Blockchain Acceptance Models

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Blockchain is a promising breakthrough technology that is highly applicable in manifold sectors. The adoption of blockchain technology is accompanied by a range of issues and challenges that make its implementation complicated. To facilitate the successful implementation of blockchain technology, several blockchain adoption frameworks have been developed. However, selecting the appropriate framework based on the conformity of its features with the business sector may be challenging for decision-makers.

Keywords: Blockchain ; Adoption ; Technolocy Acceptance ; Blockchain Acceptance ; Adoption Models ; Blockchain Technology

1. Introduction

Blockchain (BC) was initially introduced in 2008 by Nakamoto, and it is currently the focus area of many businesses because of its role in the transformation of operational processes. According to the main characteristics of blockchain technology including traceability, transparency, smart contracts, and security, this technology is not only used for its main application as a cryptocurrency but is also applicable in manifold areas such as government elections, healthcare, logistics, identity management, supply chain, etc. [1].

Each block in the structure of the blockchain is made of a new set of transactions. All the transactions that have occurred in the network are recorded by the blockchain through applying a distributed database and the collaborated nodes among them. The blocks are performed by these nodes which are known as miners. Thus, the problems happening due to the trust of a centralized party can be addressed successfully using this system, and this technology can bring security to the transactions as it employs a distributed way that is not related to any trusted party. These features bring other qualities such as decentralization, trust, and immutability to blockchain technology [2].

The popularity of this technology has brought different frameworks and platforms of blockchain for more than a decade. These different infrastructures developed the application of blockchain by addressing manifold issues in different areas such as the Internet of Things (IoT), cryptocurrencies, and smart contracts. The main frameworks are shown in **Figure 1** and are discussed in the following sections.

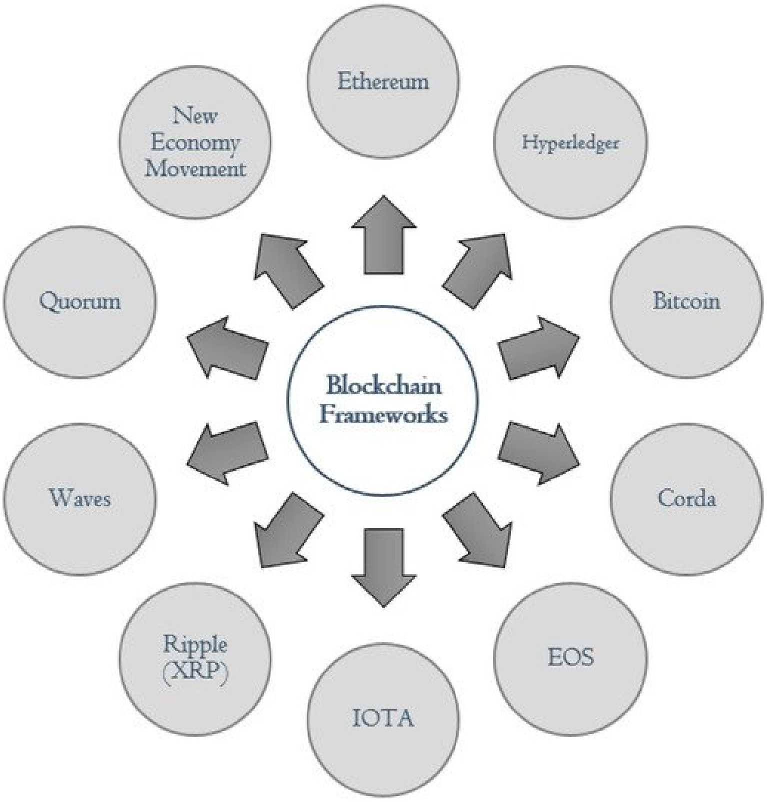

Figure 1. Blockchain frameworks.

Ethereum, as an open-source platform, provides the likelihood of developing decentralized services online, and on the decentralized applications (DApps) operating based on smart contracts. This platform includes four main components including Ethereum virtual machine (EVM), smart contracts, decentralized applications (DApps), and finally the parameters to examine the framework performance. Another platform supported by IBM and Linux Foundation is recognized as Hyperledger. This framework is applicable to advance cross-industry blockchain technologies. Additionally, Bitcoin, which is the most popular and the first internationally recognized cryptocurrency framework, was formed in 2009 [3][4]. Corda platform is another framework that was introduced for two main applications including legal contracts and data sharing between mutually trusting companies. This also brings the possibility of manifold applications based on the inter-operating on a single network [5].

