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Evaluating Blockchain Success: Integrating Organizational Decentralization with the DeLone and McLean IS Success Model

Subtitle

Alireza Lashkari

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NOVA Information Management School
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Universidade Nova de Lisboa

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EVALUATING BLOCKCHAIN SUCCESS: INTEGRATING ORGANIZATIONAL DECENTRA LIZATION WITH THE DELONE AND MCLEAN IS SUCCESS MODEL

by

Alireza Lashkari

Dissertation presented as the partial requirement for obtaining a Master's degree in Information Management, specialization in Information Systems and Technologies Management

Advisor: Tiago André Gonçalves Félix de Oliveira

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DEDICATION

This thesis is dedicated to my parents and my wife for their love, endless support and encouragement.

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Evaluating Blockchain Success: Integrating Organizational Decentralization with the DeLone and McLean IS Success Model

Abstract

Blockchain technology is a distributed ledger without an intermediate where delivers decentralized consensus. The tremendous potential of this technology including anonymity, persistency, auditability, and traceability along with decentralization caused blockchain to receive attention globally. This study aims to identify the role of decentralization in blockchain success at firms by proposing a theoretical model based on the theory of success in information systems. The research model was empirically tested using 193 responses over an online survey questionnaire. The result reveals that service quality, system quality, and information quality were explained by decentralization. Likewise, decentralization and user's satisfaction are an important criterion for the Net impact of blockchain success. Furthermore, this study explores the positive influence of decentralization as a moderator between the relationship of the user's satisfaction and net impact. The findings have theoretical and practical implications for academics and managers.

Keywords: Blockchain, Decentralization, IS Success, Blockchain success, DeLone & McLean

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1. Introduction

Recently Blockchain has attracted wide attention of business managers and academic researchers (J. Li, Yuan, & Wang, 2019; H. Wang, Zheng, Xie, Dai, & Chen, 2018). While the global spending on blockchain solutions in 2018 was 1.5 billion USD, today in 2020 the value is 4.3 billion USD and it is expected to grow to an estimated 15.9 billion USD by 2023. The financial sector is recognized with the highest distribution of market value in blockchain (statista, Liu, 2020). Blockchain, as its name indicates, is a chain of linked data blocks. In this technology, no data can be deleted or altered from the ledger or audit trail, but additional data can be distributed to the chain in the form of new blocks. The significance of generating a reliable publicly distributed ledger system may be essential to the relationships between people and organizations in order to trust each other to create, collect, and distribute important records (Beck, Avital, Rossi, & Thatcher, 2017). Consequently, the goal of blockchain is to deliver a decentralized solution where no intermediate third parties are required (Yli-Huumo, Ko, Choi, Park, & Smolander, 2016).Blockchain could potentially enable and impact organizations and institutions to become more transparent in their operations, simplifying and boosting business processes, reducing errors and preventing fraud and theft (Hughes, Park, Kietzmann, & Archer-Brown, 2019; Wright & De Filippi, 2015).

While ample evidence demonstrates the importance of blockchain for organizations and institutions, numerous researches have been undertaken into the technical aspects, use cases, and platform features of blockchain technology, less academic research has been done about the implications and benefits of blockchain for individuals, society, organizations, and economics (Beck *et al.,* 2017). Moreover, several studies by Francisco and Swanson (2018), Jansson and Petersen (2017), Lou and Li (2017), Mendoza-tello *et al.,* (2018), and Queiroz and Fosso (2019) have been conducted about blockchain adoption, but less research has been done in evaluating blockchain success in organizations. In IS Context, much research has been done in the area of assessing IS success using one of the most often cited theories; Delone and McLean (2003) multidimensional IS Success model (Cidral, Oliveira, Di Felice, & Aparicio, 2018). The model consisting of common IS success dimensions such as system quality, service quality, and information quality. In this model, the value constructs named “net impact” which is the final success variable, use, and satisfaction are the fundamental variables for benefits to occur (Popovič, Hackney, Coelho, & Jaklič, 2012). A study by Rossi *et al.,* (2019), The author believes that many organizations tend to change the organizational governance by decentralizing the decision rights through the blockchain and more empirical research is required to reveal how decentralized blockchain can affect the firm's performance. Although decentralization deals with two main aspects of technological and organizational structure, therefore in this study the proposed theoretical model based on DeLone and McLean (2003) is derived from the managers' aspect, aiming to provide value for the organization and on the other hand, it focuses on a type of IT system, in the case of blockchain technology.

Our study contributes to filling this research gap by investigating empirically the role of decentralization in blockchain success in twofold. First, we conducted an empirical analysis of data from 193 respondents to identify the role of decentralization in blockchain success at the firm level, with decentralization as one of the most important characteristics of blockchain integrated together with the theory of success in information systems (DeLone & McLean, 2003). Our study brings out the critical role of decentralization on the net impact as a degree of benefit perceived by participants when interacting with blockchain technology to achieve blockchain success at firms. Second, we investigated the moderation effect of decentralization between the relationship of both intentions to use and user satisfaction constructs on net impact.

The paper is structured as follows. In the next section, we describe the blockchain concept, characteristics, and current research on this topic. We then present the research model and hypotheses followed by the methodology, data analysis, and results. Finally, we discuss our findings and propose suggested avenues for future research.

2. Literature review

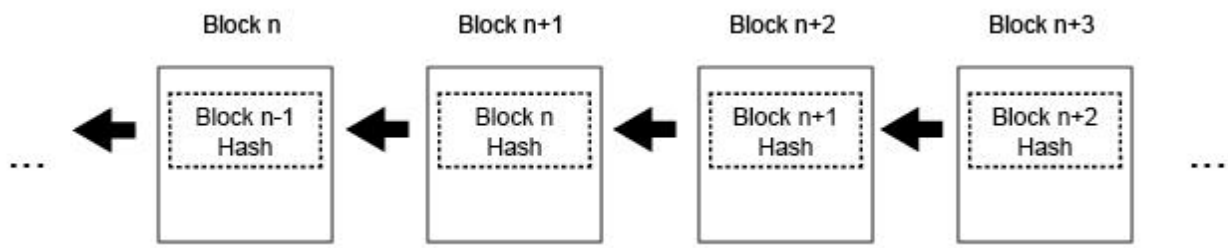
2.1. The Blockchain concept

A Blockchain is a distributed database ledger that is replicated and visible with other members in a network created by Nakamoto (2008). He explained this technology as a chain of blocks to create a publicly accessible, decentralized mechanism using cryptography algorithms to invent a peer to peer digital currency named Bitcoin. Since the reveal of Bitcoin in 2008, this technology has developed from its initial usage as only cryptocurrency and transaction verification to a broader ground of financial and applications (J. Li et al., 2019; Wörner, Von Bomhard, Schreier, & Bilgeri, 2016).

The key characteristics of blockchain technology are decentralization, persistency, anonymity, traceability, and auditability (Tang, Xiong, Becerril-Arreola, & Iyer, 2019; Zheng, Xie, Dai, Chen, & Wang, 2017), which means that nodes in the blockchain network have access to the entire list of all transactions. These elements allow nodes not only to verify but also create a new transaction record into the blocks; then each block keeps the hash of the previous block that came before it verified by a timestamp (Nakamoto, 2008).

