Predictors for distributed ledger technology adoption: integrating three traditional adoption theories for manufacturing and service operations

Nazir Ullah\textsuperscript{a*}, Waleed Mugahed Al-rahmi\textsuperscript{b} and Ali Alkhalifah\textsuperscript{c}

\textsuperscript{a}School of Management and Engineering, Department of Management Science and Engineering, Nanjing University, Nanjing, China; \textsuperscript{b}Faculty of Social Sciences and Humanities, School of Education, Universiti Teknologi Malaysia, Johor Bahru, Malaysia; \textsuperscript{c}Department of Information Technology, College of Computer, Qassim University, Saudi Arabia

**ABSTRACT**

It is expected that blockchain technology will bring a disruptive paradigm shift in the manner in which transactions are conducted in the manufacturing and service enterprises. By eliminating the drawbacks of trust-related issues in a business chain, the distributed database of blockchain can bring transparency with pseudonymity and irreversibility of records. In this paper, we advance the limited literature on DLT and its adoption in the manufacturing and service enterprises. The proposed model is based on the integration of three traditional adoption theories namely Technology Acceptance Model (TAM), Technology Readiness Index (TRI) and Theory of Planned Behavior (TPB). Based on a survey of 211 experts of Pakistan, the proposed model was tested using structural equation modelling. The study result confirms that Theory of Planned Behavior and TAM play a key role in the disruptive technology implementation. It is one of the early studies on blockchain technology adoption in the manufacturing and service enterprises and the study results indicate that more manufacturing and service industries are transforming to intelligent operations. Smart manufacturing system through blockchain applications has become the focus of attention of businesses.

**ARTICLE HISTORY**

Received 12 May 2020
Accepted 28 July 2021

**KEYWORDS**

Blockchain; adoption theories; distributed ledger technology; DLT; disruptive technology; supply chain

1. Introduction

The connection between technological innovation and business advance development has included academic talk for quite a long time (Schumpeter, 1939). By the expanding size of the businesses, differentiating item portfolio, and various geographic areas to be aided, the supply chain has gotten increasingly perplexing. Producers are thinking that it’s difficult to offer profoundly altered items to contend in market segments, although the wholesales are controlling position of huge requests as a result of the usage of lean selling rehearses. Subsequently foreseeing demands, arranging generation and synchronizing order have become a noteworthy task in the unbalanced environment (Pereira, 2009). To overcome such issues, digitalization of inventory network has been a basic...
improvement over the most recent few years moving towards an information-based budget where a move from customary assembling to a time of worldwide, shrewd and economical manufacturing is observed (Michel, 2017). The manufacturing businesses are searching for the new technologies to improve their products performance with viable inventory network joint effort and coordination (Farooq & O’Brien, 2012). For the manufacturing and service enterprises, blockchain is a disruptive innovation that provides better traceability and transparency for the supply chains (Francisco & Swanson, 2018). It stores the data in a chronological order which is shared to all the member entities (Yuan & Wang, 2016). The distributed ledger technology irreversibility of records design brings better traceability and can possibly resolve trust-related issues in the organizations (Samaniego & Deters, 2016).

However in its nascent stage, blockchain technology has few challenges to overcome as the organizations are inadequate with regards to a sorted-out environment and stages for scaling up the applications of distributed ledger technology. These issues are mainly related to the security and data governance. In the developing states most of the organizations are doubtful about disruptive technology implementation because of its high cost. Moreover, the viability and advantages in the non-financial segments are also doubtful (Koteska et al., 2017). To gain a competitive advantage the manager of each organization needs to study its potential benefits and risks. There exists a chance to make various sharing applications, for example, digital rights and cultural heritage management, peer to peer payments mechanisms (R. R. Xu et al., 2017). Due to the current risks in using blockchain technology, it is found that the logistic firms are less likely to adopt DLT as compared to the other firms (Sadouskaya, 2017). The study of Mthethwa (Mthethwa, 2016) reports that still people don’t know about disruptive technology so its adoption is slow in the developing countries. The empirical study on the adoption of DLT is limited, most of the existing literature is mainly based on conceptual expositions (Ying et al., 2018). Thusly, it is necessary to empirically study the distributed ledger technology adoption for the manufacturing and service enterprises.

To analyze the behavior of consumers across several information technology services and products, adoption models such as Technology Acceptance Model (Davis, 1989); Theory of Planned Behavior (Icek Ajzen, 1985, 1987; Icek Ajzen, 1991); Diffusion of Innovation Theory (Rogers, 1995); Technology Readiness Index by (Parasuraman, 2000) are being used in the previous studies. The major studies includes Enterprise Resource Planning (Calisir et al., 2009); RFID (M. S. Lee, 2009), virtual reality (Shih et al., 2012; Sernad & Bobek, 2013); IoT (Gao & Bai, 2014); bitcoin (Folkinshteyn & Lennon, 2016) and others. A survey of the previous literature uncovers that there has been little attention on examining the DLT applications more specifically in the developing countries. The current study expects to address the research gap by understanding the distributed ledger technology adoption in the manufacturing and service industries-Pakistan context. The finding of this study will assist the specialists with identifying the several factors that are affecting the distributed ledger technology adoption and ultimately helps the organization to design strategies for its implementation.

Many scholars have studied the adoption of distributed ledger technology in the supply chain. Some of the technology adoption models that were employed include TAM (Francisco & Swanson, 2018), Unified Theory of Acceptance Model (Queiroz & Wamba, 2019), diffusion of innovation theory (Sun et al., 2018), Technology
Organization Environment (Clohessy et al., 2019). In order to supplement these past studies, based on a survey of 211 supply chain experts working in Pakistan, the present study integrates three traditional adoption theories namely TAM (Davis, 1989), Technology readiness Index (Parasuraman, 2000) and Theory of planned behavior (Icek Ajzen, 1985). Consequently, the main purpose of this study is to address the following research questions.

RQ01. What are the factors that drive the intention of Pakistani firms to adopt distributed ledger technology?

RQ02. Among the factors, which has a greater association with the adoption intention?

Our study is structured as follows: section two enlightens prior literature on blockchain and technology adoption models, section three presents hypotheses development and research model, section four shows the methodology for DLT adoption, section five clarifies the results and section six provides a summary.

2. Related work

2.1. Blockchain technology

In the developing countries, the traditional bookkeeping system of double entry is widely used in the manufacturing and service industries. Blockchain technology evacuates all the trust-related problems related with the traditional system and improves the traceability in the transaction process (Davidson et al., 2016). Distributed ledger technology can work as a single database and incorporate all the necessary functions of inventory network (Korpela et al., 2017). Blockchain technology helps the businesses to supervise assets viably and decrease stock conveying costs due to its capacity to make records of all the operations. This aids the supply chains in risk mitigations at lesser cost contrasted with the conventional stock chain where more supplies of stock, abundance limit, and outsider reinforcement sources are created fully expecting interruptions (Ivanov et al., 2019). Blockchain technology applications will aid to upgrade the scale and extent of the tracking system (Hofmann et al., 2017). For instance, ADEPT created by IBM and Samsung could be utilized to give a protected, minimal cost approach to start the smart contract-based order to secure the item and later pay likewise (Cohn et al., 2017). Hyperledger composer is a free tool set designed to build applications for blockchain. The Hyperledger composer supports the Hyperledger Fabric architecture and enables faster business network modeling, deployment of applications and integration with existing systems (Cachin, 2016). Aside from customary assembling, recent innovative disruptions, for example, Industry 4.0 and utilization of robotics related to manage rule-based intelligence would be much increasingly focus on big data analytics (Jeschke et al., 2017). Quality documentation can likewise be institutionalized utilizing distributed ledger and could be dispersed to all participating node to help well decision making (Apte & Petrovsky, 2016). There are reports that certain organizations have begun with the coordination of blockchain technology idea into their assembling rehearses (L. D. L. D. Xu et al., 2018). Wipro’s committed distributed ledger technology
solutions are pointed towards assembling organizations and could be custom-made to the customer needs. Utilizing a special ID, Wipro plans to approve manufacturing processes by dispensing with the plausibility of fake things entering the inventory network. The things would be filtered at each purpose of the assembling procedure. Such a transparency will give advantages to quality administration and verification (Wipro, 2017). To understand the previous literature on distributed ledger technology, for supply chain finance fraud issues a recent study has been conducted by Du et al.,= (2020), blockchain base trust management system for supply chain has been presented by Malik et al., (2019), traditional adoption theories for blockchain (Kamble et al., 2019), smart contracts (S. S. Wang et al., 2019), blockchain-based business process management (Viriyasitavat et al., 2018), supply chain management objectives (Kshetri, 2018), supply chain transparency (Francisco & Swanson, 2018), blockchain applications (Dobrovnik et al., 2018), Supply chain Provenance (Kim & Laskowski, 2018), Fintech operations (Lou & Li, 2017), supply chain finance (Omran et al., 2017), supply chain traceability (Tian, 2017), information sharing for supply chain management (Nakasumi, 2017), digital supply chain (Korpela et al., 2017), Product ownership management (Toyoda et al., 2017), fraud detection for online business (Cai & Zhu, 2016), manufacturing (Abeyratne & Monfared, 2016b), protection of personal data using blockchain (Zyskind & Nathan, 2015). The recent literature review is presented in Table 01.