EOS is also another blockchain framework that is applicable for the private and public sectors. This platform can address special business needs such as industry-leading speeds, secure application processing, and role-based security permissions [3]. The next framework is the IoT applications (IOTA) platform, which was introduced initially in 2016 for IoT applications as a new transaction settlement. Transactions can be performed through a new peer-to-peer method recognized as tangle by using this platform [6]. This system, unlike other platforms, does not possess the structure of the traditional blockchain. Ripple (XRP) platform is also another framework that was introduced formerly as OpenCoin Ripple, which is used for exchange and payment networks. The network (RippleNet) is on top of a ledger database known as XRP Ledger, which is a distributed database. This framework aims to provide a connection between banks, digital asset exchanges, and the providers of payments, which makes global payments cost-efficient and faster.

In addition to the discussed platforms, the Waves framework is a decentralized and open platform that provides to build applications through the employment of new cryptocurrencies. The noted unique quality of this blockchain platform can help application developers to build all applications created based on the blockchain using a software platform including several utilities and tools. Furthermore, the main issues of using distributed registry and small contracts applications in the financial sector were addressed by using the Quorum blockchain framework. This platform was introduced by JP Morgan to generate the volumes of institutional transactions. The restrictions to access the transaction history are possible using the Quorum framework with the system transparency. The final platform is known as the new economy movement (NEM or XEM) and was developed to obtain high speed and scalability. This private platform includes a proof-of-concept (POI) mechanism that is a revolutionary consensus system that can add a block to the blockchain and is utilized to assess the important network participants [3].

2. Acceptance Models

After developing and introducing new technologies, it is important to consider the adoption rate of the platform utilizing the users' acceptance to gain more development [7]. The acceptance rate helps decision-makers in the development step to consider the problems that users may face through applying technology. This factor is illustrated as an important antagonism to the term refusal, which also means the decision to apply a technology/innovation positively [8].

In other words, if it is possible for researchers to recognize whether people accept new specific technology or not as well as the reasons behind that; these can help them to acquire better results in the innovation process [9][10]. These studies, which are known as adoption or acceptance models, also encourage them to obtain better mechanisms to evaluate and predict the responses. These frameworks are used in a variety of fields such as education, supply chain, voting, transportation modes, computer users, and even blood donating [10][11]. Different frameworks have been developed to illustrate the users' adoption based on considering diverse factors in the models. The most common models are discussed in the following sections.

2.1. Theory of Reasoned Action (TRA)

Although first-time TRA was developed by Fishbein and Ajzen [12] for the studies on the psychological and sociological fields, nowadays, it is utilized to study the behavior of the people when they use IT. Three main components that are used in this model are as the following:

- Attitudes which include favorableness or favorableness of the feelings of individuals for an attitude;The behavior of the
- Social norms which are about people's social influence [11][13];individuals can be considered as systematic and volitional.
- Intentions including whether individuals decide to perform a behavior or this factor is influenced by the former ones [14][15].

In addition to these components, for testing and evaluating the TRA model, three boundary factors are defined including the stability of intention over time, volitional control, and the intention measurement considering context, target, time, specificity, and auction terms. Although this model also employs methods such as time horizon and generality to enhance the robustness between attitude and the corresponding intention, some terms are not addressed yet in this framework. For example, there is still a lack in the role of habit, the moral factors, and misunderstanding through a survey, the cognitive deliberation, and the issues due to the usage voluntariness for the validation process [11].

2.2. Theory of Planned Behavior (TPB)

This adoption framework was initially introduced by Ajzen [16] through developing the TRA. In this model, perceived behavioral control (PBC) is added to the traditional TRA factors. The perceived significance of the skills, opportunities, and resources as well as the availability of them are used to determine the PBC and gain the outcomes [14].

By using PBC, TPB is able to consider and compose the people's actions that are not under volitional control and realistic limitations as well as obtaining a self-efficacy type factor. However, in both TRA and TPB models, the people's behavior is influenced by the behavioral intention (BI) of individuals [11].

2.3. Technology Acceptance Model (TAM)

Derived from the TRA framework, this model was initially developed by Davis [17][18] to address the uncertain status of psychometric and theoretical in TRA through eliminating subjective norms. The TAM framework is one of the most widely cited adoption frameworks and includes the perceived ease of use and perceived usefulness as the main factors [7]. Although the impact of attitude toward technology use is another vital factor in applying the TAM framework (**Figure 2**), not only does TAM contain BI, but the impact of two vital beliefs (perceived ease of use and perceived usefulness) is also considered on the users' attitudes, which are examined as the favorableness and unfavourableness toward the system [11].

