Decision Science Letters 12 (2023) 55–68

Contents lists available at GrowingScience

Decision Science Letters

homepage: www.GrowingScience.com/dsl

Adoption of IoT by telecommunication companies in GCC: The role of blockchain

Mohammed Alarefi[a*]

[a]*Department of management information system, faculty of Business Administration, University of Tabuk, Saudi Arabia*

C H R O N I C L E

Article history:
Received June 2, 2022
Received in revised format: June 30, 2022
Accepted October 24, 2022
Available online October 24, 2022

Keywords:
Internet of Things
Blockchain
Competitive Advantage
GCC

A B S T R A C T

The Internet of Things (IoT) has become essential for business. The adoption rate of IoT has dropped recently and this could be due to security, privacy, and trust issues. Blockchain (BC) has the potential to mitigate the risk of security, privacy, and trust. However, few studies examined the integration between IoT and BC in the context of developing countries. The purpose of this study is to examine the predictors of IoT adoption by telecommunication companies in the Gulf Cooperation Council (GCC). In addition, the study aims to examine the moderating role of BC as well as the effect of using IoT and BC on the competitive advantage of companies. Based on technology acceptance model, social exchange theory, and resource-based view, the study proposed that security, privacy, trust, communication quality, perceived ease of use (PEOU), and perceived usefulness (PU) affect positively the adoption of IoT. BC is proposed as a moderating variable and expected with IoT to affect the competitive advantage of companies. The population includes all the telecommunication companies in GCC. Data was collected using purposive sampling from IT professionals. The results of data analysis using SmartPLS showed that security, privacy, trust, PU, and PEOU positively affected the adoption of IoT. BC and IoT adoption have a positive effect on competitive advantage. Further, BC moderated only the effect of security and privacy on the adoption of IoT. Services providers must enhance the security, privacy, and trust of IoT services by deploying BC technology. Effective integration of IoT and BC will lead to the achievement of competitive advantages.

1. Introduction

Security and privacy of using the technology are ongoing issues. The Internet of things (IoT) is no exception. Based on statistics from the world bank, the adoption rate of IoT worldwide reached 11% in 2016 and increased to 18% in 2018 (Dataprot, 2022). However, due to the outbreak of COVID-19, the compound annual growth rate (CAGR) of IoT reduced to 8.2% in 2020 which is less than the expected growth of 14.9%. IoT is expected to grow to 11.3% during the 2020-2024 period (Dataprot, 2022). In terms of statistics, the IoT makes a contribution of 6% to the global economy, and the number of connected devices accounted for 15.4 billion in 2015, 26.7 billion in 2019, and it is anticipated to reach 75 billion devices by 2025. (Blanter & Holman, 2020). The IoT is used by a variety of industries, including healthcare (22%), industrial IoT (26.4%), smart cities (28.6%), smart homes (15.4%), and smart cars (7.7%) (Ge et al., 2021). Despite this, the IoT is just beginning to see limited usage in the telecommunications industry (Indiani & Fahik, 2020).The IoT has a wide range of potential applications. Because of this, the size of the IoT market has reached $330,6 billion, and it is anticipated that it will reach $875 billion in 2025 (Market Data Forecast, 2021). According to the findings of the researchers, the IoT is a developing technology that has not yet been perfected. There has not been much research done on the acceptance and adoption of the IoT (Khan et al., 2021; Mircea et al., 2021; Romero-Rodrguez et al., 2020; Shaikh et al., 2021). According

* Corresponding author.
E-mail address: malarefi@ut.edu.sa (M. Alarefi)

doi: 10.5267/dsl.2022.10.006

to findings from earlier research, the existing body of knowledge on the subject of the acceptance and adoption of IoT technologies, as well as the lack of trust and uncertainty produced by new technologies, has a number of lacunae (Almetere et al., 2020).The application and usage of IoT are dominated by developed countries. The use of IoT technologies is less investigated by developing countries. IoT in developing countries is still in its infancy stage (Alazie Dagnaw & Ebabye Tsige, 2019). Further, the majority of the articles on IoT come from China, the US, and the UK (Nascimento et al., 2019).