2.2. Technology adoption models

Technological advancements consistently assume an essential job in the current business environment. Technological development encourages scattering of information too. But, until and unless, it is accepted or used, technology is of little use (Oye et al., 2012). While acceptance is implemented at the discrete level, technology adoption will prompt dispersion (Sharma & Mishra, 2014). Accordingly, understanding innovation adoption is of most extreme significance. Carr, (1999) has characterized innovation adoption as the phase of choosing an innovation for individual and association use. Technology selection can additionally be characterized as eagerness inside a gathering of users to utilize innovation for their advantage (Samaradiwakara & Gunawardena, 2014). Some research have uncovered that innovation adoption is not identified with the parts of innovation alone still has developed as a considerably more muddled procedure including measurements of customer character (Venkatesh et al., 2012), trust (Gefen et al., 2003a) and many facilitating situations (Thompson et al., 1991). Moreover, to determine the dynamics that affect organizations decision to implement IT, several conceptual models through adoption theories have been created (Imran & Gregor, 2007). These proposed models have increased a lot of prevalence in the literature (Venkatesh & Davis, 2000) because of its accomplishment in deciding the implementation of IT are: Technology Acceptance Model (TAM) and Theory of Planned Behavior (TPB). Though, these theories have been created and tested for the most part with regards to western nations and scarcely any investigations have been done with regards to developing nations (Imran & Gregor, 2007), what’s more specifically it has not been studied in the context of Pakistan.
Table 01. Prior literature.

| Author                        | Major Findings                                                                                                                                 |
|-------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------|
| (Yoon et al., 2020)           | This study introduces an analytical model that reflect the adoption of distributed ledger technology in international transactions, to evaluate whether the blockchain advances an exporting companies performance under demand volatility risk. |
| (Queiroz et al., 2019)        | This paper shed light on blockchain technology applications in Supply chain management and what are challenges on implementation of distributed ledgers in Supply chain domain. |
| (Francisco & Swanson, 2018)   | By using the Unified Theory of Acceptance and use of Technology (UTAUT), the finding indicates the concept of technological innovation as a basic structure for the traceability of the Supply chain. The proposed model is being developed, and the work culminates with blockchain Supply chain implications inspired by analysis of theory and literature. |
| (Fosso Wamba et al., 2018)    | The study aims at bridging the knowledge gap in the current Bitcoin, distributed ledger technology and Fintech literature. The results indicate that these innovations are emerging, and for competitive advantage they are being adopted by organizations. |
| (Choi et al., 2020)           | The paper proposed a stylized duopoly model to evaluate product information disclosure game Nash between two rental service platforms whose rent to rent goods are substantial. Moreover, they extract the equilibrium degree of disclosure of product information and define conditions under which the platforms chose to disclose or not disclose information that corresponds to different sorts of supply chain. |
| (Chang et al., 2020)          | The study provides a comprehensive and detailed analysis of the state of the art threats, vulnerabilities and opportunities for both the public and private agencies in the global supply chain and trade operations by synthesizing a wide range of information from industry leaders and academic papers. |
| (Bai & Sarkis, 2020)          | The paper introduced distributed ledger technology performance actions incorporating several sustainable supply chain transparency and technical attributes. The study proposed a new hybrid group decision method for the evaluation and selection of disruptive technology by Integrating hesitant fuzzy set and regret theory. |
| (Babich & Hilary, 2020)       | This study identified the five main strength for understanding the blockchain technology namely visibility, aggregation, validation, automation and resiliency. Moreover, several question of industrial organization with respect to OM are discussed. |
| (Du et al., 2020)             | The study proposed a blockchain-based model for solving the fraud problems in the supply chain finance.                                                                                              |
| (Malik et al., 2019)          | The paper proposed a Trust chain as a three-layer trust management system that used a blockchain consortium to monitor interactions between supply chain participants and dynamically allocate trust and reputation scores based on these interactions. |
| (Kamble et al., 2019)         | The results suggest that integration of theory of planned behavior and TAM plays a pivotal role in the blockchain technology adoption. However, technology readiness index has no significant impact during disruptive technology implementation in the Supply chain. |
| (S. S. Wang et al., 2019)     | The study presents a systematic and detailed overview of smart contracts enabled by blockchain, with the goal of stimulating further research into this emerging field of study. |
| (Viriyasitavat et al., 2018)  | The study proposed a Business process management framework to demonstrate how to incorporate distributed ledger technology to enable efficient and cost-effective assessment and transition of quality service in the composition and management of workflows. |
| (Kshetri, 2018)               | By using an innovative diffusion theory, the findings suggest that ventures would increase as the pioneer in blockchain appropriation, for example, oil trading will various provider layers. Using the rancher’s case, the study predicted that a blockchain endorsement by one entity would apply standardizing pressure on various supply network elements. |
| (Francisco & Swanson, 2018)   | The conceptual model was based on UTAUT for supply chain traceability. A theoretical approach is created and the research finishes with supply chain ramifications of blockchain that are roused by prior literature and theory. |
| (Dobrovnik et al., 2018)      | Using academic and practitioner literature, the study defines potential applications for implementation and provide a structure for identifying opportunities for blockchain in the logistic industry. |
| (Kim & Laskowski, 2018)       | The paper discusses the effect of DLT along with its application in ontological engineering, on supply chain provenance. The research focuses on possible effect and idea evidence for the demonstration of technique based on formal and informal ontology. |
| (Lou & Li, 2017)              | The study proposed a model based on the TAM with innovative diffusion theory to understand the applications of distributed ledger technology in the Fintech operations. |

(Continued)
Table 01. (Continued).

| Author | Major Findings |
|--------|----------------|
| (Omran et al., 2017) | This study suggested a proposed model for blockchain driven supply chain finance. Transparency, automatic reconciliation and quality have been described as the supply chain prime value drivers. The distributed ledger technology is designed to achieve the paradigms set out. |
| (Tian, 2017) | The study proposes a blockchain-based traceability system for food tracing based on hazard analysis and critical control points. In addition, the author also introduced a new model BigchainDB to meet the gap in the decentralized system at scale. |
| (Nakasumi, 2017) | The author proposed a blockchain-based system to tackle the supply chain issues like information asymmetry & double marginalization. |
| (Korpela et al., 2017) | The study proposed a cloud-based system to address the difference between business readiness and present functionalities. In addition, the findings suggested that smart contracts are the most important functionalities for transforming the digital supply chain through incorporation into blockchain. |
| (Toyoda et al., 2017) | The study introduced a distributed ledger technology-based product ownership management system of RFID for anti-counterfeits goods. |
| (Cai & Zhu, 2016) | The paper indicates that disruptive technology-based reputation systems are more robust against bad-mouthing than ballot-stuffing fraud. |
| (Abeyratne & Monfared, 2016b) | The study claims that distributed ledger technology and Internet of things will profoundly affect next-generation manufacturing. |
| (Zyskind & Nathan, 2015) | The study proposed a blockchain based decentralized model for the personal data management ensuring users own and control their data. They implement a protocol that transforms distributed ledgers into an automated access-control manager that needs no third-party trust. |

Table 02. Technology adoption models.

| Author | Findings |
|--------|----------|
| (Ma et al., 2018) | The study disclosed that by integrating the theory of Planned behavior (TPB) with TAM, the factors influencing municipal solid waste sources were analyzed. The proposed model findings explained how householder’s subjective norms, attitude and perceived behavior control affect their overall behavior. |
| (Xie et al., 2017a) | In this paper, the integrated construct of TAM, TPB is used with Trust & Perceived risk. The findings proposed that trust have positive impact on subjective norms for e-government adoption while perceived risk shows negative impact. |
| (Issa & Hamm, 2017) | The study revealed that theory of planned behavior framework plays pivotal role for the adoption of organic farming. |
| (Howell, 2016) | The study result indicates that trust with TAM have a significant impact on intention to use social media sites. |
| (Alalwan et al., 2016) | The results suggested that TAM have significant impact on the behavioral intention for the consumer adoption of mobile banking. |
| (Folkinshteyn & Lennon, 2016) | The study suggested the TAM model to establish similarities and discrepancies in how different stakeholders embrace the bitcoin adoption. |
| (Awa et al., 2015) | The study suggested that the constructs implemented in the integrated system (company purpose, trust and service quality) introduced socio-technical systems and strengthened the theoretical base of e-commerce adoption by SMEs. |

To review the recent studies on the technology adoption models by using traditional adoption theories, for municipal solid waste source-separated collection behavior a recent study has been conducted by Ma et al., (2018), e-government adoption (Xie et al., 2017a), organic farming adoption (Issa & Hamm, 2017), social media site use (Howell, 2016), mobile banking adoption (Alalwan et al., 2016), bitcoin (Folkinshteyn & Lennon, 2016), and e-commerce adoption (Awa et al., 2015). The recent study on the technology adoption models is presented in Table 02.
3. Hypotheses development

3.1. Technology Acceptance Model (TAM)

In this paper, consequently the theoretical grounding originates from the traditional adoption theories. As indicated TAM, regardless of whether end-user is inclined to acknowledge and use information system, is dependent on two particular beliefs: Perceived ease of use (PEOU), Perceived usefulness (PU) and Attitude (ATT) (Davis, 1989); PEOU is the degree to which an individual affirms that using a specific system would be free of physical and mental efforts while PU is the degree to which an person recognizes the use of a system to improve one’s output (Davis, 1989). Both convictions impact one’s attitude towards information system use, which impacts individual social expectation to utilize information system which thus decides real system utilization as depicted in Figure 01. The fundamental connections have been endorsed empirically in numerous investigations of individual acceptance in various situations: for instance, for mobile computing a study has been conducted by Wu et al., (2007), to examine the acceptance of online shopping (Gefen et al., 2003b) and e-government services (Carter & Bélanger, 2005). Moreover, attitude is the degree to which an person has a great or unfavorable assessment of the conduct being referred to H.-d. Yang & Yoo, (2004). Attitude with regard to user acceptance of IT is characterized as a person’s general productive response (loving, delight, happiness, and joy) to utilize technology (Davis, 1989). The results from the previous studies proposed that perceived ease of use has significant impact on perceived usefulness (Davis et al., 1989; Kleijnen et al., 2004; Wamba et al., 2020). Moreover, perceived ease of use positively affect attitude (Chen & Chen, 2008; Queiroz & Wamba, 2019; Y. S. Y. S. Wang et al., 2003). Perceived usefulness positively impact attitude (Karamchandani et al., 2019; Venkatesh et al., 2003). Attitude have positive impact on behavioral intention (I Ajzen & Fishbein, 2005; Davis, 1989; Folkinshteyn & Lennon, 2016; Guriting & n.d.ubisi, 2006; Taylor & Todd, 1995).

![Figure 01. Conceptual model.](image-url)
Perceived usefulness have positive and significant impact on behavioral intention (Agarwal & Prasad, 1998; Gefen et al., 2003a; Kamble et al., 2019). So, we formulate the following hypotheses.