The links between blocks create a chain of blocks or blockchain. Each block carries a hash of the previous block with the exception of the first block, which has no parent (see, Figure 1).

Figure 1. Blockchain; Chain of blocks.



From a technical point of view, users interact with the blockchain through a pair of private/public keys (Adams & Lloyd, 1999). The private key is used for users to sign their own transaction, which is addressable on the blockchain through their public key (X. Li & Wang, 2017). The next peers make sure the incoming transaction is authentic; otherwise invalid transactions are rejected. The validated transaction in the blockchain is ordered and packed into a timestamp applicant block. The next node verifies the recommended block, which contains the valid transaction, via the hash of the previous block on the blockchain. In this way, the new block is added to the chain (Qin, Yuan, & Wang, 2019). This operation is a repeating process. In the case of the proposed block being rejected, this is considered as the end of the chain (Christidis & Devetsikiotis, 2016; Mandolla, Petruzzelli, Percoco, & Urbinati, 2019).

There are cases of blockchain used within a business or group of organizations where reading and writing into the blocks is restricted to a certain group of entities. These systems involve a limited number of members and are known as private blockchains (Olleros, Zhegu, & Pilkington, 2016). Private blockchains can protect available information confidentiality and maintain the privacy of business transactions (Dai & Vasarhelyi, 2017). Permissioned blockchain is another type of blockchain in which trusted participants are chosen by an authority department and granted approval to verify the transaction (Peters & Panayi, 2016). There are numerous use cases and practical examples of blockchain technology in different industries. In supply chain and logistics, "IBM" using this technology to allows transparency to track the location and ownership of products in real-time. In the insurance industry, "Accenture" builds blockchain solutions for its clients to implant trust in the system. In Healthcare, "MedicalChain" is the pioneer company using blockchain that facilitates the storage of health records into blockchain and aims to deliver a comprehensive telemedicine experience. In the Real Estate industry, there are companies like "Uniquity" using blockchain platforms to record the property information and sharing the clean record of ownership.

2.2. Blockchain characteristics

2.2.1. Decentralization

According to Mintberg (1979) the organization structure called centralized when all the power for decision making rests at a single point, and when the power is dispersed between the entities the structure will be called decentralized. Some public organizations have a hierarchical centralized structure with the central decision making, where decisions are made by a board or committee appointed by the authority. On the other hand, there are organizations having the decentralized structure grounded on the principle of social P2P, implementing peer-production, peer-trust, and peer-vote mechanisms for decentralized communication and decision making (Boissier, Rychkova, Zdravkovic, Enterprise, & Organizations, 2017). Similarly, in the Blockchain context, Decentralization is the process of distributing and scattering power away from a central authority (Anderson, 2019).

The data used in blockchain technology is distributed through the ledger and cannot be accumulated and stored at a centralized point but instead scattered instantaneously on different computers named nodes (MacDonald, Allen, & Potts, 2016). More specifically, transactions are stored in a likely unlimited sequence of cryptographically unified data blocks, and blocks are ordered by a time-stamping algorithm in a decentralized ledger (Gipp, Meuschke, & Gernandt, 2015). Decentralization reduces the risk of access failure compared to the single access point in centralized databases (Y. Wang, Han, & Beynon-Davies, 2019). Moreover, decentralization enhances trust among the participants in blockchain technology (Kamble, Gunasekaran, & Sharma, 2019).

The blockchain structure is set up to be a decentralized public ledger to enable every member to read, update, and confirm the transaction in the network. In other words, every node in the network has access to the detail of every transaction (Dai & Vasarhelyi, 2017). Organizations implementing decentralization are provided with simpler access data and control, along with better responsiveness to their members (Applegate, McKenney, & McFarlan, 1999). In traditional centralized structures, intermediate trustee authority guarantees the validity of transactions. In this platform where databases are central, vast issues arise due to extra performance and costs. Blockchain and a decentralized distributed ledger is the answer to the problem of transaction management (Dinh *et al.,* 2017). Blockchain technology can potentially improve decision making and management issues by making them less hierarchically coordinated (Atzori, 2016; Bendul & Blunck, 2019). Incompetence and defectiveness of traditional organizations due to vicarious decision making and unnecessary centralization could be eliminated with blockchain technology. While decision making in traditional organizations is centralized at an executive level, in a decentralized organizational environment decision making can be processed with less human intermediation (Benitez, Llorens, & Braojos, 2018; Castelo-Branco, Cruz-Jesus, & Oliveira, 2019) and programmed into a piece of code, called smart contracts, and distributed between participants without the need of a centralized authority (Wright & De Filippi, 2015). Antonopoulos and Wood (2018) identified smart contracts as a "set of promises, specified in a digital form, including protocols within which the parties perform on the other promises". The execution of a smart contract in blockchain creates a platform for performing transactions based on specific rules and principles. Moreover, Contracts are designed to perform and execute when certain conditions have been met in blockchain (Jabbar & Dani, 2020; Shermin, 2017). Smart contracts are flexible enough to be programmed if they have been jointly agreed on a set of rules (H. M. Kim & Laskowski, 2018). In this way, smart contracts are placed in an environment in which they cannot be altered, and blockchain play as a permanent state (Castellanos, Coll-Mayor, & Notholt, 2017). Once the smart contracts are deployed, due to the blockchain rules it is impossible to make the changes or revision in contracts. This can generate an automated system that makes decisions based on rules and regulations in a locked and secure environment.

In this way, decentralization brings a smooth flow of information by granting superior independence to employees and the degree of dispersing decision making in an organization (Hempel, Zhang, & Han, 2012; S. Y. Wang, Hsu, Li, & Lin, 2018). With decentralization architecture, the impasse in communication and harmony between team members in organizations will be set aside (Kudaravalli & Johnson, 2017). Moreover using decentralization enables participants to store and recover messages without the risk of being compromised by third parties (Wright & De Filippi, 2015). A study on decentralized communication between teams by Katz *et al.,* (2004) declares better performance in complex tasks.

Furthermore, due to the lack of a central authority to verify transactions in the blockchain, decentralization can minimize difficulty and ambiguity in the process (H. Kim & Laskowski, 2017). A theory by Garicano (2000) explains the potential of a decentralized structure and its possibility to reduce communication and information transfer costs, which leads to increasing a better response to market situations and changes. Other authors explain responding to technological changes, market, and consumer needs, and better responsiveness to business requirements are clarified through the flexibility of decentralization (Ljasenko, Ferreira, Justham, & Lohse, 2019; Pick, 2015; Teece J., 2007).

2.2.2. Anonymity

Nakamoto(2008), in his whitepaper, declared that the blockchain is anonymous, which ensures data privacy through deploying a cryptographic private key. Participants in blockchain hold a private key that corresponds to a unique set of public keys without disclosing the addresses. Blockchain transactions happen between addresses and users do not need to reveal their real identities (Lansiti Marco & Lakhani R. Karim, 2017).