Technology adoption models such as TAM and UTAUT are widely used in predicting the adoption of new technology. UTAUT is designed for the individual level, and TAM is developed to predict the adoption of the organizational level. Nevertheless, UTAUT and TAM were criticized for focusing on individual and social factors while ignoring technological characteristics such as privacy, trust, and security of technology (Shachak et al., 2019). Privacy and security are critical for all clients and businesses. Telecommunication companies should benefit from blockchain (BC) technology in mitigating the risk of privacy and security and increasing the trust in telecommunication companies and with IoT service providers. In addition, using this disruptive technology provides the first movers with competitive advantages (Cranmer et al., 2022).

This research will thus look at how the telecommunications industry has embraced IoT. The research used TAM, which incorporates PEOU and PU into the analysis. The UTAUT variables of "effort expectancy" and "performance expectancy" are analogous to PEOU and PU, respectively (Venkatesh et al., 2003). There will be no need for banks or other centralized institutions to process transactions while using BC technology (Pennino et al., 2022). The present iteration of the IoT suffers from severe limitations in terms of its widespread use due to issues of data security and trust (Xu Wang et al., 2019; Mahadeo, 2009). Thus, by integrating the IoT with BC, more trusted, accurate, and transparent transactions can be made (R. Singh & Singh, 2021). Nevertheless, since the BC technology is still relatively new, most of the prior literature was conceptual or review of the usage of BC (Ali Syed et al., 2019; Alkhateeb et al., 2022; Dedeoglu et al., 2020; Florea et al., 2022; Mahlous & Ara, 2020; Pennino et al., 2022). This research contributes to the field by investigating the moderating effect of BC technology in preventing security and privacy breaches. Research methodology, results, discussion, implications, and concluding remarks are presented below.

2. Literature Review

2.1 IoT

IoT is a trendy technology, and it is being used by various fields and industries. In simple terms, it refers to the communication between machines without human intervention. The usage of sensors, cloud computing, IoT gateway, connectivity, and user interface are the components of IoT (Kim et al., 2021; Rastogi et al., 2021; Rastogi & Garg, 2021). The adoption rate of the technology has dropped as a result of the outbreak of COVID19 and it is expected to grow to 11.4% in the coming four years (Dataprot, 2022). In IoT, there are several layers. However, researchers agreed that there are three basic and essential layers which are the perception layer, application layer, and network layer (Kumar & Mallick, 2018). Adoption studies of IoT are limited especially from the organizational perspective. The IoT is being used by several industries. However, its usage in telecommunication companies and in particular in developing countries is still limited and there is an avenue for more studies. Therefore, this study is conducted in GCC to examine the adoption of IoT among telecommunication companies.

2.2 Blockchain

BC is described to be a decentralized, distributed, and public ledger which can be deployed to record and verify transactions between any two parties, and it eliminates the need for third party involvement in the transactions. As a result of this defining feature, BC technology may find applications in many different sectors. Bitcoin and other monetary transactions are where BC technology has found its most widespread use so far. BC is a distributed ledger system that uses a peer-to-peer (P2P) architecture to make all transaction records permanently accessible to all nodes in the network. Without the requirement for a trusted third party, it enables anonymous users to safely deal with one another and broadcast those transactions to others in the network (Hasan et al., 2022). BCs' distributed consensus process is a key component. It enables a number of geographically scattered network members to guarantee the authenticity and accuracy of all financial dealings. There have been many different consensus algorithms created by academics since the advent of BC and distributed ledger technologies, each catering to the needs of the user (Lustenberger et al., 2021; Sun et al., 2018). The implementation of BC into the operations of both small and large-scale firms may increase security, privacy, and data transparency; however, few studies have explored the potential influence of BC on organizations (Joshi et al., 2022). This study will examine the usage of BC as a moderating variable.