$H_1$. Perceived ease of use positively affect perceived usefulness of blockchain technology

$H_2$. Perceived ease of use positively affect attitude towards using the blockchain technology

$H_3$. Perceived usefulness positively affect attitude towards using the blockchain technology

$H_4$. Attitude positively affect behavioral Intention to use the blockchain technology

$H_5$. Perceived usefulness positively affect behavioral Intention to use the blockchain technology

### 3.2. Technology Readiness Index (TRI)

Parasuraman (Parasuraman, 2000; Parasuraman & Colby, 2015) defines TRI as the construct that can be seen as a common perspective coming about because of a gestalt of psychological empowering agents and inhibitors that by and large decide a person preference for using new technology. TRI refers to a human’s ability to use new technology for achieving goals. TRI measures discrete general innovation convictions and comprises four sub-measurements: optimism (OPTIM), innovativeness (INNOV), discomfort (DISCOM) and insecurity (INSEC). Optimism is termed as a positive view of technology and a belief that it provides increased flexibility, adaptability and ability in individuals’ lives (Parasuraman & Colby, 2007). Innovativeness is characterized as a desire to be a leader and pioneer of a technology. Positive thinking can be seen as a guide to a positive innovation outlook and fills in as a belief that it can build capabilities, improve flexibility and adaptability. Discomfort is stated as a perceived lack of control over creativity and a feeling of being overwhelmed by it (Parasuraman & Colby, 2007). Discomfort portrays the sentiment of absence of control and a feeling of overpowering while at the same time utilizing the innovation. Consequently, insecurity identifies with stresses or doubt for the technology and doubt towards its ability (Parasuraman & Colby, 2007). However, optimism and innovativeness are studied as the sparks of the technology while discomfort and insecurity fill in as inhibitors. Technology Readiness Index has been utilized in mix with Technology acceptance model to anticipate the technology selection before (Pattansheti et al., 2016). The previous finding indicate that Optimism and Innovativeness have positive and significant impact on perceived usefulness (Walczuch et al., 2007; Yi et al., 2003). Moreover, Optimism and Innovativeness have positive impact on perceived ease of use (Kuo et al., 2013; Sun et al., 2018; Yoon et al., 2020). However, the previous studies indicate that discomfort and insecurity have negative impact on perceived usefulness (Tsikriktsis, 2004; Z. Yang et al., 2015). Furthermore, discomfort and Insecurity have negative impact on perceived ease of use (Walczuch et al., 2007; Pires et al., 2011). Therefore, we postulate the following hypotheses.

$H_6$. Optimism positively affect perceived usefulness of blockchain technology

$H_7$. Optimism positively affect perceived ease of use of blockchain technology

$H_8$. Innovativeness positively affect perceived usefulness of blockchain technology
H9. Innovativeness positively affect perceived ease of use of blockchain technology
H10. Discomfort negatively affect perceived usefulness of blockchain technology
H11. Discomfort negatively affect perceived ease of use of blockchain technology
H12. Insecurity negatively affect perceived usefulness of blockchain technology
H13. Insecurity negatively affect perceived ease of use of blockchain technology

3.3. Theory of Planned Behavior (TPB)

Theory of Planned Behavior, proposed by Icek Ajzen (1985), is an extension of the theory of reasoned action (TRA). The TRA depended on a reconciliation of different theories of attitude, for example, learning, consistency and attribution theory. The TRA indicates that individuals are bound to develop motivation in the event that they have an uplifting frame of mind towards a subject and their peers. The theory of planned behavior tends to circumstances where the people don’t have unlimited authority over their conduct. The several constructs included in theory of planned behaviors are subjective norms (SUBJ), perceived behavioral control (PBC) and behavioral intention to use (BI). Subjective norms are the person’s recognition that the enormous majority who are imperative to him figure he ought to or ought not play out the behavior in question. Choi et al., (2008) examined that (SUBJ) had the most notable influence on the behavioral intention. Perceived behavioral control refers to people’s understanding of their capacity to perform a given action to the degree that it is a precise reflection that perceived behavior control may be used to predict actions along with behavioral intention. The previous finding indicates that theory of planned behavior constructs play a noteworthy impact on behavioral intention (Kamble et al., 2019). More specifically, Subjective norms indicates a substantial influence on perceived usefulness (Choi et al., 2008; Y. Lee et al., 2006). In addition, subjective norms have positive and significant impact on behavioral intention (Icek Ajzen, 1985; Choi et al., 2008). Moreover, perceived behavior control also shows a positive and significant impact on behavioral intention to use the Information System (Chai & Pavlou, 2004; George, 2004). Therefore, we assume the following hypotheses.

H14. Subjective norms positively affects the perceived usefulness of blockchain technology
H15. Subjective norms positively affect behavioral intention to use the blockchain technology
H16. Perceived behavioral control positively affect behavioral intention to use the blockchain technology

In the present study, the Technology Readiness Index model gives the theoretical premise to estimating the perceived risks and opportunity that go about as the hindering variables during Blockchain technology adoption in the manufacturing and service industries of Pakistan. TAM model should estimate how the attitude towards the social intention is generated and what role Perceived ease of use and Perceived usefulness is played. Theory of Planned Behavior assesses the impact of the adoption process on subjective standards and perceived regulation of behavior. The proposed model is shown in Figure 01.
4. Analysis and Methodology

4.1. Data Collection

To analyze the relationship between the constructs proposed in the conceptual model, survey method was developed. In 2019, a sample of 211 experts working in the Pakistan major cities (Abbottabad, Charsadda, Kohat, Mardan, Peshawar, Swabi) were considered for this study. The pilot testing process and five likert scale was used (Allen & Seaman, 2007; Croasmun & Ostrom, 2011). The respondents in our target population were professionals working in the manufacturing, logistic, finance and Information Technology department of Pakistan. Every respondent was given an envelope with a questionnaire, a letter welcoming respondent to take an interest, describing the reason for the research and the classification of their feedbacks. Out of the 350 distributed questionnaires, complete 211 responses were received with a response rate of 60.28 per cent. The sample of 211 respondents fulfils the minimum requirement of five observations per parameter (Bollen, 1989; Willis et al., 2016). Moreover, we select 27 parameter for SEM analysis, with a minimum requirement for a sample size of 165 respondents. Hence, Wolf et al., (2013) suggested small samples as appropriate for structural equation model analysis. The sample of 211 experts is considered suitable for performing the SEM study, taking into account practical constraints in collecting data on an exploring topic such as distributed ledger technology adoption. The respondent’s demographic information is presented in the Table 03.

Table 03. Respondents profile.

| Profile                                  | Frequency |
|------------------------------------------|-----------|
| Jobs                                     |           |
| Inventory Manager                        | 77        |
| Operations Manager                       | 43        |
| Finance Manager                          | 36        |
| Research and Development Manager         | 21        |
| Testing Officers                         | 16        |
| Others (Senior Account, Production Supervisor, sales staff etc) | 18 |
| Employees                                |           |
| >500                                     | 76        |
| 500 ≤ 1000                               | 93        |
| >1000                                    | 42        |
| Experience                               |           |
| ≤5 years                                  | 55        |
| >5 ≤ 10 years                            | 85        |
| >10 years                                | 71        |
| Industries                               |           |
| Textile                                  | 63        |
| Sugar                                    | 44        |
| Food                                     | 26        |
| Mineral Products                         | 21        |
| Fuel & Energy                            | 17        |
| Electrical Machinery and Apparatus       | 12        |
| Cement                                   | 11        |
| Coke & Refined Petroleum Products        | 07        |
| Motor Vehicles                           | 06        |
| Transport Services                       | 03        |
| Paper, Paperboard and Products           | 01        |
| Operations                               |           |
| Manufacturing                            | 126       |
| Services                                 | 85        |

N = 211
4.2. **Structural equation modeling**

In this study, partial least square structural equation modeling (PLS-SEM) is used. It is a multivariate data analysis technique which enables linear and additive models and widely used in operations management research (Shah & Goldstein, 2006). It has been used increasingly in various researches, because of its appropriate and robust methods that enable it to examine composite models in the exploratory research (Chin, 1998). The first-generation techniques were opting out because of their limited capability with regards to casual and complex modeling (Lowry & Gaskin, 2014), among the second-generation analysis technique PLS-SEM was applied instead of Covariance-Based because of the complex nature of structural models, i.e. many constructs with several indicators. The study of Hwang et al. (Hwang et al., 2010) encourages using PLS-SEM. SmartPLS is widely adopted and accepted method in term of studying technology adoption models (J. F. Hair et al., 2011). The details of the measurement items is presented in Table 04.

4.3. **Common method bias**

The use of a single instrument to assess exogenous and endogenous structures usually raises questions about common method bias issues (Tan et al., 2018). Therefore, both methodological and statistical methods were used to prevent the common method bias problems. The statistical solution was applied using the Harmon’s single factor test. The findings showed that the data variation was recorded by the first factor by 42.915 percent. Since the outcome is below the 50 percent, it can be assumed that there was no common method bias problem (Wong et al., 2015). In addition, the variance inflation factor (VIF) was tested before inspecting the structural model to detect the existence of highly correlated constructs. The findings showed that the highest VIF values of all constructs were (2.724) below the standard cut-off threshold of 3 (Chuah et al., 2017). The VIF is presented in Table 05. Endogeneity can be generated by the structural model recursively. Thus, we applied a Ramsey regression equation error test and found no endogeneity problem (Babatunde et al., 2014; Guide & Ketokivi, 2015). The results indicate that this research does not pose a significant multicollinearity problem and suitable for the structural model analysis.

5. **Analysis and results**

In this paper, the conceptual model was tested using a two-step method. In the first step the reliability and validity were checked for the evaluation of the measurement items and the structural equation model was analyzed in the next step.