2.2.3. Persistency

Transaction records in the blockchain can be validated very quickly and considered persistent upon spreading across the network where each node in the blockchain controls and maintains its records (Viriyasitavat & Hoonsopon, 2019; Zheng et al., 2017). Once transactions are included in the blockchain, they are impossible to tamper with, delete, and rollback (Mandolla *et al.,* 2019; Zheng *et al.,* 2017). The persistency characteristic includes other properties such as transparency and immutability, thereby making blockchain auditable (Chris Hammerschmidt, 2017).

2.2.4. Auditability

Auditability provided in decentralized databases is one of the most important characteristics in blockchain to make it free of error and help to keep the auditing trace (Wijaya, Liu, Suwarsono, & Zhang, 2017). In a blockchain, every transaction is publicly visible to all participants, leading to an increase in trust and auditability (Prescott & Vann, 2007).

2.2.5. Traceability

Blockchain technology provides the capability of traceability, meaning all distributed information can be traced on each block of data by a timestamp (Sharples & Domingue, 2016). Timestamp records and persistent data allow participants to verify and trace previous records through nodes in a blockchain (Viriyasitavat & Hoonsopon, 2019). Traceability makes the validity and reliability of data guaranteed in blockchain technology (Zhao *et al.,* 2019).

2.3. Prior research on blockchain

Blockchain is amongst the most trending technologies and claimed to disrupt many intermediate business and services (Don Tapscott & Alex Tapscott, 2016; Gartner, 2016). Iansiti M. & Lakhani R. K. (2017) introduced blockchain as a technology able to impact business and economics. From a technical aspect, it is a new means of recording transactions in a decentralized database context. From an economic point of view, it offers innovative tools where a fully trustable and reliable record of the transaction is required (Lindman, Tuunainen, & Rossi, 2017). Blockchain technology has the potential to solve business problems and reform the way of doing business (Rabah, 2017; Zalan, 2018). This likely situates blockchain as a disruptive enabler for technological changes. The study by Iansiti M. & Lakhani R. K. (2017) revealed that blockchain technology has the capability of bringing significant savings in operational efficiencies as well as reducing the cost of transactions, but challenges in blockchain adoption are significant.

Blockchain technology can facilitate the interaction between people and machines in a decentralized based organization regardless of the necessity of central authority (Hawlitschek, Notheisen, & Teubner, 2018; Wright & De Filippi, 2015). Decentralization is a new phenomenon, and societies need to realize the potential freedoms and limits that come with them (Risius & Spohrer, 2017). Compared to centralized systems implementing blockchain is expensive; consequently, firms need to position viability facts when evaluating the perceived benefits of blockchain and decentralization features versus centralized solutions (Drescher, 2017). Michelman (2017) studied blockchain cost benefits. The research emphasized that auditability and verification along with the ability of transactions between participants without an intermediary are the two key cost benefits of blockchain technology.

Another study indicates that organizations implementing blockchain as a new technology or deploying it as an alternative to their current business model require significant changes in their business processes (Tan, Zhao, & Halliday, 2018; Weber et al., 2016). Some authors consider shifting to blockchain is about the transitional impact on business and not about the technology. Organizations that discover the true value of blockchain are able to reform their whole business and accomplish the utmost benefits (Michelman, 2017; Ying, Jia, & Du, 2018).

While some researches in IS context was conducted based on blockchain adoption, other than a study by Janze (2017), There is no evidence of other research on blockchain success at an individual or firm level. Janze (2017) attempted to propose a conceptual model based on the technology acceptance model (TAM) (Davis, Bagozzi, & Warshaw, 1989) and DeLone & McLean model (DeLone & McLean, 2003), however, their proposed model was not tested, and the results are unknown. A study on blockchain adoption challenges in supply management by Queiroz and Fosso (2019), the authors attempted to develop a research model based on technology acceptance models (TAM) (Davis *et al.,* 1989) and unified theory of acceptance and use of technology (UTATU) (Venkatesh, Morris, Davis, & Davis, 2003) to identify the adoptions behaviors between India and USA based professionals. Their result highlighted important differences between the adoption of blockchain in different countries due to the low level of blockchain awareness, and the impact of blockchain usefulness and productivity in their operations. However, the authors emphasize that the blockchain adoption by logistics and supply chain management professionals is still at its early stage. In another study by (Francisco & Swanson, 2018), the authors developed a conceptual model based on the unified theory of acceptance and use of technology (UTATU) (Venkatesh *et al.,* 2003) and found blockchain provide a reliable means to track and trace the origin and process of products, and helps firms and organizations to mitigate and evaluate supply chain risks. In the context of blockchain and trust, Mendoza-tello *et al.,* (2018) studied the role of social media in growing the trust and intention to use of cryptocurrencies. The authors proposed the model combining the construct from the technology acceptance model (TAM) (Davis *et al.,* 1989), social commerce, and the social support theory. The authors found the trust is a determinant factor in causing a competitive advantage in the cryptocurrencies market, and social networks play an important role as an instrument for raises and added value in the Cryptocurrencies adoption. While these studies are valuable and useful at providing awareness into the opportunities and limitations on the adoption of blockchain technology, limited research has been conducted on blockchain success.

2.4. Information System (IS) success

In information systems literature, one of the most cited and tested models that provides a comprehensive overview of "IS Success" was proposed by DeLone & McLean (1992) (Delone & McLean, 2003; DeLone & McLean, 1992; Ul-Ain, Giovanni, DeLone, & Waheed, 2019). The model highlights the understanding of relationships between the different dimensions of information systems success. DeLone & McLean (1992) established the first IS Success model with six factors, namely, information quality, system quality, user's satisfaction, use, individual impact, and organizational impact. Later in 2003, they updated the model with new constructs. "Service quality" was added to the original model and "net benefits" replaced two constructs, namely, individual impact and organizational impact (Delone & McLean, 2003).

Some other researches have tried to propose an alternate framework for measuring IS Success. Grover *et al.,* (1996) used the theory of organization effectiveness to extend the D&M IS Success model, hence the authors created six effectiveness categories based on Unit of Analysis and Evaluation Type context dimensions including infusion measures, market measures, economic measures, usage measures, perceptual measures, and productivity measures. In another study, Smithson and Hirschheim (1998) proposed a conceptual framework for IS evaluation of an outsourcing situation that consists of three "zones" of measures: efficiency, effectiveness, and understanding. Martinsons *et al.,* (1999) suggest an adaptation of the Balanced Scorecard method to evaluate the performance of organizations. The Balanced Scorecard consists of four performance perspectives: the financial, the customer, the internal business process, and the learning and growth perspectives. The author proposed a balanced scorecard in IS context to include business-value measurement, a user orientation, an internal-process, and a future-readiness dimensions. In a comprehensive study by Mirani and Lederer (1998) the authors attempted to measure organizational benefits derived from IS projects. Their measurement framework involved three categories of organizational benefits: strategic, informational, and transactional. Based on their results three subcategories for each of the benefit groups have been identified. These subcategories are a competitive advantage, alignment, and customer-relations benefits for the strategic benefits category; information access, information quality, and information flexibility for informational benefits; Communication efficiency, systems development efficiency, and business efficiency for transactional benefits. In order to study and identify new IS success dimensions that are not covered in Delone and McLean, (2003), we reviewed the above studies and found these frameworks do not present any new construct to present in our research model.