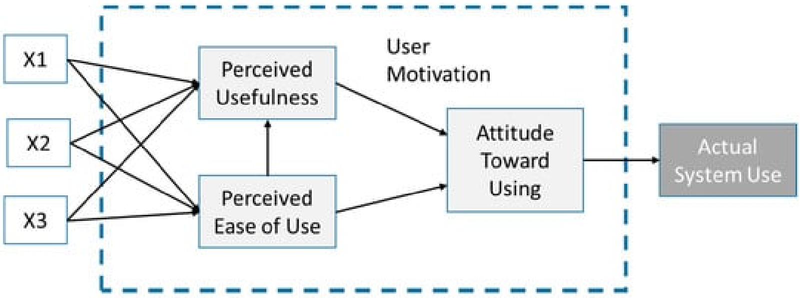

Figure 2. Original TAM [17].

In this model, the influence of perceived ease of use and perceived usefulness on the attitude and BI are direct and indirect, respectively, and the perceived ease of use impacts the perceived usefulness directly. This model also considers external variables such as system characteristics, user training, user participation in design, etc., as is shown in **Figure 2**.

2.4. Extension of TAM (ETAM)

Adding new factors to the traditional TAM and developing the extended models helps to address the limitations of the original model, which can improve the adoption models' capabilities. These factors are added to enhance the specificity as well as explanatory power of normal TAM. Thus, the predictive power of perceived usefulness and social influence can be improved by adding these factors [14]. There are two main studies on ETAM that are mentioned in the following:

The first one is known as TAM2 that is based on the antecedent of perceived usefulness and BI. There are two main constructs added to TAM including social influence (voluntariness, subject norms, and image), and cognitive (output quality, job relevance, and result demonstrability). These can help to enhance the predictive power of perceived usefulness [19][20].

The second one considers additional constructs impacting the perceived ease of use which are two main categories known as anchors and adjustments. The anchors are the general beliefs about the usage of computer systems, and the adjustments are the factors about the basis of direct experience of a given technology such as computer playfulness and computer anxiety [11][21]. Different researchers have provided different extended TAM models in their studies. One of these models used by [22] to study the adoption in the aviation industry is shown in **Figure 3**. The modified framework is also described in the next sections.

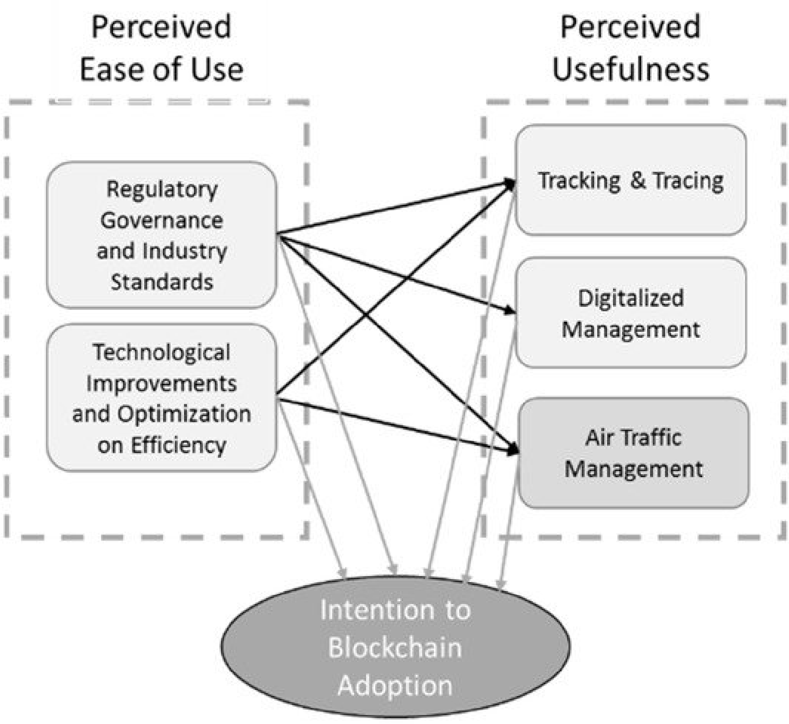

Figure 3. Extended TAM [22].

2.5. Diffusion of Innovation (DOI)

The diffusion of innovation includes different steps considering five important factors as effective variables in the acceptance of innovation in the characteristics of the innovation step, including compatibility, observability, complexity, trial ability, and relative advantage [14][23]. In the next step, known as the adopter characteristics step, the categories are considered as innovators, early adopters, late majority, early majority, and laggards. Finally, the innovation-decision step includes implementation, knowledge, persuasion, confirmation, and decision over time and through communication channels' set between the members of similar social systems [24]. This model also introduces four factors to determine a diverse range of innovations that can influence the extension of a new idea [25]. These factors are channels of communication, time, innovation, or social system.

The DOI framework can address the organizational, individual, and even global levels of adoption using a theoretical foundation. This acceptance model employs the integration of the main components including the innovation-decision process, characteristics of an innovation, and adopter characteristics. In addition, the DOI addresses the environmental factors, the characteristics of the system, and the organizational attributes. It is also less focused on the explanatory analysis. Therefore, this method has also demonstrated less power in the prediction of outcomes practically compared to the other acceptance frameworks [11].