5.1. **Measurement model**

Sanders et al. (Sanders et al., 2009) define validity as the extent within which data information methods calculate precisely what they intended to calculate. In this study the following reliability and validity tests were applied.
| Construct     | Items       | Measurement                                                                                           | References                                                                 |
|---------------|-------------|-------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------|
| Optimism      | OPTIM1      | Blockchain technology will make you more efficient in your job                                        | Parasuraman, 2000; Shirahada et al., 2019; Spenkelink, 2014 |
|               | OPTIM2      | Blockchain will give you more control on your daily business life                                      |                                                                            |
|               | OPTIM3      | You like the idea of blockchain technology because you are not restricted to systematic business hours |                                                                            |
| Innovativeness| INNOV4      | Blockchain will give you more flexibility                                                            | (Parasuraman, 2000; Shirahada et al., 2019; Spenkelink, 2014)              |
|               | INNOV5      | You like the task of figuring out high-tech devices                                                   |                                                                            |
|               | INNOV6      | Developers/service providers come to your firm for suggestion of blockchain technology adoption       |                                                                            |
|               | INNOV7      | You keep up with the high-tech developments                                                           |                                                                            |
|               | INNOV8      | Your firm have less problems than others in adopting new technology                                   |                                                                            |
| Discomfort    | DISCOM9     | It’s difficult to understand the blockchain technology                                                | Kamble et al., 2019; Parasuraman, 2000; Shirahada et al., 2019             |
|               | DISCOM10    | You think blockchain is only for the use of complex supply chain firms                                 |                                                                            |
|               | DISCOM11    | You think blockchain service providers may take the advantage of your supply chains                   |                                                                            |
|               | DISCOM12    | Technology seems mostly to fail at the worst                                                           |                                                                            |
| Insecurity    | INSEC13     | You consider, it is not secure for your firm to adopt blockchain technology                            | (Kamble et al., 2019; Parasuraman, 2000; Shirahada et al., 2019)            |
|               | INSEC14     | You are worried, blockchain technology adoption will disturb your firm security in the future         |                                                                            |
|               | INSEC15     | You do not feel confident and reliable in adopting blockchain technology                              |                                                                            |
| Perceived     | INSEC16     | Online transactions will disturb your privacy                                                          | (Davis, 1989; Queiroz et al., 2019; Rehouma & Hofmann, 2018; Spenkelink, 2014) |
| usefulness    | PU17        | Using distributed ledger technology can help your firm for fast and speedy transactions                |                                                                            |
|               | PU18        | Using distributed ledger technology can improve your firm transparency                                  |                                                                            |
|               | PU19        | Using distributed ledger technology can improve your firm’s traceability                               |                                                                            |
|               | PU20        | Using distributed technology can improve your firm Supply chain effectiveness, productivity & performance |                                                                            |
| Perceived ease| PEOU21      | You feel distributed ledger technology features is easy to use                                         | (Davis, 1989; Rehouma & Hofmann, 2018; Spenkelink, 2014)                   |
| of use        | PEOU22      | You feel distributed ledger technology is understandable and faultless                                |                                                                            |
|               | PEOU23      | You feel it is easy to perform multi task on the blockchain technology                                 |                                                                            |
|               | PEOU24      | You think distributed ledger is easier to use than normal supply chain management activities           |                                                                            |
| Attitude      | ATT25       | You will be happy if your firm adopt blockchain technology                                             | (Davis, 1989; Kamble et al., 2019; Shirahada et al., 2019; Spenkelink, 2014) |
|               | ATT26       | In your opinion, it is right for your firm to use the Blockchain technology                            |                                                                            |
|               | ATT27       | You think, it is good for the future of Pakistan firms to use the blockchain technology                |                                                                            |
|               | ATT28       | Overall, yours attitude towards adoption of distributed ledger technology is favorable                 |                                                                            |
| Subjective    | SUBJ29      | Most of your firm employee believe adoption of blockchain is a good decision                           | (Icek Ajzen, 1985; Baker et al., 2007; Kamble et al., 2019)                |
| norms         | SUBJ30      | Most of your firm partners expect your firm will adopt disruptive technology                           |                                                                            |

(Continued)
Table 04. (Continued).

| Construct | Items                                                                 | Measurement                                                                                           | References                                                                 |
|-----------|------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------|
| SUBJ31    | You prefer opinion of employee regarding adoption of peer to peer transmission technology |                                                                                                        | (Icek Ajzen, 1985; Baker et al., 2007; Kamble et al., 2019; Madden et al., 1992) |
| SUBJ32    | Competitors can get advantage if they adopt blockchain earlier than you |                                                                                                        |                                                                           |
| PBC33     | Your firm has the capability and resources to adopt the blockchain technology |                                                                                                        |                                                                           |
| B135      | Behavioral intention                                                  | Your firm will use Blockchain in the near future your organization would be able to use Blockchain technology very well |                                                                           |
| B136      | Behavioral intention                                                  | You expect your firm will use distributed ledger technology in manufacturing domain to measure anti-counter feits and improve transparency in the supply chain |                                                                           |

Table 05. VIF Values.

| VIF  |
|------|
| OPTM1| 2.409 |
| OPTM2| 2.724 |
| OPTM3| 1.111 |
| OPTM4| 2.012 |
| INNOV5| 1.703 |
| INNOV6| 1.484 |
| INNOV7| 1.711 |
| INNOV8| 1.495 |
| DISCOM9| 1.570 |
| DISCOM10| 1.719 |
| DISCOM11| 1.497 |
| DISCOM12| 1.508 |
| INSEC13| 1.699 |
| INSEC14| 1.972 |
| INSEC15| 1.568 |
| INSEC16| 1.284 |
| PU17  | 1.717 |
| PU18  | 2.071 |
| PU19  | 2.162 |
| PU20  | 2.005 |
| PEOU21| 1.799 |
| PEOU22| 1.940 |
| PEOU23| 2.137 |
| PEOU24| 1.874 |
| ATT25 | 1.917 |
| ATT26 | 2.019 |
| ATT27 | 2.114 |
| ATT28 | 2.004 |
| SUBJ29| 1.482 |
| SUBJ30| 1.858 |
| SUBJ31| 1.794 |
| SUBJ32| 1.391 |
| PBC33| 1.538 |
| PBC34| 1.538 |
| B135 | 1.845 |
| B136 | 1.845 |
5.1.1. Convergent validity

Convergent validity test applied, when the hypothetical construct developed for the analysis is closely correlated with the items used to measure it, a high proportion of variance shared by the indicators of a given construct must be present. In the present study, ten constructs were evaluated by following the guidelines for finding their convergent validity.

- For the reflective model, the factor loadings of all the measurement items shall be checked for the significance level, the value of all the items must be above 0.70 (Jr, J. Hair et al., 2016).
- After checking the loadings, the composite reliability test have to be applied on all the constructs, the value of each construct must be above 0.70 (Jr, J. Hair et al., 2016).
- Average Variance Extracted of each construct must be tested after checking the reliability, the standard for each construct is 0.50 and above (Fornell & Larcker, 1981).
- The Discriminant validity test to examine the extent within which measurement constructs in a conceptual model are different from each other (Fornell & Larcker, 1981).

By using the SmartPLS 3.2.8, all the tests were conducted for the study. The loading values for the measurement item OPTIM3 (λ = 0.44) and INSEC 16 (λ = 0.48) were found to be less than standard (0.50) indicating internal consistency issues. So, OPTIM3 and INSEC 16 both the items were dropped from the study. The measurement model loading of each construct item is shown in Figure 02. The composite reliability and the AVE after loadings were tested. The results were above the standard

![Figure 02. Measurement model.](image-url)
value (0.7) and (0.5), representing a strong indicator reliability of the measurement constructs as presented in Table 06. The square root of average variance extracted in each latent variable were tested to check the discriminant validity. Based on the tests, the square root of AVE is considered to be greater than the correlation between the constructs reflecting that all constructs satisfied the validity and can be used for the testing the structural equation model. The discriminant validity is presented in Table 07.

5.2. Structural model

In the second step to evaluate the structural equation modeling, bootstrapping was applied for the structural path’s significance testing. In the bootstrapping procedure, a large number of subsamples (5000) were tested from the original sample with replacement to check standard bootstrap errors, which in turn directed the approximate T-values for significance testing of the structural model. The bootstrapping process result approximates data normality for a structural model, as shown in Figure 03. The final decision about the hypothesis development is presented in Table 08.

6. Discussion and conclusion

6.1. Major findings

Based on the final decision about the hypotheses development in the Table 08, it is considered that nine of them were found statistically significant from the total sixteen tested hypothesis relationships in the structural equation model. The finding further indicate that the latent constructs explained 62.6% of the variance in the behavioral Intention ($R^2 = 0.626$). Consequently, the current study findings indicate that Theory of Planned Behavior with Technology Acceptance Model plays a pivotal role in the adoption of the distribution ledger technology. The Technology acceptance model constructs-perceived ease of use, perceived usefulness, attitude and Theory of planned behavior construct-perceived behavior control shows a significant impact during the behavioral intention of disruptive technology in the manufacturing and service industries of Pakistan. However, Technology readiness constructs-optimism and insecurity shows insignificant impact with regards to adopting complex technologies. Both the constructs neither influence technology acceptance model construct-perceived ease of use and
Table 07. Discriminant Validity.

|                   | Attitude | Behaviour intention | Discomfort | Innovativeness | Insecurity | Optimism | Perceived Behavioural control | Perceived Usefulness | Perceived ease of use | Subject Norms |
|-------------------|----------|---------------------|------------|----------------|------------|----------|-------------------------------|---------------------|---------------------|-----------------|
| Attitude          | 0.829    |                     |            |                |            |          |                               |                     |                     |                 |
| Behaviour intention| 0.750    | 0.916               |            |                |            |          |                               |                     |                     |                 |
| Discomfort        | −0.434   | −0.412              | 0.778      |                |            |          |                               |                     |                     |                 |
| Innovativeness    | 0.700    | 0.618               | −0.375     | 0.785          |            |          |                               |                     |                     |                 |
| Insecurity        | −0.479   | −0.489              | 0.562      | −0.475         | 0.823      |          |                               |                     |                     |                 |
| Optimism          | 0.670    | 0.587               | −0.494     | 0.780          | −0.558     | 0.888    |                               |                     |                     |                 |
| Perceived Behavioural control | 0.739 | 0.683               | −0.359     | 0.628          | −0.448     | 0.617    | 0.891                         |                     |                     |                 |
| Perceived Usefulness | 0.783 | 0.701               | −0.387     | 0.555          | −0.366     | 0.547    | 0.653                         |                     | 0.829               |                 |
| Perceived ease of use | 0.792 | 0.725               | −0.434     | 0.621          | −0.423     | 0.594    | 0.684                         |                     | 0.789               | 0.823           |
| Subject Norms     | 0.743    | 0.653               | −0.371     | 0.625          | −0.355     | 0.576    | 0.703                         | 0.663               | 0.728               | 0.781           |
perceived usefulness. Therefore, rejecting hypothesis (H6, H7, H12, H13) and the result is supported by the finding of the other studies of (Walczuch et al., 2007), (Kamble et al., 2019).