2.3 Theoretical Framework

Several theories can be used to explain the relationships among the variables. One of the widely used theories in the context of technology adoption is the TAM which was developed by Davis (1989). AM consists of two main variables that are PEOU and PU which are similar to other variables in other theories such as the diffusion of innovation and UTAUT (Venkatesh et al., 2003). TAM allows for adding external or contextual factors. In this study, IoT adoption is investigated

and there are variables that need to be tested in this context. These variables were also sources of criticism of TAM and these include security, privacy, and trust. Therefore, these variables also with PU and PEOU are included in this study. Another theory that might explain the usage of technology is the social exchange theory (SET). SET is based on an exchange in which the benefit and cost are analyzed and a cost-benefit ratio is used for decision-making (Maley & Moeller, 2014). Using the BC and IoT might be costly but it provides a competitive advantage in terms of security and privacy of transactions. Thus, organizations might evaluate the benefits and costs and make decisions about using the technology. Having secure communication and transaction is highly preferable by all organizations while this might bear the cost of implementing these technologies. From the resource-based view (RBV), the theory suggests that an organization can deploy its resources and capabilities to enhance performance and create a competitive advantage (Barney, 1991). Thus, using these new technologies might lead telecommunication companies to achieve a competitive advantage. Accordingly, the study proposes a link between the adoption of IoT and BC on the competitive advantage of telecommunication companies.

2.4 Critical analysis

Behavioral studies that are related to the usage of BC technology are limited. We have done a critical analysis to understand the status of integrating the IoT with BC technology to improve security, privacy, trust, and communication as well as the outcome of using these technologies. Table 1 shows the author and year as well as the deployed technology. The variable of studies is shown. The technical study is referred to by "T", and behavioral studies are referred to by "B". Variables of this study that are included in the Table are security (SE), privacy (PV), trust (TR), Blockchain usage (BC), perceived usefulness (PU), communication quality (CQ) perceived ease of use (PEOU). Adoption of technology (AD), and competitive advantage (CA). Table 1 shows a critical analysis of the variables of the study.

Table 1
Critical Analysis of the Variables

Author/year	Technology	Variable	T	B	SE	PV	TR	CQ	BC	PU	PEOU	AD	CA
(Lustenberger et al., 2021)	IoT-BC	Organizational Technological Environmental BC knowledge		√					√				
(Joshi et al., 2022)	BC	Security Privacy		√	√	√							
(Clohessy & Acton, 2019)	BC	TMS Size Readiness		√									
(Teisserenc & Sepasgozar, 2021)	BC	Political Economic Social Technological	√		√	√	√						
(Muzammal & Murugesan, 2018)	IoT-BC	Security Privacy	√		√	√							
(Ali Syed et al., 2019)	BC	Security Trust	√		√		√						
(Sciarelli et al., 2021)	BC	PU PEOU Security Attitude		√	√					√	√	√	
(Taufiq et al., 2018)	BC	PU PEOU		√						√	√		
(Sujata & Shalini, 2021)	BC	Organizational Technological Organizational Trust		√			√						
(Choi et al., 2020)	BC	Organizational Technological Environmental		√									
(Post et al., 2018)	BC	Strategic Technical Operational		√									

As can be seen in Table 1, a large portion of the studies are technical and none of the included studies have examined collectively the variables of this study. Therefore, this study aims to examine the PU, PEOU, security, privacy, trust, and communication quality of IoT adoption. Additionally, the BC and IoT adoption on competitive advantage as well as the moderating role of BC usage.

2.5 Conceptual Model and Hypotheses Development

This research suggests that PU and PEOU have a beneficial influence on IoT adoption based on TAM, RBV, and SET. The research also suggested that extraneous factors like security, privacy, trust, and communication quality have a major role in

determining how widely IoT is adopted. The impact of concerns about safety, privacy, trust, and communication quality on IoT uptake is anticipated to be moderated with the use of BC. The competitive advantage may be impacted by businesses' use of BC and the widespread use of IoT.