2.6. Unified Theory of Acceptance and Use of Technology (UTAUT)

This framework was initially developed by Venkatesh [26] by using a combination of eight models including TRA, TPB, TAM, DOI, and extended TAM as well as the motivational model, social cognitive theory, and model of PC utilization. This model compares these frameworks to examine similarities and differences. Four constructs are derived as the result of this process as facilitating conditions, social influences, efforts, and performance expectancies. However, in addition to those constructs, age, gender, voluntariness of use, and experience were utilized as the moderating variables in this model [14].

2.7. Task Technology Fit Model (TTF)

This model examines whether the capabilities of new technology or innovation can cover the tasks that must be performed. This framework is based on eight vital constructs including systems reliability, ease of training/use, production timeliness, quality, authorization, compatibility, users' relationship, and capability [27][28].

2.8. Technology–Organization–Environment (TOE)

This model was initially described in the processes of technological innovation by Tornatzky and Fleischer [29]. This is about the whole innovation process ranging from the development by the entrepreneurs or engineers to its adoption by users. TOE, however, includes one section of this process about the impact of the firm context on the innovation implementation and its acceptance. This framework considers three main contexts (technological, environmental, and organizational) to explain how the elements of a firm impact the adoption decisions at an organizational level [30].

3. Blockchain Adoption in Supply Chain

Different studies were conducted on the adoption of BC in the supply chain. These studies used manifold acceptance frameworks such as TAM, UTAUT, TOE as well as the integration of the models, extended frameworks, and also new specific models that have been used in some studies.

Kamble et al. [31] has referred to an integrated model using the TAM, TRI, and TPB frameworks to study blockchain adoption in India. TAM constructs were used to investigate the perceptions of the end-users on the utility and ease of use, by considering perceived usefulness and perceived ease of use as the model's variables. Various variables were also considered including actual use, intention to use, behavioral attitudes, subjective norms, and perceived behavior control that stem from control factors of the observation in the TPB theory. Finally, the general beliefs of individuals about technology, including innovativeness ("the aptitudes towards being a leader in the technology area"), discomfort (stems from lack of control), insecurity (stems from the suspicion feeling about the incapability of the innovation), and optimism or positive view, are studied to gain the constructs of the TRI model

In addition, in the supply chain area, two different studies were extracted based on the employment of the UTAUT model for blockchain acceptance investigation. First, Queiroz and Wamba [32] developed their model using the information adopted from their provided literature study and TAM and used the information to gain an altered/extended UTAUT model. They explained performance expectancy as "the degree to which an individual believes that using the system will help him or her to attain gains in job performance”. They also considered other factors such as social influence to present “the degree to which an individual perceives that important other believe he or she should use the new system”, facilitating conditions which are “the degree to which an individual believes that an organizational and technical infrastructure exists to support the use of the system”. Blockchain transparency was also defined in their paper as “the models through which an organization communicates and reports its action to its relationships across the supply chain network, to support the visibility of the operations at all levels”. Trust among supply chain stakeholders was found as another construct of their model to identify “the willingness of a party to be vulnerable to the actions of another party based on the expectation that the other will perform a particular action important to the trustor, irrespective of the ability to monitor or control that other party”. The final variable was the behavioral intention (BI) which considers “the degree to which a person has formulated conscious plans to perform some specified future behavior”.

Additionally, Wong et al. [33] have listed some similar factors as the former paper as performance expectancy, facilitating condition, and trust. However, they also used effort expectancy as “the degree of ease associated with consumers’ use of technology”, technology readiness as “the people’s propensity to embrace and use new technologies for accomplishing goals in home life or at work”, technology affinity as “an individual’s propensity for active engagement or avoidance with technology to cope with technology; and is considered a personal resource to successfully cope with technology”, and finally, they considered regulatory support among the most important challenges in bitcoin adoption.

The TOE model, as another main framework, was applied in different articles to discuss blockchain acceptance in the supply chain. Kouhizadeh et al. [34] used a TOE framework to identify the adoption barriers together with force field theory to examine the importance of organizational change and transformation. In this research, two groups of people including academics and practitioners were under study. However, the TOE sub-categories can change in different studies. For example, in another study, TOE was integrated into TAM using a machine learning approach by Kamble et al. [35] to identify the significant factors of BC acceptance in the supply chain. The TAM factors were the perceived usefulness and perceived ease of use, and the TOE factors were as the follows:

- Technological constructs: perceived financial benefits, technical know-how, complexity, relative advantage, compatibility, and information security.
- Organizational constructs: training and education as well as top management support.Additionally, another example is a
- Environmental constructs: competitive pressure and partner readiness.framework based on the three general constructs of TOE conducted by Lanzini et al. [36]. They have listed their sub-categories as organizational including top management enthusiasm, people’s readiness, process readiness, technology readiness, and top management support; and technological constructs such as cost, governance, observability, perceived compatibility, perceived ease-of-use, perceived usefulness, privacy, and trial ability. Environmental factors were customers’ influence, competitive pressure, cooperation with information and communications technology (ICT) providers, government support, trading partners’ readiness, and regulatory status. This model was used to determine the most important construct. Kouhizadeh et al. [34] realized that the security challenges, the negative perception toward technology, and technology immaturity have demonstrated the most influence as the technological contexts. The significant organizational variables were listed as shortage of management commitment and support, knowledge, and expertise together with hesitation that may be faced in case of converting to new systems. Academics identified cultural differences of supply chain partners as the effective factor between the supply chain barriers. However, practitioners introduced the lack of customer awareness and tendency as an important factor. For external barriers, academics found a lack of industry involvement, external stakeholder involvement, and rewards and incentives as the most significant barriers. However, a lack of industry involvement, external stakeholder involvement, and government policies were listed as critical factors.

A TOE model was used by Suwanposri et al. [37] by introducing new constructs including (1) operational efficiency (technological), (2) suitable application (organizational), (3) supportive governmental regulations and policies (environmental), and (4) stakeholder cooperation (environmental). Data integrity and data security were other factors of the technological group. Organizational readiness, employee readiness, and top management support were used as the organizational ones. Finally, the network effect was considered as the environmental factor.

In addition to the main frameworks, some researchers prefer to focus on the new conceptual/theoretical frameworks in this field. A new conceptual model was used in 2020 to investigate adoption in the supply chain in India and USA. Wamba et al. [38] considered the trading partner relationship as a factor that is about a business relationship involving two or more organizations and customers. They also used knowledge sharing, transparency of the supply chain and blockchain, and supply chain performance variables in their model. According to their results, knowledge sharing and trading partner pressure are important factors in blockchain adoption.

Another modified framework was used by Aslam et al. [39]. Their framework was based on the relationship between the supply chain management (SCM) practices and blockchain features as well as the impact of SCM practices on operational performance. The blockchain factors were studied as different variables such as transparency, cyber-security, and reliability. The SCM practices were listed as the factors such as the close partnership with the supplier and the customer, and third-party logistics, subcontracting, and outsourcing. They also focused on operational performances such as reduced lead time and flexibility. The researchers identified the positive relationship between supply chain management and operational performance as the result.

Among new frameworks, some were conducted similar to the TOE frameworks with the main dimensions that were discussed before and based on the models with different main and sub-categories in their studies. For example, a decision-aid model was used by Karuppiah et al. [40] by considering 40 prominent variables under six main challenges in blockchain adoption including organizational, facial, technological, privacy and security, regulatory, and societal challenges. To hit this target, they investigated different sub-categories in six main groups of challenges. The organizational category included challenges such as a lack of knowledge about BC technology, blockchain framework development, new organizational policies, skilled workers, and management support. The second group as facial challenges considered the factors such as the high initial cost of implementation, the expensive cost for research and development, and the cost of resources. Technological aspects were variables such as low transaction scalability, high latency, high power requirement, immutability, difficulty in data integration, single point of failure, and also the quality of data. Privacy and security were considered as another challenge, covering challenges such as inefficient data security protocol, lack of privacy, vulnerability to cyber attacks, lack of trust, anonymity, loss of private key, double spending, and false data injection. Regulatory in this paper was also about factors such as lack of government support, and taxation issues. Finally, societal challenges include misconceptions about blockchain technology. The variables were weighted and ranked to obtain the most significant challenges. According to the weights, a lack of BC knowledge, non-existence of universal regulatory binding, and new organizational policies ranked as the first three top positions with 0.0283, 0.0276, and 0.0274 reported weights, respectively. The researchers also identified the cause and effect parameters.

Using integrated approaches was the main focus area of the study conducted in 2020 by Yadav et al. [41] based on an ISM-DEMATEL (decision-making trial and evaluation laboratory) approach for modeling the constructs and investigating adoption in the agricultural supply chain in India. A diverse range of barriers has been considered by applying the literature together with the experts' opinions. Some of the barriers included the complexity of blockchain-based system design, huge resource and initial capital requirement, security and privacy concerns, and agro-stakeholder resistance to blockchain culture. Finally, a lack of trust among agro-stakeholders and lack of government regulation were identified as the most significant factors. Sunmola et al. [42] have conducted a similar work by using the variables reached from systematic literature to study blockchain adoption in the digital transformation of the supply chain. Sahebi et al. [43] also examined the list of barriers including 14 factors based on the literature, as well as experts from different fields such as humanitarian experts, academics, and cryptocurrency experts. Then, they analyzed the factors using the integration of the best-worst method (BWM) to the fuzzy Delphi method and finalized the number of accepted variables to nine factors. Regulatory uncertainty, high sustainability costs, and lacking knowledge or the lack of employee training were identified as the most significant factors. Farooque et al. [44] also identified 13 barriers in four main categories in the adoption of blockchain-based life cycle assessment (LCA).