The study results indicate that technology acceptance model construct-perceived ease of use influence the perceived usefulness and supported by the finding of other major studies of (Amoako-Gyampah & Salam, 2004) (M. S. Lee, 2009), (Shih et al., 2012) (Gao & Bai, 2014) (Kumpajaya & Dhewanto, 2015) (Rajan & Baral, 2015) (Bröhl et al., 2016; Kamble et al., 2019). Therefore, accepting Hypothesis (H1).
The study findings show that the technology acceptance model construct-perceived ease of use has a substantial effect on the attitude of the supply chain experts, so accepting Hypothesis (H2) and the finding is supported by the other studies of (Amoako-Gyampah & Salam, 2004) (M. S. Lee, 2009), (Shih et al., 2012), (Pattansheti et al., 2016). The study results show that construct-perceived ease of use of technology acceptance model has a significant impact on the behavioral intension to use the distributed ledger technology. So accepting Hypothesis (H3) and the findings are accompanied by other relevant studies carried out for technology adoption (M. S. Lee, 2009), (Gamal Aboelmaged, 2010), (Shih et al., 2012), (Pattansheti et al., 2016), (Kamble et al., 2019).

The findings also indicate that the technology acceptance model construct-attitude has a significant impact on the behavioral intension to use the blockchain technology so accepting Hypotheses (H4). The outcome conforms to the other research of (Amoako-Gyampah & Salam, 2004), (M. S. Lee, 2009), (Gamal Aboelmaged, 2010), (Shih et al., 2012), (Moons & De Pelsmacker, 2015), (Safa et al., 2015), (Pattansheti et al., 2016), (Kamble et al., 2019).

Based on the findings, the current study further confirms that technology acceptance model construct-perceived usefulness has a significant effect on the behavior strength, so accepting Hypothesis (H5) and the findings are backed by the major earlier studies of (Gamal Aboelmaged, 2010), (Gao & Bai, 2014), (Kumpajaya & Dhewanto, 2015), (Bröhl et al., 2016; Rajan & Baral, 2015). The overall constructs indicate that technology acceptance model is essential for the adoption of distributed ledger technology. The results further suggest that more manufacturing and service sectors are turning into smart operations. smart manufacturing system through blockchain applications have become the focus of attention of businesses (Qu et al., 2019), (Kumar et al., 2020).

The analysis indicates that technology readiness index construct-innovativeness shows negligible effect on technology acceptance model construct- perceived usefulness, thus denying Hypothesis (H8) and supported by the finding of the previous studies of (Walczuch et al., 2007; Yi et al., 2003), (Godoe & Johansen, 2012), (Kamble et al., 2019). However, the findings of the study further indicate that innovativeness shows a significant impact on the perceived of use, So accepting Hypothesis (H9) and supported by the study of (Walczuch et al., 2007), (Pires et al., 2011), (Godoe & Johansen, 2012).

The result shows that technology readiness index construct-discomfort shows an insignificant effect on the technology acceptance model construct-perceived usefulness, thus rejecting the Hypothesis (H10) and supported by the findings of other studies (Walczuch et al., 2007), (Pires et al., 2011), (Kamble et al., 2019). The findings also consider that discomfort have a significant effect on perceived ease of use, therefore accepting hypothesis (H11) and supported by the previous study of (Walczuch et al., 2007).

This study was find more interesting when results show that Theory of planned behavior construct-subjective norms shows a significant impact on the technology acceptance model construct-perceived usefulness, so accepting Hypothesis (H14) and is supported by the findings of the other interesting studies of (Gumussoy et al., 2007), (Kamble et al., 2019). This findings consider that adoption of a distributive ledger technology can play a key role in improving traceability and transparency in the supply chains (Abeyratne, 2016a; Francisco & Swanson, 2018) and additive manufacturing for improving the anti-counterfeiting measures (J Battistini, 2016; Kennedy et al., 2017).
However, the subjective norms shows negligible impact on the behavioral intension to use the blockchain so rejecting Hypothesis (H15) and backed by the prior studies of (Sentosa & Mat, 2012), (Moons & De Pelsmacker, 2015), (Safa et al., 2015). Moreover, the theory of planned behavior construct- perceived behavior also show a significant impact on the behavioral intension to use the blockchain technology by the manufacturing and service enterprises of Pakistan, and supported by the previous studies of (Baker et al., 2007; Issa & Hamm, 2017; Kamble et al., 2019; Xie et al., 2017b), so accepting final Hypotheses (H16).

6.2. Theoretical implications

There has been increasing attention in the research of Blockchain technology which is indicated by the large number of calls for manuscripts on several aspects of Blockchain technology from reputable journals like International Journal of Production Economics, Harvard Business Review, International Journal of Production Research and others. The current study proposed a model to better understand the adoption of distributed ledger technology in the Supply chain-Pakistan context. It is one of the primary studies by using the three traditional adoption theories namely TAM with technology readiness Index and theory of planned behavior. Previous literature on distributed ledger technology has been conducted from the TOE perspective (Clohessy et al., 2019), UTAUT (Queiroz & Wamba, 2019), TAM perspective (Francisco & Swanson, 2018). The present study thus expands the literature on innovation adoption by testing a unified traditional adoption theory, and hence has far enough resolved the gap in the existing literature with respect to the adoption of distributed ledger technology in Information System and Supply chain management. In addition, few studies have been done in the developing nations for the blockchain adoption, and it has not been studied in the Pakistan context. This study can be act as a starting point for the other Information System researchers to deeply analyze the blockchain implementation. The results of the proposed model offer significant insights which could aid supply chain experts to better understand blockchain technology implementation in the supply chain management.

6.3. Managerial implications

This study shows that the conceptual model has a strong explanatory power ($R^2 = 0.626$ and $R^2$ adjusted = 0.618), reflecting a 62.6 percent variance of the intention to use blockchain technology. Moreover, a variation of ($R^2 = 0.643$ and $R^2$ adjusted = 0.633) was shown by the perceived usefulness towards disruptive technology. Subsequently, a variation of ($R^2 = 0.447$ and $R^2 = 0.436$) was shown by the perceived ease of use. Finally, the highest variation was shown by attitude representing ($R^2 = 0.693$ and $R^2$ adjusted = 0.690). Accordingly, the major findings also have important strategic implications and insights that could enable organizations to better manage and organize the effective adoption of distributed ledger technology. For the organizations implementing distributed ledger technology, the finding suggests that their marketing endeavors need not concentrate only on awareness about distributive ledger technology, however they are required to create intrigue and drive the professionals towards its effective usage through viable buyer and
supplier dyads. For the blockchain enterprises, the finding indicates that their marketing strategies need to concentrate on influencing the decision makers to purchase blockchain applications. The using of the blockchain applications will help the retailers to track and control stock in the real time, thus reduce product misplacement, stock level, and labor costs. Moreover, in the manufacturing domain, the blockchain applications will help the organizations for the anticounter measures (Mohamed & Al-Jaroodi, 2019).

6.4. Limitation and conclusion

This study also has some limitations as in other studies. Some of the limitations are due to the inherent features of disruptive technology. Blockchain technology is comparatively a new idea in Pakistan with few organizations planning to implement in their enterprises. So, future studies have to answer the following issues. For example: Does blockchain adoption by end users affect the form of product of service? Since, would blockchain impact more on industries such as medicine and aviation, where goods have to follow very strict standards? Would the component parts and services like nails, grains and lawnmowers also be less impactful or demanded?

In the current study we didn’t examine the blockchain integration with other technologies for security and privacy. Therefore, it is suggested that the future studies should consider incorporating other technologies like IoT that support distributed ledger technology. For instance: How to integrate the proliferation of the Internet of things, a technology that can deliver information inputs, and blockchain? Maybe IoT will provide more inputs and blockchain will produce more production through application such as smart contracts. Such a model of integration necessitates less emphasis on human involvement.

In the present study we didn’t examine the government regulations that supports blockchain technology adoption. So, the future studies will be required to conduct a comparative study between the states where the government rules and regulation support the disruptive technology adoption and the states where the government regulation is skeptical. The outcome of these analyses will be interesting.

In conclusion, this study has provided an overview of potential factors for consideration from a holistic view via the three traditional adoption theories framework. In response to RQ1, perceived ease of use, perceived usefulness, attitude and perceived behavioral control shows a significant relationship with the intention to adopt blockchain technology. However, Optimism and Insecurity shows insignificant influence during disruptive technology adoption. On the other hand, Innovativeness and discomfort shows a significant impact on perceived ease of use while insignificant influence on perceived usefulness. Consequently, subjective norms show significant impact on perceived usefulness while insignificant influence on intention to use blockchain technology. Pertaining to RQ2, perceived ease of use matters most in adoption of distributed ledger technology. While the present study may not be comprehensive, in future some other important factors like compatibility, complexity, relative advantage, observability and trialability have to be tested for Pakistan- service and manufacturing operations. Hence, this study may offer a reference to academics as well as experts. For
blockchain technology implementing experts, the research offers valuable insights for developing disruptive technology solutions, it allow organizations to get the customer information quickly and thereby contribute to the competitive advantage of their businesses.

**Disclosure statement**

No potential conflict of interest was reported by the author(s).

**ORCID**

Nazir Ullah [http://orcid.org/0000-0002-0230-0635](http://orcid.org/0000-0002-0230-0635)

Waleed Mugahed Al-rahmi [http://orcid.org/0000-0002-0980-7439](http://orcid.org/0000-0002-0980-7439)

Ali Alkhalifah [http://orcid.org/0000-0001-5581-5336](http://orcid.org/0000-0001-5581-5336)

**References**

Abeyratne, S. A. (2016a). Blockchain ready manufacturing supply chain using distributed ledger. *International Journal of Research in Engineering and Technology, 5*(9), 1–10. [https://doi.org/10.15623/ijret.2016.0509001](https://doi.org/10.15623/ijret.2016.0509001)

Abeyratne, S. A., & Monfared, R. P. (2016b). Blockchain ready manufacturing supply chain using distributed ledger.

Agarwal, R., & Prasad, J. (1998). The antecedents and consequents of user perceptions in information technology adoption. *Decision Support Systems, 22*(1), 15–29. [https://doi.org/10.1016/S0167-9236(97)00006-7](https://doi.org/10.1016/S0167-9236(97)00006-7)

Ajzen, I. (1985). From intentions to actions: A theory of planned behavior. In *Action control* (pp. 11–39). Springer.