2.5. Hypotheses

Decentralization corresponds to structural changes in order to achieve higher flexibility and responsiveness to business demands by improving decision making and promoting better communication among participants and reducing barriers in coordination (Kudaravalli & Johnson, 2017; Loukis, Janssen, & Mintchev, 2019; Pick, 2015). According to Delone & McLean (2003) and Urbach, Smolnik, & Riempp (2010) service quality is considered as general support related to users and can be measured by covering reliably, accurately and overall support related to the participants delivered of an important dimension. In another study using confirmatory factor analysis, the authors found this construct as a satisfactory tool for measuring IS service quality (Jiang, Klein, & Carr, 2008). A study by Pitt, Watson, & Kavan (2006) explains that responsiveness is an example of the service quality dimension in information systems success. Likewise, Applegate et al. (1999) describe responsiveness to users and simpler access to data as service provided in decentralization. Therefore, we hypothesize:

H1a: *Decentralization is positively associated with the service quality provided in the blockchain.*

In IS literature, system quality refers to the characteristics and features expected by users when they are working with the associated system (Delone & McLean, 2003; Hsieh & Lin, 2018). Therefore, system quality can be considered to explore the ease of use of a system to complete tasks (Aparicio, Oliveira, Bacao, & Painho, 2019). Since the decentralization feature is to enable every participant in the network to read, update and confirm the transactions (Dai & Vasarhelyi, 2017) therefore, we examine success dimensions covered by usability, functionality, and performance (McKinney, Yoon, & Zahedi, 2002; Schaupp, Weiguo Fan, & Belanger, 2006; Urbach et al., 2010) in blockchain context. Thus:

H1b: *Decentralization is positively associated with the system quality provided in the blockchain.*

Focuses on the desirable quality of the information provided in systems, it is expected to be complete, understandable, useful, and reliable (Chang, Lu, & Lin, 2019; Nicolaou, Ibrahim, & Van Heck, 2013). Information quality is often not notable as a unique construct but is measured as a factor of user's satisfaction (Jiang *et al.,* 2008). Reading and verifying transactions are the features implemented in blockchain decentralized ledger (Dai & Vasarhelyi, 2017). Therefore:

H1c: *Decentralization is positively associated with the information quality provided in the blockchain.*

The net impact is the degree of benefit perceived by participants when interacting with blockchain technology. Petter, DeLone, & McLean (2008) declared improved decision making, enhanced productivity, and cost-saving are examples of measuring the success of organizations. Similarly, Decentralization offers tangible advantages in terms of saving speed and costs (Cuccuru, 2017). Thus:

H2a: Decentralization is positively associated with the net impact of blockchain.

One of the most important measures when studying IS success is user satisfaction (Urbach *et al.,* 2010). The success dimension in a blockchain context is considered as efficiency, effectiveness, and adequacy and general satisfaction of users interacting with blockchain technology. In IS success literature, Delone & McLean (2003) emphasize the intention as a user attitude. Some authors define the intention to use as an attitude of users toward the assumption about the probability of increasing his/her job performance (Montesdioca & Macada, 2015). In this study, we examine the role of decentralization as a moderator between both user satisfaction and intention to use on net impact in the blockchain. Therefore, we have hypothesized:

H2b: *Decentralization moderates the relationship between user satisfaction and the net impact of blockchain.*

H2c: *Decentralization moderates the relationship between intention to use and the net impact of blockchain.*

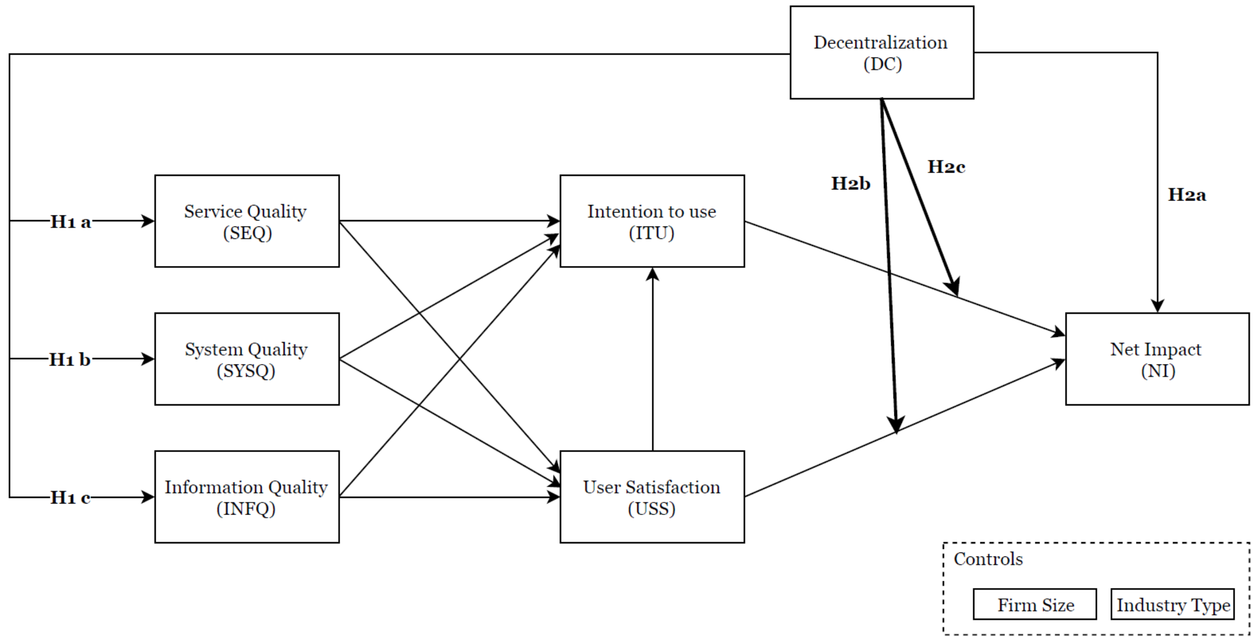
2.6. Control variables

In information systems use of control variables are frequently used. Control variables are needed when data variation cannot be described by the explanatory variables (Cruz-Jesus, Pinheiro, & Oliveira, 2019). We use industry type and firm size as a control variable to capture its effect on our conceptual model, and also to minimize the variance in the firm performance that may be influenced by these variables (Chae, Koh, & Prybutok, 2014).

2.7. Research Model

The research model is shown in Figure 2. The model integrates decentralization as one of the main characteristics of blockchain with the Delone & McLean (2003) success model. The proposed model contains seven theoretical constructs: decentralization (DC), service quality (SEQ), system quality (SYSQ), information quality (INFQ), intention to use (ITU), user satisfaction (USS), and net impact (NI).