On the other hand, Saberi et al. [45] also classified the barriers of BC adoption in the supply chain into four main categories with the sub-categories. The developed model was based on the following elements:

- Intra-organizational barriers: identifying the internal activities of the company.
- Inter-organizational: stemming from relationships of the organizations and their network partners.
- System-related: stemming from the technology (BC) itself.
- External barriers: stemming from the outside of the organization by other influenced stakeholders such as legal entities, society, and the environment.

In this field, another comprehensive model was also conducted based on the integration of the information system success (ISS), TTF, and UTAUT by Alazab et al. [46]. Variables such as performance expectancy, facilitating conditions as discussed before [32], and also considered trust factors as technology trust and inter-organizational trust were used.

Additionally, some researchers have employed new frameworks to study the impact of their utilized factors in BC adoption. One of these methods used in the supply chain area was cross-impact matrix multiplication applied to classification (MICMAC) and interpretive structural modeling (ISM) implemented by Balki and Surucu-Balci [47]. Eight factors in BC adoption were investigated such as perceived resource, the adoption resistance of some stakeholders, initial capital requirement, and the concerns stemming from privacy or business information sharing in BC frameworks that were four critical factors. The most significant factors as the result of their study were also found. On the other hand, another new approach based on nine factors was developed by Jardim et al. [48]. Using the design science research (DSR) approach, technology, trust, trade, and traceability or transparency were introduced as the most significant factors.

Then, Saurabh and Dey [49] investigated adoption by using a new theoretical framework. Their result showed that all adopted factors in their proposed model. Finally, Ali et al. [50] used a new practical framework using exploratory research and have identified five factors, to examine BC acceptance in the supply chain of the halal food. They conducted different case-studies and determined the low, moderate, and high impact of the five variables in each case.

4. Blockchain Adoption in Industries and Firms

Blockchain adoption in different industries such as aviation, logistics, elderly care, education, etc. was the subject of several works. For this purpose, the researchers used different frameworks such as TOE, UTAUT, and TAM. In addition, extended models, the integration of frameworks, and using new conceptual models were considered by some studies as well.

Extended TAM, as discussed in the supply chain, was also utilized here for studying the BC adoption in the aviation industry in Korea. For this purpose, Li et al. [22] used three sub-factors for each of the main categories of the standard TAM (perceived ease of use and perceived usefulness). They listed the factors with a positive impact on the BC adoption as digitized management, tracking and tracing, the management of air traffic, industry standards and regulatory governance, optimization on efficiency and technological improvements.

In another work, Caldarelli et al. [51] studied the BC adoption in Italian firms using the UTAUT framework. They considered four main constructs in their work. Three of four main factors were considered as the study conducted by Queiroz and Wamba [32], but they also used effort expectancy as another factor, which was also used by Alazab et al. [46]. They found that, firstly, social influence and performance expectancy strongly influence individuals' intention to apply blockchain; secondly, the results identified that experience has a negative impact on the intention of adopting blockchain technology.

The TOE-based framework was used in the studies on blockchain adoption in industries as well. BC acceptance in the freight logistics industry using the TOE was discussed by Orji et al. [52]. They used different sub-categories for three main constructs including organizational, technological, and environmental. For example, they listed the firm size, top management support, possibility of training facilities, human resources capability and perceived costs of investment, and organizational culture as the organizational sub-categories. However, between those factors, they identified government support and policy, infrastructural facilities, and the availability of specific blockchain tools as the most significant ones. Wong et al. [53] also used a TOE model to study blockchain adoption in small and medium enterprises (SMEs) in Malaysia. They provided the significant and insignificant factors in the blockchain adoption as the result. In another different concept, Fernando et al. focused on examining the drivers of blockchain adoption together with carbon performance. They chose a TOE model and identified technical competency and lack of competitive pressure as the important adoption factors. They also did not find any evidence to show the relationship between early BC adoption and low-carbon performance. The TOE model was also applied by Schmitt et al. [54] to recognize the important factors in the adoption of IoT, blockchain, and smart contracts in the firms. They examined 13 sub-categories as the main factors impacting the adoption, six of which are similar to the traditional TOE introduced by Tornatzky and Fleischer [29].