Ajzen, I. (1987). Attitudes, traits, and actions: Dispositional prediction of behavior in personality and social psychology. In *Advances in experimental social psychology* (Vol. 20, pp. 1–63). Elsevier.

Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior and Human Decision Processes, 50*(2), 179–211. [https://doi.org/10.1016/0749-5978(91)90020-T](https://doi.org/10.1016/0749-5978(91)90020-T)

Ajzen, I., & Fishbein, M. (2005). Handbook of attitudes. In D. Albarracín, B. T. Johnson, & M. P. Zanna (Eds.), *Erlbaum*.

Alalwan, A. A., Dwivedi, Y. K., Rana, N. P., & Williams, M. D. (2016). Consumer adoption of mobile banking in Jordan: Examining the role of usefulness, ease of use, perceived risk and self-efficacy. *Journal of Enterprise Information Management, 29*(1), 118–139. [https://doi.org/10.1108/JEIM-04-2015-0035](https://doi.org/10.1108/JEIM-04-2015-0035)

Allen, I. E., & Seaman, C. A. (2007). Likert scales and data analyses. *Quality Progress, 40*(7), 64–65.

Amoako-Gyampah, K., & Salam, A. F. (2004). An extension of the technology acceptance model in an ERP implementation environment. *Information & Management, 41*(6), 731–745. [https://doi.org/10.1016/j.im.2003.08.010](https://doi.org/10.1016/j.im.2003.08.010)

Apte, S., & Petrovsky, N. (2016). Will blockchain technology revolutionize excipient supply chain management? *Journal of Excipients and Food Chemicals, 7*(3), 910.

Awa, H. O., Ojiabo, O. U., & Emecheta, B. C. (2015). Integrating TAM, TPB and TOE frameworks and expanding their characteristic constructs for e-commerce adoption by SMEs. *Journal of Science & Technology Policy Management, 6*(1), 76–94. [https://doi.org/10.1108/JSTPM-04-2014-0012](https://doi.org/10.1108/JSTPM-04-2014-0012)
Babatunde, O., Oguntunde, P., Ogunmola, A., & Balogun, O. (2014). On the performance of RESET and Durbin Watson tests in detecting specification error. Copyright© 2014 by Modern Scientific Press Company, Florida, USA International Journal of Modern Mathematical Sciences, 11(3), 144–151.

Babich, V., & Hilary, G. (2020). OM Forum—Distributed ledgers and operations: What operations management researchers should know about blockchain technology. Manufacturing & Service Operations Management, 22(2), 223–240. https://doi.org/10.1287/msom.2018.0752

Bai, C., & Sarkis, J. (2020). A supply chain transparency and sustainability technology appraisal model for blockchain technology. International Journal of Production Research, 58(7), 2142–2162. https://doi.org/10.1080/00207543.2019.1708989

Baker, E. W., Al-Gahtani, S. S., & Hubona, G. S. (2007). The effects of gender and age on new technology implementation in a developing country. In Information Technology & People.

Bollen, K. A. (1989). Structural equations with latent variables Wiley. In New York.

Bröhl, C., Nelles, J., Brandli, C., Mertens, A., & Schlick, C. M. (2016). TAM reloaded: A technology acceptance model for human-robot cooperation in production systems. Paper presented at the International conference on human-computer interaction.

Cachin, C. (2016). Architecture of the hyperledger blockchain fabric. Paper presented at the Workshop on distributed cryptocurrencies and consensus ledgers.

Cai, Y., & Zhu, D. (2016). Fraud detections for online businesses: A perspective from blockchain technology. Financial Innovation, 2(1), 20. https://doi.org/10.1186/s40854-016-0039-4

Calisir, F., Altin Gumsusoy, C., & Bayram, A. (2009). Predicting the behavioral intention to use enterprise resource planning systems: An exploratory extension of the technology acceptance model. Management Research News, 32(7), 597–613. https://doi.org/10.1108/01409170910965215

Carr, J. V. (1999). Technology adoption and diffusion. In The Learning Center for Interactive Technology.

Carter, L., & Bélanger, F. (2005). The utilization of e-government services: Citizen trust, innovation and acceptance factors. Information Systems Journal, 15(1), 5–25. https://doi.org/10.1111/j.1365-2575.2005.00183.x

Chai, L., & Pavlou, P. A. (2004). From “ancient” to “modern”: A cross-cultural investigation of electronic commerce adoption in Greece and the United States. Journal of Enterprise Information Management, 17(6), 416–423. https://doi.org/10.1108/17410390410566706

Chang, Y., Iakovou, E., & Shi, W. (2020). Blockchain in global supply chains and cross border trade: A critical synthesis of the state-of-the-art, challenges and opportunities. International Journal of Production Research, 58(7), 2082–2099. https://doi.org/10.1080/00207543.2019.1651946

Chen, S., & Chen, H. (2008). The influence of technology readiness on the theory of planned behavior with self-service technologies. Paper presented at the Proceedings of WMSCI. The 12th World Multi-Conference on Systemics, Cybernetics and Informatics.

Chin, W. W. (1998). The partial least squares approach to structural equation modeling. Modern Methods for Business Research, 295(2), 295–336.

Choi, T.-M., Feng, L., & Li, R. (2020). Information disclosure structure in supply chains with rental service platforms in the blockchain technology era. International Journal of Production Economics, 221, 107473. https://doi.org/10.1016/j.ijpe.2019.08.008

Choi, T.-M., Liu, S.-C., Pang, K.-M., & Chow, P.-S. (2008). Shopping behaviors of individual tourists from the Chinese Mainland to Hong Kong. Tourism Management, 29(4), 811–820. https://doi.org/10.1016/j.tourman.2007.07.009

Cho, S. H.-W., Marimuthu, M., Kandampully, J., & Bilgihan, A. (2017). What drives Gen Y loyalty? Understanding the mediated moderating roles of switching costs and alternative attractiveness in the value-satisfaction-loyalty chain. Journal of Retailing and Consumer Services, 36, 124–136. https://doi.org/10.1016/j.jretconserv.2017.01.010

Clohessy, T., Acton, T., & Rogers, N. (2019). Blockchain adoption: Technological, organisational and environmental considerations. In Business transformation through blockchain (pp. 47–76). Springer.
Cohn, J. M., Finn, P. G., Nair, S. P., Panikkar, S. B., & Pureswaran, V. S. (2017). Autonomous decentralized peer-to-peer telemetry. Google Patents.

Croasmun, J. T., & Ostrom, L. (2011). Using likert-type scales in the social sciences. Journal of Adult Education, 40(1), 19–22.

Davidson, S., De Filippi, P., & Potts, J. 2016. Economics of blockchain. SSRN: Available at 2744751.

Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. In MIS quarterly (pp. 319–340).

Davis, F. D., Bagozzi, R. P., & Warshaw, P. R. (1989). User acceptance of computer technology: A comparison of two theoretical models. Management Science, 35(8), 982–1003. https://doi.org/10.1287/mnsc.35.8.982

Dobrovnik, M., Herold, D. M., Fürst, E., & Kummer, S. (2018). Blockchain for and in logistics: What to adopt and where to start. Logistics, 2(3), 18. https://doi.org/10.3390/logistics2030018

Du, M., Chen, Q., Xiao, J., Yang, H., & Ma, X. (2020). Supply chain finance innovation using blockchain. IEEE Transactions on Engineering Management, 67(4), 1045–1058. https://doi.org/10.1109/TEM.2020.2971858

Faroq, S., & O’Brien, C. (2012). A technology selection framework for integrating manufacturing within a supply chain. International Journal of Production Research, 50(11), 2987–3010. https://doi.org/10.1080/00207543.2011.588265

Folkinshteyn, D., & Lennon, M. (2016). Braving Bitcoin: A technology acceptance model (TAM) analysis. Journal of Information Technology Case and Application Research, 18(4), 220–249. https://doi.org/10.1080/15228053.2016.1275242

Fornell, C., & Larcker, D. F. (1981). Structural equation models with unobservable variables and measurement error: Algebra and statistics. SAGE Publications Sage CA.

Fosso Wamba, S., Kala Kamdjoug, J. R., Bawack, R., & Keogh, J. G. (2018). Bitcoin, Blockchain, and FinTech: A systematic review and case studies in the supply chain. In Production Planning and Control, Forthcoming.

Francisco, K., & Swanson, D. (2018). The supply chain has no clothes: Technology adoption of blockchain for supply chain transparency. Logistics, 2(1), 2. https://doi.org/10.3390/logistics2010002

Gamal Abouelmaged, M. (2010). Predicting e-procurement adoption in a developing country: An empirical integration of technology acceptance model and theory of planned behaviour. Industrial Management & Data Systems, 110(3), 392–414. https://doi.org/10.1108/02635571011030042

Gao, L., & Bai, X. (2014). A unified perspective on the factors influencing consumer acceptance of internet of things technology. Asia Pacific Journal of Marketing and Logistics, 26(2), 211–231. https://doi.org/10.1108/APJML-06-2013-0061

Gefen, D., Karahanna, E., & Straub, D. W. (2003a). Inexperience and experience with online stores: The importance of TAM and trust. IEEE Transactions on Engineering Management, 50(3), 307–321. https://doi.org/10.1109/TEM.2003.817277

Gefen, D., Karahanna, E., & Straub, D. W. (2003b). Trust and TAM in online shopping: An integrated model. MIS Quarterly, 27(1), 51–90. https://doi.org/10.2307/30036519

George, J. F. (2004). The theory of planned behavior and internet purchasing. In Internet research.

Godoe, P., & Johansen, T. (2012). Understanding adoption of new technologies: Technology readiness and technology acceptance as an integrated concept. Journal of European Psychology Students, 3, 1.

Guide, J. V. D. R., & Ketokivi, M. (2015). Notes from the editors: Redefining some methodological criteria for the journal*. Journal of Operations Management, 37(1), v–viii. https://doi.org/10.1016/S0272-6963(15)00056-X

Gumussoy, C., Calisir, F., & Bayram, A. (2007). Understanding the behavioral intention to use ERP systems: An extended technology acceptance model. Paper presented at the 2007 IEEE International Conference on Industrial Engineering and Engineering Management.