Figure 2. Conceptual research model of blockchain success.



3. Methods

3.1. Measurement

The constructs defined in this study and presented in Appendix A were adapted from Urbach et al. (2010), Chen, Jubilado, Capistrano, & Yen (2015), and Zahra, Hayton, & Salvato (2004) with small modifications regarding the available literature. Since the indicators caused by the constructs (Diamantopoulos & Siguaw, 2006) reflective indicators were used to define the constructs. Our target population was the managers, experts, and technical employees working in blockchain companies globally. We identify 315 companies in the blockchain industry provided by online directories such as Dun & Bradstreet and LinkedIn, then after the survey was conducted among these companies by a questionnaire, and a total of 1043 invitation to participate in our survey were distributed through email, Twitter, LinkedIn, and other communications apps to blockchain C-level and mid-level managers including technical staff. Each item was measured using a seven-point Likert scale ranging from "1- Strongly disagree" to "7-strongly agree". We also included four demographic questions; position/role of the participant in their company, industry type, company's annual turnover and the number of full-time employees (Table 1).

3.2. Data collection

The questionnaire was formed and run in English. In order to test the survey and reduce possible errors, the questionnaire was pilot tested with a sample of 30 participants in March 2019. The result approves the reliability and validity of the scales. Subsequently, there were no changes made to the questionnaire. As a direct outcome based on a study by Thabane *et al.,* (2010), the data from the pilot test has been included in the primary data collected from our survey. As described in Table 1, a total of 193 responses were obtained from November 2018 to July 2019, yielding a response rate of 18.5 percent. A large number of respondents were in C-level and managerial positions, 9% were in C-Level, 17% were finance managers, 21% were marketing managers, equally 21% were production managers, 16% were sales managers, and 16% were in other positions. The respondents belonged to various type of industries; 33% to Information and communication, 16% to Financial, 5% to Health, 12% to Retail, 9% to Services, and 24% to other industries. The firms' size classified to; 38% micro, 30% small, 17% medium, and 15% large.

Table 1. Sample characterization (N=193).

Position in company			**Industry types**		
C-Level (CIO, CFO, CEO, ...)	17	9%	Information & Communication	64	33%
Finance managers	32	17%	Financial	31	16%
Marketing managers	41	21%	Health	10	5%
Production managers	41	21%	Retail	23	12%
Sales managers	31	16%	Services	18	9%
Other positions	31	16%	Others	47	24%
Company's annual turnover			**No. of full-time employees**		
Up to $2 million	117	61%	Micro (Less 10 peoples)	73	38%
Between $2-10 million	45	23%	Small (Between 10-49 peoples)	58	30%
Between $10-50 million	22	11%	Medium (Between 50-250 peoples)	34	17%
More than $50 million	9	5%	Large (More than 250 peoples)	28	15%

4. Data Analysis and results

4.1. Measurement model evaluation

Reflective indicators were used to define the constructs. Standard rules were applied to test the validity of reflective measurement including internal consistency, discriminant validity, convergent validity, and indicator reliability as per the instruction proposed by Lewis, Templeton, & Byrd (2005) and Straub, Boudreau, & Gefen (2004). In order to verify indicator reliability, outer loadings must be statistically significant and ideally greater than 0.7 (Chin, 1998; Cleff, 2014; Henseler, Ringle, & Sinkovics, 2009). Table 2 demonstrates that all the outer loadings are higher than the minimum expected value. Composite reliability was used to assess internal consistency. The model shows (based on Table 2) the composite reliability for all constructs are above 0.800, which met the criteria appointed by Peter (1979). To assess the convergent validity, a standard measure to establish this is the average variance extracted (AVE) which should be greater than 0.5, meaning each construct should explain at least half of the variance of its indicators (Hair, Sarstedt, Hopkins, & Kuppelwieser, 2014). According to Table 2, AVE for each construct is above the expected threshold.

Table 2. Measurement model results

Constructs	Items	Loadings	Composite Reliability (CR)	Cronbach's Alpha (CA)	Average Variance Extracted (AVE)	Discriminant Validity
Decentralization (DC)	DC1	0.781	0.878	0.815	0.644	Yes
	DC2	0.824				
	DC3	0.780				
	DC4	0.822				
Service quality (SEQ)	SEQ2	0.834	0.831	0.593	0.711	Yes
	SEQ4	0.852				
System quality (SYSQ)	SYSQ2	0.808	0.870	0.776	0.691	Yes
	SYSQ3	0.809				
	SYSQ4	0.875				
Information quality (INFQ)	INFQ1	0.851	0.847	0.732	0.649	Yes
	INFQ2	0.775				
	INFQ4	0.789				
User satisfaction (USS)	USS1	0.840	0.890	0.814	0.730	Yes
	USS2	0.839				
	USS3	0.883				
Intention to use (ITU)	ITU1	0.807	0.864	0.796	0.614	Yes
	ITU2	0.740				
	ITU3	0.795				
	ITU4	0.792				
Net impact (NI)	NI1	0.791	0.878	0.814	0.643	Yes
	NI2	0.850				
	NI3	0.747				

NI4	0.817

Two criteria should be considered to verify the discriminant validity. First, the square root of AVE must be larger than the correlation among the constructs (Henseler *et al.*, 2009). This assessment entails that each construct explain more of its indicator's variance than is shared with other constructs (Fornell & Larcker, 1981). All constructs show evidence of discrimination, as illustrated in Table 3. Second, the values of outer loadings should be greater than cross-loadings Hair et al. (2014), where the values in Appendix B. show the support of these criteria for the discriminant validity test. Finally, Table 4 confirms the discriminant validity of constructs since all the HTMT are lower than the threshold of 0.9 (after we deleted SEQ1, SEQ3, SYSQ1, INFQ3, and USS4).

Table 3. Fornell-Larcker Criterion: Matrix of correlation and the square root of AVE (in bold).

Constructs	DC	SEQ	SYSQ	INFQ	USS	ITU	NI
Decentralization (DC)	**0.802**						
Service quality (SEQ)	0.539	**0.843**					
System quality (SYSQ)	0.498	0.594	**0.831**				
Information quality (INFQ)	0.482	0.581	0.665	**0.805**			
User satisfaction (USS)	0.556	0.616	0.661	0.629	**0.854**		
Intention to use (ITU)	0.481	0.485	0.411	0.438	0.466	**0.784**	
Net impact (NI)	0.534	0.581	0.582	0.594	0.712	0.446	**0.802**

Table 4. Heterotrait-Monotrait (HTMT).