The other areas that researchers focused on in their works were the studies on the blockchain application in education and healthcare industries to obtain the significant variables in the adoption of this technology. For this, Balasubramanian et al. [55] used a readiness assessment framework to study BC acceptance in healthcare. Individual stakeholder readiness, stakeholder collaboration readiness, and facilitating conditions readiness were considered as the main categories which also include different variables as the sub-categories (which can be found in the literature). They identified trust, infrastructure, privacy, innovation propensity, and regulatory/legal aspects as the key conditions required for widespread blockchain adoption and also highlighted the vital role of governments. Another work by Srivastava et al. [56] also focused on different ethical challenges in BC adoption in E-healthcare. They used several factors (given from their literature) to develop a framework. They used accountability, fairness (treating reasonable/equal to all people in terms of protocols or technology), privacy, accuracy, access to data, data ownership, and governance. They also used the "right to be forgotten" as a challenging factor, which refers to the right to delete irrelevant/no longer relevant or inadequate personal information from the databases. As a result, they identified the former challenge together with accuracy as the most important challenges of BC adoption.

In addition, an integrated model was used to study the intention of using blockchain in higher education by Iftikhar et al. [57]. They integrated TOE and TAM concepts by adding perceived ease of use and perceived usefulness to the technological dimension of TOE together with using relative advantage and scalability concern as the other variables of the context. On the other hand, they also used top management support for organizational dimensions and competitive pressure, and the regulatory policy as the constructs of environmental factors. Competitive pressure was found as the most significant factor. TAM-based integrated frameworks in this sector were also applied by Ullah et al. [58] to study the adoption of smart learning environments. They designed their integrated model based on TAM and DOI by adding the trialability, relative advantage, and compatibility to the TAM factors. They identified the significant effect of the compatibility factor (defined as how compatible technology is considered with the adopters' current expectations, needs, and beliefs) on blockchain adoption.

The higher education sector was the subject of another work by Kumar et al. [59]. They, however, applied an extended TAM framework in the study. They used perceived security/privacy and trust as the additional variables. The result of this study identified the positive effect of incorporated factors on the adoption intention of the individuals. In addition, the perceived security and privacy factor were found as important factors impacting trust, ease of use, and perceived usefulness. Some of the considered factors in their study were also used in an article with the focus on another application of blockchain technology in gaming by Gao and Li [60]. They used an extended TAM to gain the significant factors of blockchain adoption in this sector. For this purpose, they chose additional factors such as perceived security, trust, privacy, perceived enjoyment, and subjective norms in their model. These subjective norms are defined as "the factors shaped by normative beliefs that the individuals attribute to what a relative other awaits them to do for adopting technology as well as their motivation to comply with those views". On the other hand, the perceived security is bringing events, conditions, or circumstances with the possibility of causing economic hardship to network resources and information in the data modification, destruction, disclosure, and fraud types. Finally, perceived enjoyment identifies how enjoyable a specific activity of technology can be considered (while eliminating other performance consequences stemming from system use). Another extended TAM was also used by Mnif et al. [61] to discuss blockchain adoption in social media.

Blockchain technology can also be applied in smart lockers. A combination of an extended TAM and a TTF model was used by Lian et al. [62] to obtain the important factors of blockchain adoption in this system. They used additional variables including attitude (feeling toward BC) and usage intention (willingness of users) to TAM factors. They also applied TTF factors including individual technology fit (completing the logistic services using blockchain) and task technology fit (dealing with logistics). They, in addition, added the perceived safety and network externality (positive relationship between the number of users and the amount of the technology merits). Their results found perceived usefulness and perceived ease of use as the critical factors. However, the effect of network externality and safety was not identified as the main concerns in their findings.

Using new frameworks with several factors as the barriers and challenges of the adoption and integrated frameworks were the approaches of some other studies in the industry field. For example, Xu et al. [63] used eleven barriers in their model to study adoption in the architecture, engineering, and construction (AEC) industry. Barriers were selected as the variables such as scalability issues (due to the low data transmission speed together with inefficient transactions), lack of interoperability and standardization (stems from facing challenges in the integration of BC and other technologies), lack of knowledge and expertise (especially the challenges of implementation of BC in the early stages), project complexity (due to the temporal nature, uncertainty of construction, and the projects' fragmentation), and industry resistance to change (especially traditional industries). They identified a lack of information technology infrastructure and legal and regulatory uncertainty (as many countries do not yet have the required laws, policies, or supervisions) as the important variables by deriving the power factor for each variable. Another example, the study by Biswas and Gupta [64], was reviewed. They identified the barriers in the industry and service sectors using a literature study as well as the opinion of the experts. They categorized the barriers as 10 main constructs such as risks of technology, privacy, cyber-attacks, and market-based together with different uncertainties due to the legal and regulatory and transaction-level. Other factors were also considered as scalability challenges, high sustainability cost, poor economic behavior in the long run, and usages in the underground economy.