Guriting, P., & Ndubisi, N. O. (2006). Borneo online banking: Evaluating customer perceptions and behavioural intention. In Management research news.
Hair, J. F., Ringle, C. M., & Sarstedt, M. (2011). PLS-SEM: Indeed a silver bullet. *Journal of Marketing Theory and Practice, 19*(2), 139–152. https://doi.org/10.2753/MTP1069-6679190202

Hair, J. J., Hult, F., Ringle, C., G. T. M., & Sarstedt, M. (2016). A primer on partial least squares structural equation modeling (PLS-SEM). Sage publications.

Hofmann, E., Streeve, U. M., & Bosia, N. (2017). Supply chain finance and blockchain technology: The case of reverse securitisation. Springer.

Howell, D. W. (2016). *Social media site use and the technology acceptance model: Social media sites and organization success*. Capella University.

Hwang, H., Malhotra, N. K., Kim, Y., Tomiuk, M. A., & Hong, S. (2010). A comparative study on parameter recovery of three approaches to structural equation modeling. *Journal of Marketing Research, 47*(4), 699–712. https://doi.org/10.1509/jmkr.47.4.699

Imran, A., & Gregor, S. (2007). A comparative analysis of strategies for egovernment in developing countries. *Journal of Business Systems, Governance and Ethics, 2*(3), 89–99. https://doi.org/10.15209/jbsge.v2i3.112

Issa, I., & Hamm, U. (2017). Adoption of organic farming as an opportunity for Syrian farmers of fresh fruit and vegetables: An application of the theory of planned behaviour and structural equation modelling. *Sustainability, 9*(11), 2024. https://doi.org/10.3390/su9112024

Ivanov, D., Dolgui, A., & Sokolov, B. (2019). The impact of digital technology and Industry 4.0 on the ripple effect and supply chain risk analytics. *International Journal of Production Research, 57*(3), 829–846. https://doi.org/10.1080/00207543.2018.1488086

J Battistini, D. (2016). Using Blockchain Technology to Facilitate Anti-Money Laundering Efforts. Jeschke, S., Brecher, C., Meisen, T., Ozdemir, D., & Eschert, T. (2017). Industrial internet of things and cyber manufacturing systems. In *Industrial Internet of Things* (pp. 3–19). Springer.

Kamble, S., Gunasekaran, A., & Arba, H. (2019). Understanding the Blockchain technology adoption in supply chains-Indian context. *International Journal of Production Research, 57*(7), 2009–2033. https://doi.org/10.1080/00207543.2018.1518610

Karamchandani, A., Srivastava, S. K., & Srivastava, R. K. (2019). Perception-based model for analyzing the impact of enterprise blockchain adoption on SCM in the Indian service industry. *International Journal of Information Management, 102019.*

Kennedy, Z. C., Stephenson, D. E., Christ, J. F., Pope, T. R., Arey, B. W., Barrett, C. A., & Warner, M. G. (2017). Enhanced anti-counterfeiting measures for additive manufacturing: Coupling lanthanide nanomaterial chemical signatures with blockchain technology. *Journal of Materials Chemistry C, 5*(37), 9570–9578. https://doi.org/10.1039/C7TC03348F

Kim, H. M., & Laskowski, M. (2018). Toward an ontology-driven blockchain design for supply-chain provenance. *Intelligent Systems in Accounting, Finance and Management, 25*(1), 18–27. https://doi.org/10.1002/isaf.1424

Kleijnen, M., Wetzels, M., & De Ruyter, K. (2004). Consumer acceptance of wireless finance. *Journal of Financial Services Marketing, 8*(3), 206–217. https://doi.org/10.1057/palgrave.fsm.4770120

Korpela, K., Hallikas, J., & Dahlberg, T. (2017). Digital supply chain transformation toward blockchain integration. Paper presented at the proceedings of the 50th Hawaii international conference on system sciences.

Koteska, B., Karafiloski, E., & Mishev, A. (2017). Blockchain implementation quality challenges: A literature. Paper presented at the SQAMIA 2017: 6th Workshop of Software Quality, Analysis, Monitoring, Improvement, and Applications.

Kshetri, N. (2018). 1 Blockchain’s roles in meeting key supply chain management objectives. *International Journal of Information Management, 39*, 80–89. https://doi.org/10.1016/j.ijinfomgt.2017.12.005

Kumar, A., Liu, R., & Shan, Z. (2020). Is blockchain a silver bullet for supply chain management? technical challenges and research opportunities. *Decision Sciences, 51*(1), 8–37. https://doi.org/10.1111/dsci.12396

Kumpajaya, A., & Dhewanto, W. (2015). The acceptance of bitcoin in Indonesia: Extending TAM with IDT. *Journal of Business and Management, 4*(1), 28–38.
Kuo, K.-M., Liu, C.-F., & Ma, C.-C. (2013). An investigation of the effect of nurses’ technology readiness on the acceptance of mobile electronic medical record systems. *BMC Medical Informatics and Decision Making, 13*(1), 88. https://doi.org/10.1186/1472-6947-13-88

Lee, M. S. (2009). An empirical study about RFID acceptance—focus on the employees in Korea. *International Journal of Human and Social Sciences, 4*(14), 997–1006.

Lee, Y., Lee, J., & Lee, Z. (2006). Social influence on technology acceptance behavior: Self-identity theory perspective. *ACM SIGMIS DATABASE: The DATABASE for Advances in Information Systems, 37*(2–3), 60–75. https://doi.org/10.1145/1161345.1161355

Lou, A. T., & Li, E. Y. (2017). Integrating innovation diffusion theory and the technology acceptance model: The adoption of blockchain technology from business managers’ perspective. Paper presented at the International Conference on Electronic Business.

Lowry, P. B., & Gaskin, J. (2014). Partial least squares (PLS) structural equation modeling (SEM) for building and testing behavioral causal theory: When to choose it and how to use it. *IEEE Transactions on Professional Communication, 57*(2), 123–146. https://doi.org/10.1109/TPC.2014.2312452

Ma, J., Hipel, K. W., Hanson, M. L., Cai, X., & Liu, Y. (2018). An analysis of influencing factors on municipal solid waste source-separated collection behavior in Guilin, China by using the theory of planned behavior. *Sustainable Cities and Society, 37*, 336–343. https://doi.org/10.1016/j.scs.2017.11.037

Madden, T. J., Ellen, P. S., & Ajzen, I. (1992). A comparison of the theory of planned behavior and the theory of reasoned action. *Personality and Social Psychology Bulletin, 18*(1), 3–9. https://doi.org/10.1177/0146167292181001

Malik, S., Dedeoglu, V., Kanhere, S. S., & Jurdak, R. (2019). TrustChain: Trust management in blockchain and IoT supported Supply Chains. Paper presented at the 2019 IEEE International Conference on Blockchain (Blockchain).

Michel, R. (2017). The evolution of the digital supply chain. In *Logistics management* (Highlands Ranch, Colo.: 2002).

Mohamed, N., & Al-Jaroodi, J. (2019). Applying blockchain in industry 4.0 applications. Paper presented at the 2019 IEEE 9th Annual Computing and Communication Workshop and Conference (CCWC).

Moons, I., & De Pelsmacker, P. (2015). An extended decomposed theory of planned behaviour to predict the usage intention of the electric car: A multi-group comparison. *Sustainability, 7*(5), 6212–6245. https://doi.org/10.3390/su7056212

Mthethwa, S. (2016). The analysis of the blockchain technology and challenges hampering its adoption. *World Academy of Science, Engineering and Technology, International Science Index, Computer and Information Engineering, 10*(12), 1937–1948.

Nakasumi, M. (2017). Information sharing for supply chain management based on block chain technology. Paper presented at the 2017 IEEE 19th Conference on Business Informatics (CBI).

Omran, Y., Henke, M., Heines, R., & Hofmann, E. (2017). Blockchain-driven supply chain finance: Towards a conceptual framework from a buyer perspective.

Oye, N., Iahad, A., & Rahim, N. A. (2012). Acceptance and usage of ICT by university academicians using UTAUT model: A case study of university of Port Harcourt Nigeria. *Journal of Emerging Trends in Computing and Information Sciences, 3*(1), 81–89.

Parasuraman, A. (2000). Technology Readiness Index (TRI) a multiple-item scale to measure readiness to embrace new technologies. *Journal of Service Research, 2*(4), 307–320. https://doi.org/10.1177/109467050024001

Parasuraman, A., & Colby, C. L. (2007). *Techno-ready marketing*: How and why your customers adopt technology: The Free Press.

Parasuraman, A., & Colby, C. L. (2015). An updated and streamlined technology readiness index: TRI 2.0. *Journal of Service Research, 18*(1), 59–74. https://doi.org/10.1177/1094670514539730
Pattansheti, M., Kamble, S. S., Dhume, S. M., & Raut, R. D. (2016). Development, measurement and validation of an integrated technology readiness acceptance and planned behaviour model for Indian mobile banking industry. International Journal of Business Information Systems, 22 (3), 316–342.

Pereira, J. V. (2009). The new supply chain’s frontier: Information management. International Journal of Information Management, 29(5), 372–379. https://doi.org/10.1016/j.ijinfomgt.2009.02.001

Pires, P. J., da Costa Filho, B. A., & da Cunha, J. C. (2011). Technology readiness index (TRI) factors as differentiating elements between users and non users of internet banking, and as antecedents of the technology acceptance model (TAM). Paper presented at the International Conference on ENTERprise Information Systems.

Qu, Y., Ming, X., Liu, Z., Zhang, X., & Hou, Z. (2019). Smart manufacturing systems: State of the art and future trends. The International Journal of Advanced Manufacturing Technology, 103(9–12), 3751–3768. https://doi.org/10.1007/s00170-019-03754-7

Queiroz, M. M., Telles, R., & Bonilla, S. H. (2019). Blockchain and supply chain management integration: A systematic review of the literature. Supply Chain Management: An International Journal, 25(2), 241–254. https://doi.org/10.1108/SCM-03-2018-0143

Queiroz, M. M., & Wamba, S. F. (2019). Blockchain adoption challenges in supply chain: An empirical investigation of the main drivers in India and the USA. International Journal of Information Management, 46, 70–82. https://doi.org/10.1016/j.ijinfomgt.2018.11.021

Rajan, C. A., & Baral, R. (2015). Adoption of ERP system: An empirical study of factors influencing the usage of ERP and its impact on end user. IIMB Management Review, 27(2), 105–117. https://doi.org/10.1016/j.iimb.2015.04.008

Rehouma, M. B., & Hofmann, S. (2018). Government employees’ adoption of information technology: A literature review. Paper presented at the Proceedings of the 19th Annual International Conference on Digital Government Research: Governance in the Data Age.