Constructs	DC	SEQ	SYSQ	INFQ	USS	ITU	NI
Decentralization (DC)							
Service quality (SEQ)	**0.773**						
System quality (SYSQ)	0.617	**0.874**					
Information quality (INFQ)	0.614	0.869	**0.874**				
User satisfaction (USS)	0.678	0.888	0.828	**0.802**			
Intention to use (ITU)	0.591	0.691	0.493	0.543	**0.551**		
Net impact (NI)	0.652	0.837	0.728	0.750	0.873	**0.521**	

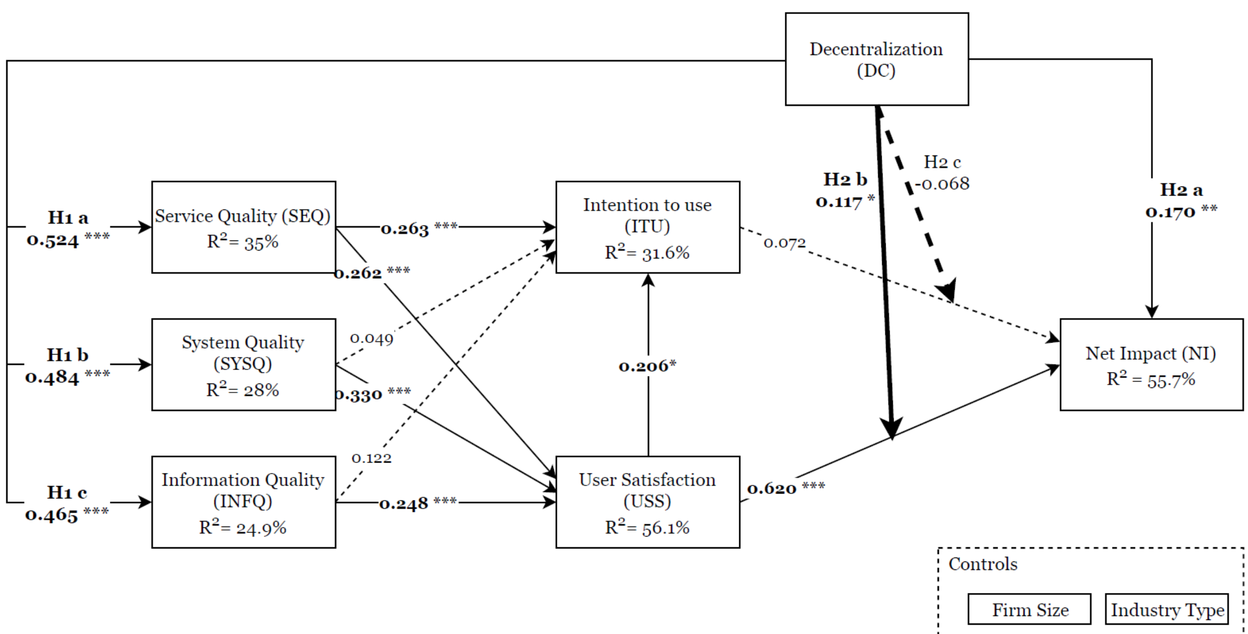
4.2. Assessment of the structural model

The bootstrap method with 5000 iterations of subsamples was used in Smart PLS 3 to evaluate the validity and significance level of paths, (Ringle, Wende, & Becker, 2015). To confirm the lack of multicollinearity problem among the variables, the result of variance inflation factor (VIF) indicates that the VIF values are in ranges from 1.216 (lowest) to 2.065 (highest), whereas the threshold is 5.0 (Hair, Ringle, & Sarstedt, 2011).

Based on Figure 3, Intention to Use (ITU) and User Satisfaction (USS) explains 55.7% of the variation in Net Impacts (NI). Hypothesis linked to net impact, decentralization (H2a) and user satisfaction relationship are confirmed, decentralization ($\hat{\beta}$ = 0.170; $p < 0.05$), user satisfaction ($\hat{\beta}$ = 0.620; $p < 0.01$) are statistically significant, although the relationship between intention to use and net impact is not confirmed. Decentralization positively moderates the user satisfaction on net benefits ($\hat{\beta}$ = 0.117; $p < 0.10$), H2b is confirmed. The decentralization does not moderate the intention to use on net benefits, H2c is not confirmed.

In this model service quality (SEQ), system quality (SYSQ), and information quality (INFQ) explains 56.1% of the variation in user satisfaction (USS). All three constructs of service quality, system quality, and information quality have confirmed relationship with user satisfaction. Service quality ($\hat{\beta}$ = 0.262; $p < 0.01$), system quality ($\hat{\beta}$ = 0.330; $p < 0.01$) and information quality ($\hat{\beta}$ = 0.248; $p < 0.01$) are statistically significant. The model revealed service quality (SEQ), system quality (SYSQ), information quality (INFQ), and user satisfaction (USS) explains 31.6% of the variation in intention to use (ITU). The relationship between service quality and intention to use is confirmed, service quality ($\hat{\beta}$ = 0.263; $p < 0.01$) is statistically significant while system quality and information quality does not have a confirmed relationship with intention to use. This model also explains the relationship between user satisfaction and intention to use is confirmed, User satisfaction ($\hat{\beta}$ = 0.206; $p < 0.10$) is statistically significant.

Figure 3. Research model results.



Notes: * significant at $p < 0.10$; ** significant at $p < 0.05$; *** significant at $p < 0.01$

Consequently, the relationship between decentralization and all three constructs of service quality, system quality, and information quality are confirmed (respectively, $\hat{\beta}$ = 0.524; p < 0.01, $\hat{\beta}$ =0.484; p < 0.01, and $\hat{\beta}$ = 0.465; p < 0.01). The model explains decentralization (DC) explains 35% of the variation in service quality (SEQ), 28% of the variation in system quality (SYSQ), and 24.9% of the variation in information quality (INFQ).

The controls variables are not statistically significant to explain the net impact.

Table 5. Hypotheses and relationship findings

Hypothesis	Variable		Variable	Findings	Support	$f2$	Effect Size
H1a	DC	->	SEQ	Positively & statistically significant ($\hat{\beta}$ = 0.524)	Yes	0.403	Large
H1b	DC	->	SYSQ	Positively & statistically significant ($\hat{\beta}$ = 0.484)	Yes	0.310	Medium
H1c	DC	->	INFQ	Positively & statistically significant ($\hat{\beta}$ = 0.465)	Yes	0.275	Medium
H2a	DC	->	NI	Positively & statistically significant ($\hat{\beta}$ = 0.170)	Yes	0.040	NS
Hypothesis	**Variable**		**Relationship**	**Findings**	**Support**	**$f2$**	**Effect Size**
H2b	(DC)	->	USS * NI	Positively & statistically significant ($\hat{\beta}$ = 0.117)	Yes	0.021	NS
H2c	(DC)	->	ITU * NI	Negatively & statistically insignificant ($\hat{\beta}$ = -0.068)	No	0.009	NS
Variable			**Variable**	**Findings**	**Support**	**$f2$**	**Effect Size**
SEQ		->	ITU	Positively & statistically significant ($\hat{\beta}$ = 0.263)	Yes	0.051	NS
SEQ		->	USS	Positively & statistically significant ($\hat{\beta}$ = 0.262)	Yes	0.087	Small
SYSQ		->	ITU	Positively & statistically insignificant ($\hat{\beta}$ = 0.049)	No	0.02	NS
SYSQ		->	USS	Positively & statistically significant ($\hat{\beta}$ = 0.330)	Yes	0.119	NS
INFQ		->	ITU	Positively & statistically insignificant ($\hat{\beta}$ = 0.122)	No	0.010	NS
INFQ		->	USS	Positively & statistically significant ($\hat{\beta}$ = 0.248)	Yes	0.070	NS
USS		->	ITU	Positively & statistically insignificant ($\hat{\beta}$ = 0.206)	Yes	0.027	NS
ITU		->	NI	Positively & statistically insignificant ($\hat{\beta}$ = 0.072)	No	0.008	NS