Zhou et al. [65] also used the former method based on identifying variables from the literature in the maritime industry. They then conducted different surveys to collect data and analyzed them using an analytic hierarchical process (AHP) together with a PESTEL (political, economic, social, technological, environmental and legal) analysis and fishbone diagram. They used five main dimensions including several factors. Sufficient capital, staff training, ease of local legislation, the shipping community's support, professional assistance and consultation, and senior management support were ranked as the most important critical success factors with 0.25, 0.24, 0.16, 0.15, 0.12, and 0.006 priority factors, respectively. The challenges of implementation of BC were also ranked in the same way, and, for example, implementation cost and a lack of experienced partners were ranked as the two first ones with 0.25 and 0.22 priorities, respectively.

Another work by Pu and Lam [1] focused on a novel conceptual framework, based on the TAM and TOE model, and also added new features in maritime industries. They used five main dimensions including technical features of blockchain, commercial benefits of blockchain to the industry, applicable areas in the maritime domain, major maritime stakeholders involved, and the potential adoption challenges in the industry. However, they also used several sub-categories for each of the main ones (which can be obtained in [1]). They found all technical aspects as the significant basis of the commercial benefits gained by the industry. They also reported the positive relationship between technological factors and commercial benefits. In another similar study, Lu et al. [66] used a combination of DOI and TOE approaches. They applied the factors under three main categories of the TOE. They listed the factors with a positive impact, insignificant factors, and factors with an indirect impact on the BC adoption. They also reported the positive effect of information security and technology trust on the relative advantages of BC, which also showed an indirect impact on the blockchain adoption intention. However, privacy protection is an insignificant factor.

Empirical research was conducted by Lohmer et al. [67] to find the barriers impacting the adoption of BC in operations management and manufacturing within the industry. They used several interviews with the experts and then proposed the findings of their study using the Saberi et al. [45] model, which is based on classifying the barriers into four main categories (discussed before).

6. Blockchain Acceptance in Banking and Financial Institutions

The TPB adoption model was used to examine the adoption of BC in the financial sector. A research conducted by Chang et al. [68] identified knowledge-hiding as the most vital issue that can be faced in the adoption and development process. A modified TAM was used for studying the blockchain global banking industry. Generally, Kawasmi et al. [69] introduced three categories of blockchain adoption in banking as supporting, hindering, and circumstantial (sub-categories are discussed in the literature). In this work, adoption variables were also listed in three categories: (1) the external variables included currency stability, interoperability, legislations, and regulations; (2) the internal variables were management factors (security, governance, regulatory compliance, and increased transparency), cost, and infrastructure (stability, energy consumption); (3) the perceived usefulness included improving the Know Your Customer (KNC) process, improved transaction speed, competitive advantage, smart contracts, and enhanced data exploration. They reported that the regulation lacks as an important issue that must be not dismissed; they also highlighted that there is a vital need for the revision of current legislation and regulations.

The integration of TOE, DOI, and NIP models was used for studying the BC adoption in the financial market in Iran by Heidari et al. [70]. In this work, the blockchain acceptance readiness levels were considered based on the TOE model. For this, the three levels of technology readiness, environment readiness, and organization readiness were chosen as the levels forming the blockchain acceptance readiness. The variables creating each level have been obtained based on the DOI theory and National Institutional Perspective (NIP). They also used the BC adoption consequences category including the consequences due to the organizational, strategic, economic, information, and technological factors. They identified enjoyment of required technical needs for utilizing platforms working based on BC, enjoyment of suitable speed of Internet connection, and maturity in applying the Internet as well as Internet-related technologies as the most significant factors. Another important finding was that the community's willingness to adopt BC will not overshadow the markets in the financial sector.

In the next work, Saheb and Mamaghani [71] modified the TOE model to study blockchain adoption in banking. For this purpose, they added four categories listed as a business, strategy, operation, and knowledge management as the organizational values (with 25 variables) to 20 barriers found in three main TOE categories. They introduced the most important business process factors as traceability, transparency, and trustworthiness. They also identified the most critical barriers in the industries as organizational and environmental, lack of understanding by top managers, marketing noise, and finally compliance and regulatory requirements. Khalil et al. [72] also studied the significant factors in the adoption of the financial sector by using a moderated mediated model by adding the bank's performance, digital strategy, and blockchain technology factors to the traditional factors. They found the role of the BC adoption between digital business strategy, business process innovation, and financial performance mediating. In addition, the role of information technology alignment between process innovation and blockchain adoption was recognized as the same. They also obtained the positive relationship between digital business strategy with the financial performance of the firm and business process innovation.

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