Rogers, E. M. (1995). Diffusion of Innovations: Modifications of a model for telecommunications. In Die diffusion von innovationen in der telekommunikation (pp. 25–38). Springer.

Sadouskaya, K. (2017). Adoption of blockchain technology in supply chain and logistics.

Safa, N. S., Sookhak, M., Von Solms, R., Furnell, S., Ghani, N. A., & Herawan, T. (2015). Information security conscious care behaviour formation in organizations. Computers & Security, 53, 65–78. https://doi.org/10.1016/j.cose.2015.05.012

Samaniego, M., & Deters, R. (2016). Blockchain as a Service for IoT. Paper presented at the 2016 IEEE International Conference on Internet of Things (iThings) and IEEE Green Computing and Communications (GreenCom) and IEEE Cyber, Physical and Social Computing (CPSCom) and IEEE Smart Data (SmartData).

Samaradiwakara, G., & Gunawardena, C. (2014). Comparison of existing technology acceptance theories and models to suggest a well improved theory/model. International Technical Sciences Journal, 1(1), 21–36.

Sanders, M., Lewis, P., & Thornhill, A. (2009). Research Methods for Business Students. Prentice Hall.

Schumpeter, J. A. (1939). Business cycles (Vol. 1). McGraw-Hill New York.

Sentosa, I., & Mat, N. K. N. (2012). Examining a theory of planned behavior (TPB) and technology acceptance model (TAM) in internet purchasing using structural equation modeling. Researchers World, 3(2 Part 2), 62.

Shah, R., & Goldstein, S. M. (2006). Use of structural equation modeling in operations management research: Looking back and forward. Journal of Operations Management, 24(2), 148–169. https://doi.org/10.1016/j.jom.2005.05.001

Sharma, R., & Mishra, R. (2014). A review of evolution of theories and models of technology adoption. Indore Management Journal, 6(2), 17–29.

Shih, B.-Y., Chen, C.-Y., & Chen, C.-L. (2012). An enhanced acceptance model for exploring user intention towards virtual reality environment: Partial least squares (PLS) statistical method. International Journal of Physical Sciences, 7(5), 776–786.
Shirahada, K., Ho, B. Q., & Wilson, A. (2019). Online public services usage and the elderly: Assessing determinants of technology readiness in Japan and the UK. Technology in Society, 58, 101115. https://doi.org/10.1016/j.techsoc.2019.02.001

Spenkelink, H. (2014). The adoption process of cryptocurrencies: Identifying factors that influence the adoption of cryptocurrencies from a multiple stakeholder perspective. University of Twente.

Sternad, S., & Bobek, S. (2013). Impacts of TAM-based external factors on ERP acceptance. Procedia Technology, 9, 33–42. https://doi.org/10.1016/j.proct.2013.12.004

Sun, S., Cegielski, C. G., Jia, L., & Hall, D. J. (2018). Understanding the factors affecting the organizational adoption of big data. Journal of Computer Information Systems, 58(3), 193–203. https://doi.org/10.1080/08874417.2016.1222891

Tan, G. W.-H., Lee, V.-H., Hew, -J.-J., Ooi, K.-B., & Wong, L.-W. (2018). The interactive mobile social media advertising: An imminent approach to advertise tourism products and services? Telematics and Informatics, 35(8), 2270–2288. https://doi.org/10.1016/j.tele.2018.09.005

Taylor, S., & Todd, P. A. (1995). Understanding information technology usage: A test of competing models. Information Systems Research, 6(2), 144–176. https://doi.org/10.1287/isre.6.2.144

Thompson, R. L., Higgins, C. A., & Howell, J. M. (1991). Personal computing: Toward a conceptual model of utilization. In MIS quarterly (pp. 125–143).

Tian, F. (2017). A supply chain traceability system for food safety based on HACCP, blockchain & Internet of things. Paper presented at the 2017 International Conference on Service Systems and Service Management.

Toyoda, K., Mathiopoulou, P. T., Sasase, I., & Ohtsuki, T. (2017). A novel blockchain-based product ownership management system (POMS) for anti-counterfeits in the post supply chain. IEEE Access, 5, 17465–17477. https://doi.org/10.1109/ACCESS.2017.2720760

Tsikritktsis, N. (2004). A technology readiness-based taxonomy of customers: A replication and extension. Journal of Service Research, 7(1), 42–52. https://doi.org/10.1177/1094670504266132

Venkatesh, V., & Davis, F. D. (2000). A theoretical extension of the technology acceptance model: Four longitudinal field studies. Management Science, 46(2), 186–204. https://doi.org/10.1287/mnsc.46.2.186.11926

Venkatesh, V., Morris, M. G., Davis, G. B., & Davis, F. D. (2003). User acceptance of information technology: Toward a unified view. In MIS quarterly (pp. 425–478).

Venkatesh, V., Thong, J. Y., & Xu, X. (2012). Consumer acceptance and use of information technology: Extending the unified theory of acceptance and use of technology. MIS Quarterly, 36(1), 157–178. https://doi.org/10.2307/41410412

Viriyasitavat, W., Da Xu, L., Bi, Z., & Sapsomboon, A. (2018). Blockchain-based business process management (BPM) framework for service composition in industry 4.0. Journal of Intelligent Manufacturing, 1–12.

Walczuch, R., Lemmink, J., & Streurkens, S. (2007). The effect of service employees’ technology readiness on technology acceptance. Information & Management, 44(2), 206–215. https://doi.org/10.1016/j.im.2006.12.005

Wamba, S. F., Queiroz, M. M., & Trincherla, L. (2020). Dynamics between blockchain adoption determinants and supply chain performance: An empirical investigation. International Journal of Production Economics, 229, 107791. https://doi.org/10.1016/j.ijpe.2020.107791

Wang, S., Ouyang, L., Yuan, Y., Ni, X., Han, X., & Wang, F.-Y. (2019). Blockchain-enabled smart contracts: Architecture, applications, and future trends. IEEE Transactions on Systems, Man, and Cybernetics: Systems, 49(11), 2266–2277. https://doi.org/10.1109/TSMC.2019.2895123

Wang, Y. S., Wang, Y. M., Lin, H. H., & Tang, T. I. (2003). Determinants of user acceptance of Internet banking: An empirical study. International Journal of Service Industry Management, 14 (5), 501–519. https://doi.org/10.1108/09564230310500192

Willis, G., Genchev, S. E., & Chen, H. (2016). Supply chain learning, integration, and flexibility performance: An empirical study in India. The International Journal of Logistics Management, 27(3), 755–769. https://doi.org/10.1108/IJLM-03-2014-0042
Wipro. (2017). Wipro joins hyperledger to catalyze collaboration on enterprise-grade blockchain solutions. https://www.wipro.com/newsroom/press-releases/2017/wipro-joins-hyperledger-to-catalyze-collaboration-on-enterprise-grade-blockchain-solutions/

Wolf, E. J., Harrington, K. M., Clark, S. L., & Miller, M. W. (2013). Sample size requirements for structural equation models: An evaluation of power, bias, and solution propriety. *Educational and Psychological Measurement, 73*(6), 913–934. https://doi.org/10.1177/0013164413495237

Wong, C.-H., Tan, G. W.-H., Tan, B.-I., & Ooi, K.-B. (2015). Mobile advertising: The changing landscape of the advertising industry. *Telematics and Informatics, 32*(4), 720–734. https://doi.org/10.1016/j.chb.2014.12.022

Wu, J.-H., Wang, S.-C., & Lin, L.-M. (2007). Mobile computing acceptance factors in the healthcare industry: A structural equation model. *International Journal of Medical Informatics, 76*(1), 66–77. https://doi.org/10.1016/j.ijmedinf.2006.06.006

Xie, Q., Song, W., Peng, X., & Shabbir, M. (2017a). Predictors for e-government adoption: Integrating TAM, TPB, trust and perceived risk. *The Electronic Library, 35*(1), 2–20. https://doi.org/10.1108/EL-08-2015-0141

Xie, Q., Song, W., Peng, X., & Shabbir, M. (2017b). Predictors for e-government adoption: Integrating TAM, TPB, trust and perceived risk. In *The Electronic Library.*

Xu, L. D., Xu, E. L., & Li, L. (2018). Industry 4.0: State of the art and future trends. *International Journal of Production Research, 56*(8), 2941–2962. https://doi.org/10.1080/00207543.2018.1444806

Xu, R., Zhang, L., Zhao, H., & Peng, Y. (2017). Design of network media’s digital rights management scheme based on blockchain technology. Paper presented at the 2017 IEEE 13th International Symposium on Autonomous Decentralized System (ISADS).

Yang, H.-D., & Yoo, Y. (2004). It’s all about attitude: Revisiting the technology acceptance model. *Decision Support Systems, 38*(1), 19–31. https://doi.org/10.1016/S0167-9236(03)00062-9

Yang, Z., Sun, J., Zhang, Y., & Wang, Y. (2015). Understanding SaaS adoption from the perspective of organizational users: A tripod readiness model. *Computers in Human Behavior, 45*, 254–264. https://doi.org/10.1016/j.chb.2014.12.022

Yi, Y., Tung, L. L., & Wu, Z. (2003). Incorporating technology readiness (TR) into TAM: Are individual traits important to understand technology acceptance? *DIGIT 2003 proceedings, 2.*

Ying, W., Jia, S., & Du, W. (2018). Digital enablement of blockchain: Evidence from HNA group. *International Journal of Information Management, 39*, 1–4. https://doi.org/10.1016/j.ijinfomgt.2017.10.004

Yoon, J., Talluri, S., Yildiz, H., & Sheu, C. (2020). The value of Blockchain technology implementation in international trades under demand volatility risk. *International Journal of Production Research, 58*(7), 2163–2183. https://doi.org/10.1080/00207543.2019.1693651

Yuan, Y., & Wang, F.-Y. (2016). Towards blockchain-based intelligent transportation systems. Paper presented at the 2016 IEEE 19th International Conference on Intelligent Transportation Systems (ITSC).

Zyskind, G., & Nathan, O. (2015). Decentralizing privacy: Using blockchain to protect personal data. Paper presented at the 2015 IEEE Security and Privacy Workshops.