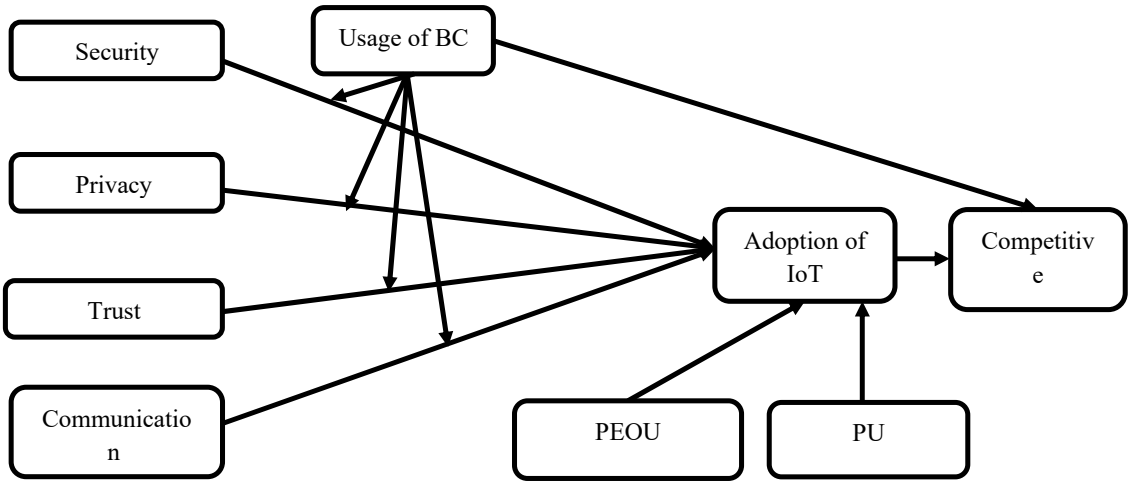


Fig. 1. Conceptual Framework

2.6 Hypotheses Development

Based on SET, TAM, and the RBV as well as the review of existing studies, this study is proposed and discussed in the next sections the hypotheses.

2.6.1 Security and adoption of IoT

Prior literature focused on security since technology adoption is a continuing concern. However, the results are inconsistent. Sepasgozar et al. (2018) discovered that mobile security has no impact on PEOU. Ireda et al. (2019) hypothesized that security would have a beneficial impact on cloud IoT adoption. Al-Hashimy et al. (2019) discovered that security positively influenced IoT adoption. Das (2019) analyzed the relationship between security and IoT adoption and discovered a favorable correlation between the two factors. Narwane et al. (2019) discovered that cloud of things adoption was impacted by security. In this research, it is expected that IoT adoption would benefit from increased security. Consequently, it is theorized.

H_1: *Security impacts have a beneficial effect on IoT adoption.*

2.6.2 Privacy and adoption of IoT

Privacy is critical for the individual's perception of the protection of their personal information (Johnson et al., 2020). In the study of Sepasgozar et al. (2018), it is found that privacy affected the observation of IoT. Similarly, findings were derived from the study of Karahoca et al. (2018) who found that privacy affected the intention to use IoT. Ireda et al. (2019) hypothesized that concerns around privacy would have a major impact on the UB of cloud-based IoT. On the other side, Hsu and Lin (2018) discovered that the presence of privacy has a detrimental impact on the value that is perceived. The evaluation of the reliability of the Internet of Things was not impacted by privacy concerns either (Garry & Harwood, 2019). In the context of this research, concerns around privacy are anticipated to have a substantial impact on the rate of IoT adoption. As a result, the following is proposed as a hypothesis:

H_2: *The adoption rate of IoT is favorably influenced by privacy concerns.*

2.6.3 Trust and adoption of IoT

According to SET, trust is an essential component for every transaction, even the introduction of a new technology (Bobko et al., 2014). According to previous research, trust is a crucial component in the implementation of the IoT (Shaikh et al., 2019). The consistency of Internet of Things evaluations is significantly impacted by trust (Garry & Harwood, 2019). Mashal and Shuhaiber (2019) conducted research in Jordan and discovered that trust has a favorable influence on the inclination to purchase a smart house. Trust was another factor that played into the PU's decision to utilize IoT. (Tsourela & Nerantzaki, 2020). Chohan and Hu (2020) discovered that trust in government and public trust has an effect on the use patterns of the IoT in the public sector. The level of trust had an effect on the desire to adopt IoT. (Dhagarra et al., 2020). The research conducted by Chakraborty and colleagues in 2020 discovered that trust plays a key role in the adoption of IoT.

