs, A., da Costa, C. A., and da Rosa Righi, R. 2017. "OmniPHR: A Distributed Architecture Model to Integrate Personal Health Records." *Journal of Biomedical Informatics* 71: 70-81. DOI: 10.1016/j.jbi.2017.05.012

Runge, K. K., Yeo, S. K., Cacciatore, M., Scheufele, D. A., Brossard, D., Xenos, M., Anderson, A., Choi, D., Kim, J., Li, N., Liang, X., Stubbings, M., and Su, L.Y. 2013. "Tweeting nano: How public discourses about nanotechnology develop in social media environments." *Journal of Nanoparticle Research* 15(1): 1381. DOI: 10.1007/s11051-012-1381-8

Savelyev, A. 2017. "Contract law 2.0:'Smart'contracts as the beginning of the end of classic contract law." *Information & Communications Technology Law* 26(2): 116-134.

Scott, B., Loonam, J., and Kumar, V. 2017. "Exploring the rise of blockchain technology: Towards distributed collaborative organizations." *Strategic Change* 26(5): 423-428.

Seidel, M. D. L. 2018. "Questioning Centralized Organizations in a Time of Distributed Trust." *Journal of Management Inquiry* 27(1): 40-44.

Senadheera, V., Warren, M., and Leitch, S. 2017. "Social media as an information system: improving the technological agility." *Enterprise Information Systems* 11(4): 512-533.

Shackelford, S. J. 2016. "Business and cyber peace: We need you!." *Business Horizons* 59(5): 539-548.

Shan, S., and Lin, X. 2017. "Research on emergency dissemination models for social media based on information entropy." *Enterprise Information Systems*. DOI:10.1080/17517575.2017.1293300

Shan, S., Ren, J., and Li, C. 2017. "The dynamic evolution of social ties and user-generated content: a case study on a Douban group." *Enterprise Information Systems* 11(10): 1462-1480.

Shermin, V. 2017. "Disrupting governance with blockchains and smart contracts." *Strategic Change* 26(5): 499-509.

Song, J., Jamous, N., and Turowski, K. 2018. "A dynamic perspective: local interactions driving the spread of social networks." *Enterprise Information Systems*. DOI: https://doi.org/10.1080/17517575.2018.1499133

Stieglitz, S., Dang-Xuan, L., Bruns, A., and Neuberger, C. (2014). "Social media analytics." *Business & Information Systems Engineering* 6(2): 89-96.

Sundararajan, A., Provost, F., Oestreicher-Singer, G., and Aral, S. 2013. "Research commentary—information in digital, economic, and social networks." *Information Systems Research* 24(4): 883-905.

Tai, X., Sun, H., and Guo, Q. 2016. "Electricity transactions and congestion management based on blockchain in energy Internet." *Power System Technology* 40: 3630-3638.

Taherdoost, H. 2018. "A review of technology acceptance and adoption models and theories." *Procedia Manufacturing* 22: 960-967.

Tang C.-B., Yang Z., Zheng Z.-L., Chen Z.-Y., and Li X. 2017. "Game Dilemma Analysis and Optimization of PoW Consensus Algorithm." *Zidonghua Xuebao/Acta Automatica Sinica* 43(9): 1520-1531. DOI: 10.16383/j.aas.2017.c160672

Tang, V. W. 2018. "Wisdom of Crowds: Cross-Sectional Variation in the Informativeness of Third-Party-Generated Product Information on Twitter." *Journal of Accounting Research* 56(3): 989-1034.

Tehrani, P. M., Manap, N. A., and Taji, H. 2013. "Cyber terrorism challenges: The need for a global response to a multi-jurisdictional crime." *Computer Law & Security Review* 29(3): 207-215.

Tschorsch, F., and Scheuermann, B. 2016. "Bitcoin and beyond: A technical survey on decentralized digital currencies." *IEEE Communications Surveys & Tutorials* 18(3): 2084-2123.

Tse, Y. K., Loh, H., Ding, J., and Zhang, M. 2018. "An investigation of social media data during a product recall scandal." *Enterprise Information Systems* 12(6): 733-751.

Van Engelenburg, S., Janssen, M., & Klievink, B. (2017). "Design of a software architecture supporting business-to-government information sharing to improve public safety and security." *Journal of Intelligent Information Systems*, 1-24. DOI https://doi.org/10.1007/s10844-017-0478-z

Van Noorden, R. 2014. "Online collaboration: Scientists and the social network." *Nature news*, 512(7513): 126.

Wang, H., and Guo, K. 2017. "The impact of online reviews on exhibitor behaviour: evidence from movie industry." *Enterprise Information Systems* 11(10): 1518-1534.

Werbach, K., and Cornell, N. 2017. "Contracts Ex Machina." *Duke Law Journal* 67:313-382.

White, G. R. 2017. "Future applications of blockchain in business and management: A Delphi study." *Strategic Change* 26(5): 439-451.

Wu, H., Li, Z., King, B., Ben Miled, Z., Wassick, J., and Tazelaar, J. 2017. "A Distributed Ledger for Supply Chain Physical Distribution Visibility." *Information* 8(4): 137. Doi:10.3390/info8040137

Xia, Q., Sifah, E. B., Asamoah, K. O., Gao, J., Du, X., and Guizani, M. 2017. "MeDShare: Trust-Less Medical Data Sharing Among Cloud Service Providers via Blockchain." *IEEE Access* 5:14757-14767.

Yi, S. K. M., Steyvers, M., Lee, M. D., and Dry, M. J. 2012. "The wisdom of the crowd in combinatorial problems." *Cognitive science* 36(3): 452-470.

Ying, W., Jia, S., and Du, W. 2018. "Digital enablement of blockchain: Evidence from HNA group. *International Journal of Information Management*" 39:1-4.

Yuan, Y., and Wang, F. Y. 2016. "Blockchain: the state of the art and future trends." *ACTA automatica sinica* 42(4): 481-494.

Yue, X., Wang, H., Jin, D., Li, M., and Jiang, W. 2016. "Healthcare data gateways: found healthcare intelligence on blockchain with novel privacy risk control." *Journal of medical systems* 40(10):218.

Zhang, J., Xue, N., and Huang, X. 2016. "A secure system for pervasive social network-based healthcare." IEEE Access 4:9239-9250.

Zhang, Y., and Wen, J. 2017. "The IoT electric business model: Using blockchain technology for the internet of things." *Peer-to-Peer Networking and Applications* 10(4): 983-994.

Zhao, Y., and Zhu, Q. 2014. "Evaluation on crowdsourcing research: Current status and future direction." *Information Systems Frontiers* 16(3): 417-434.