USS	->	NI	Positively & statistically significant ($\hat{\beta} =$ 0.620)	Yes	0.490	Large

Notes: NS = not significant; * significant at p < 0.10; ** significant at p < 0.05; *** significant at p < 0.01; effect Size $f2$:>0.350 large;>0.150 and ≤0.350 medium; 0.20 and ≤ 0.150 small; (Chin, 1998; Cohen, 2013)

5. Discussion

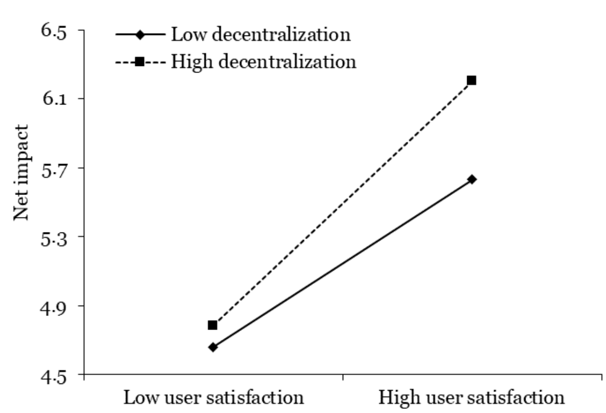
The findings reveal that most of the hypothesized relationships were verified (Table 5). Service quality, system quality, and information quality were explained by decentralization (H1a, H1b, and H1c). These findings are consistent with another study for decentralization in the organization (Applegate et al., 1999). While few studies examine the relationship between service quality and use at the organization level (Petter *et al.,* 2008) our results confirm that service quality has a positive impact on the intention to use. The results also confirm that service quality has a positive impact on user satisfaction. Other studies also revealed that a higher level of support leads to a higher level of users satisfaction (Coombs, Doherty, & Loan-Clarke, 2011; Jia, Hall, Yan, Liu, & Byrd, 2018; Osman et al., 2014; Thong, Yap, & Raman, 1996; Veeramootoo, Nunkoo, & Dwivedi, 2018). The results suggest that organizations consider it valuable to assess whether the investment in service quality of blockchain may leverage higher user satisfaction and intention to use. The study indicates that system quality is positive and statistically significant on user satisfaction, the same result founded in other studies by *Osman et al.,* (2014) and Veeramootoo *et al.,* (2018) Osman *et al.,* (2014); Veeramootoo *et al.,* (2018) However in our study system quality is not significant in intention to use of blockchain technology. Similar results found in other literature on information system success (Costa, Ferreira, Bento, & Aparicio, 2016; Ul-Ain et al., 2019; Urbach et al., 2010). Our explanation for this result is that, by the nature of decentralization features such as reading, updating, and verifying transactions, users are more satisfied to find the functionality of this technology at the first stage. Thus, system quality has no significant relationship to intention to use.

Similarly, information quality is found significant in user satisfaction but not significant in explaining the intention to use. A study on portal success by Urbach et al. (2010) obtained the same result for information quality relationships has been explored. Petter et al. (2008) explain that information quality has the propensity to be measured as a factor of user satisfaction than being assessed as a distinct construct. Responding to a lack of analysis in measuring information systems success at the organization level by Petter et al. (2008). The result indicates that user satisfaction has a positive impact on intention to use. Not surprisingly, other studies found a similar result (Mohammadi, 2015; Sharma & Sharma, 2019; Teo, Srivastava, & Jiang, 2009; Urbach et al., 2010; Wu & Wang, 2006). Thus, for organizations where the intention to use motivate their performance, the greater the level of user satisfaction and service quality needs to be stressed. The study results also show that the intention to use does not validate its effect on net impact. This highlights if users settle that the benefits will compensate for the effort of using blockchain technology, they will effectively use it, otherwise, it will not contribute to users' intention. Other studies by Iivari (2005), Lucas & Spitler (2007), and Wu & Wang (2006) also found no relationship between use and net impact. Wu & Wang (2006) emphasize, although use is necessary but not adequate to generate net benefit. Thus, the results demonstrate that user satisfaction is explained by service quality, system quality, information quality. Intention to use is also explained by service quality. This study indicates that user satisfaction positively influences net impact. The results suggest that increasing the level of user satisfaction may result in a higher net impact in blockchain success. This finding corroborates similar results from several authors that found satisfaction positively influences net impact (Aldholay, Abdullah, Isaac, & Mutahar, 2019; Gelderman, 1998; Iivari, 2005; Law & Ngai, 2007).

Finally, to comply with the important contribution of our study, the net impact on blockchain success is determined by both decentralization and user satisfaction. Our results are in line with other studies which explain decentralization leads to reducing cost and saving time and also increasing the overall performance (Siggelkow & Levinthal, 2003; Wright & De Filippi, 2015). Since our model explains 55% of the variance in net impact, the finding validates the influence of both user satisfaction and decentralization over it. Regarding the moderating effects, we found that decentralization positively influences the relationship between the user's satisfaction and net impact (H*2b*).

Figure 4 demonstrates the effect of decentralization as a moderator for blockchain success will be robust in organizations with a greater level of user satisfaction, therefore, when the levels of users' satisfaction increase, the importance of decentralization also increases in blockchain success. Contrary to our expectation, the results show that the decentralization effect is non-significant on the relationship between intention to use and net impact (H*2c*). Our explanation for this result is that users do not understand the benefits and importance of the decentralized environment in blockchain-based firms.

Figure 4. Structural model (variance-based technique) for blockchain success.



5.1. Theoretical and practical implications

Our contribution to theory is to extend and additionally empirical testing of the Delone & McLean IS Success Model (DeLone & McLean, 2003) in a blockchain environment as recommended by various authors (Beck *et al.,* 2017; Rossi *et al.,* 2019). Moreover, the important contribution of this study focusses on the impact and role of decentralization in blockchain success. From a research attitude, this study signifies a contribution to IS theory by finding that user satisfaction and decentralization can act as a possible trigger to the arising of net impact in blockchain success at the firm level. Therefore, it is not only the technical aspects of decentralization that should be stressed in the current discussion on blockchain, but the focus should be placed on the decentralization as an organizational structure. This study offers two theoretical implications. First, our research model integrated decentralization characteristic of blockchain with the well- known theory of information systems success developed by DeLone & McLean (2003). Second, the proposed model validates IS success theory for the role of decentralization in blockchain success.

This study demonstrates that decentralization and user satisfaction both have a positive influence on the net impact of blockchain success. At the same time, decentralization positively influences the relationship between user satisfaction and net impact. The hypothesis explains that decentralization is an important driver for service quality, system quality, and information quality in blockchain success. This study implies that service quality has a significant impact on both intentions to use and user satisfaction. Managers need to take into consideration user responsiveness and easier access to data in a way to increase overall success by improving efficiency, reliability, and accuracy in blockchain technology.

Moreover, system quality and information quality possessed a significant impact on user satisfaction. Reading, updating, verifying, and confirming the transaction is crucial and necessary in blockchain technology. Therefore, more attention to system quality and information quality from managers and blockchain providers leads to an increase in user satisfaction. Likewise, user satisfaction is a significant factor which positively and directly influences net impact. Also, the blockchain success model explains 55%of the variation of the net impact.

The practical implications of this study bring insights into blockchain technology developers and providers. One such implication derived from this study is that blockchain platforms should provide technological and organizational features to enable a fully decentralized environment. This study also implies that if blockchain technology provides a decentralized structure in organizations, and if users interact with blockchain systems and get the benefit of working in this environment, it will lead to an increase of satisfaction. The findings of this study indicate that by considering the net impact, managers may identify the advantage of time and cost-saving in the blockchain environment. In our understanding, this is one of the first studies which address organizational decentralization as a key factor of blockchain success at firms. Furthermore, studying the dissemination of decentralization based on Blockchain technology allows scholars to learn more about upcoming disrupting technologies and their organizational changes.

5.2. Limitations and future research

Although the aim of this study is to discuss the role of decentralization in blockchain success, our study has some limitations that may set the stage for future research. First, since blockchain is receiving impressive attention from both individuals and firms, more engagement and adoption is expected from businesses and industries; therefore, a longitudinal view in blockchain success is recommended for assessment over an extended period. Second, this research does not evaluate whether the results differ across different industries. Future research may consider a relative study among various type of industries. Third, future research can be performed based on this study by assessing the influencing role of decentralization between the relationship of the three technological dimensions in success theory; service quality, system quality, information, and the other two constructs namely user's satisfaction and intention to use. Lastly, this study measured the role of decentralization in blockchain success. It would be interesting to assess and explore the role of other characteristics of blockchain such as anonymity, persistency, auditability, and traceability in blockchain success.

6. Conclusion

Blockchain is receiving global attention recently. This study disseminates a theoretical study to assess the direct and moderator effect of decentralization in the blockchain context. The proposed research model evaluated by collecting data from numerous firms in the blockchain industry; overall, 193 samples were used to assess our conceptual model. This research demonstrates that user satisfaction and decentralization have a positive impact on blockchain success. Also, decentralization positively influences the relationship between user satisfaction and net impact. The study offers valuable insight to business managers, decision-makers, and IS researchers who may wish to study the role of decentralization in blockchain success.

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Appendix A. Measurement items

Constructs	Code	Indicators	Theoretical support
Participants were asked to rate their perception of blockchain technology success. To measure the variables, a seven-point scale ranging from 1, strongly disagree; 7, strongly agree was used. Strongly disagree 1 – 2 – 3 – 4 – 5 – 6 – 7 Strongly agree			
Decentralization			(Zahra *et al.*, 2004)
	DC1	Our company is open to change.	
	DC2	Our company encourages employees to challenge the status quo.	
	DC3	Our company is decentralized in its decision making.	
	DC4	Our company maintains open communications channels in its operations.	
Service quality			(Urbach *et al.*, 2010)
	SEQ1	blockchain applications supports the work processes efficiently.	
	SEQ2	blockchain applications supports the work processes reliably.	
	SEQ3	blockchain applications supports the work processes accurately.	
	SEQ4	blockchain applications supports the work processes in a way that allows one to trace them.	
System quality			
	SYSQ1	blockchain applications allow me to find the information I am looking for easily.	
	SYSQ2	blockchain applications are well structured.	
	SYSQ3	blockchain applications are easy to use.	
	SYSQ4	blockchain applications offer appropriate functionality.	
Information quality	INFQ1	The information provided by blockchain applications is useful.	
	INFQ2	The information provided by blockchain applications is understandable.	
	INFQ3	The information provided by blockchain applications is reliable.	
	INFQ4	The information provided by blockchain applications is complete.	
User satisfaction	USS1	How adequately do blockchain applications support your area of work and responsibility?	
	USS2	How efficient are the Blockchain applications?	
	USS3	How effective are Blockchain applications?	
	USS4	Are you satisfied with blockchain applications overall?	
Intention to use			
	ITU1	Retrieve information.	
	ITU2	Publish information.	
	ITU3	Store and share documents.	
	ITU4	Network with colleagues.	
Net impact	NI1	Blockchain technology saves me time.	(Chen *et al.*, 2015)
	NI2	Blockchain technology is cost saving.	
	NI3	Blockchain technology responds and takes my opinion or complaints into consideration.	
	NI4	Overall, Blockchain technology is more beneficial to use.	

Appendix B. Item cross-loadings

	DC	SEQ	SYSQ	INFQ	USS	ITU	NI
DC1	**0.78**	0.46	0.29	0.39	0.4	0.38	0.45
DC2	**0.82**	0.42	0.33	0.38	0.4	0.43	0.38
DC3	**0.78**	0.39	0.45	0.39	0.47	0.32	0.38
DC4	**0.82**	0.45	0.5	0.39	0.5	0.41	0.49
SEQ2	0.45	**0.83**	0.59	0.54	0.53	0.33	0.54
SEQ4	0.46	**0.85**	0.42	0.44	0.51	0.48	0.45
SYSQ2	0.35	0.43	**0.81**	0.59	0.57	0.37	0.53
SYSQ3	0.42	0.45	**0.81**	0.51	0.48	0.28	0.39
SYSQ4	0.47	0.6	**0.87**	0.55	0.59	0.37	0.52
INFQ1	0.44	0.5	0.56	**0.85**	0.6	0.39	0.56
INFQ2	0.33	0.34	0.44	**0.77**	0.44	0.25	0.39
INFQ4	0.38	0.54	0.59	**0.79**	0.45	0.41	0.45
USS1	0.54	0.51	0.52	0.49	**0.84**	0.47	0.61
USS2	0.43	0.54	0.52	0.55	**0.84**	0.37	0.58
USS3	0.46	0.52	0.64	0.57	**0.88**	0.35	0.62
ITU1	0.43	0.39	0.36	0.38	0.37	**0.81**	0.33
ITU2	0.36	0.35	0.27	0.3	0.3	**0.74**	0.25
ITU3	0.34	0.34	0.18	0.26	0.26	**0.8**	0.26
ITU4	0.37	0.41	0.41	0.4	0.47	**0.79**	0.49
NI1	0.38	0.39	0.5	0.4	0.55	0.36	**0.79**
NI2	0.46	0.49	0.51	0.51	0.58	0.35	**0.85**
NI3	0.47	0.48	0.36	0.41	0.53	0.32	**0.75**
NI4	0.4	0.51	0.49	0.58	0.62	0.4	**0.82**