It is hypothesized in this research that trust plays a crucial role in the degree to which individuals embrace IoT technologies. Therefore, the following is postulated as a hypothesis:

H_3: *Trust has a favorable impact on the spread of the Internet of Things.*

2.6.4 Communication quality and adoption of IoT

Communication quality is a critical component of business processes. Companies need to communicate internally and externally. The use of IoT helps in achieving a high level of communication quality among business partners, suppliers, and customers (Osmonbekov & Johnston, 2018). The need for having a better quality of communication might put pressure on telecommunication companies to adopt the IoT for atomizing communication with all stakeholders (Kamble et al., 2019). In addition, the communication quality with the service providers is an enabler of the adoption of IoT (Raj & Shetty, 2021). Therefore, in this study, it is proposed that the communication quality will positively affect the adoption of IoT by telecommunication companies in GCC.

H_4: *Communication quality affects positively the adoption of IoT.*

2.6.5 PEOU and adoption of IoT

The importance of PEOU to TAM cannot be overstated. The TAM model claimed that PEOU is an essential component for the successful implementation of any new technology (Davis, 1989). According to the findings of Sciarelli et al. (2021), who investigated the adoption of BC, PEOU is a significant factor in determining whether or not BC will be adopted. In a similar vein, Dong et al. (2017) discovered that PEOU influences both the PU and the intention to utilize IoT. According to the findings of Wang et al. (2018), PEOU had an effect on attitude, which in turn had an effect on the intention to adopt IoT. As a result, the results of this research indicate that PEOU should have a favorable impact on the implementation of IoT.

H_5: *PEOU positively affects the adoption of IoT.*

2.6.6 PU and adoption of IoT

PU is also one of the important variables in TAM and it is proposed to affect the intention and usage of new technology. Dhagarra et al. (2020) in Indian healthcare settings found that PU affected the adoption of IoT. Singh and Msibi (2021) also found that PU affected the adoption of IoT in higher education in South Africa. The findings of the study of Alanazi and Soh (2019) in Saudi Arabia indicated that PU is one of the most important predictors of the adoption of IoT. Abd Majid and Mohd Shamsudin (2019) in Malaysia found that PU affected positively the adoption of IoT. In this study, PU is proposed as a positive predictor of the adoption of IoT.

H_6: *PU affects positively the adoption of IoT.*

2.6.7 Impact of BC and IoT on Competitive advantage

The RBV suggested that companies can use its resources and capability to enhance their competitive advantage (Barney, 1991). In this study, the use of technology such as the IoT consumes the resources of companies such as financial and human capital resources. Several studies referred to the notion that using technology will lead to a competitive advantage. Researchers proposed that the desire for having a competitive advantage will lead companies to use the IoT (Cranmer et al., 2022; Das, 2019). Digital business strategy positively affected the innovation and the financial performance of companies in Pakistan (Khalil et al., 2021). Further, the usage of BC enhanced consumer trust (Garaus & Treiblmaier, 2021). The usage of BC also affected positively the supply chain process (Karamchandani et al., 2021). Furthermore, the usage of IoT and BC affected positively green supply chain practices (Rane et al., 2020). In this study, we argue that having the technology and being the first mover in the market will provide the companies with a competitive advantage. This argument is in line with the RBV. Accordingly, this study proposes that the adoption of IoT and the usage of BC will have a positive effect on the competitive advantage of telecommunication companies in GCC.

H_7: *Adoption of IoT positively affects the competitive advantage.*

H_8: *Usage of BC affects the competitive advantage.*

2.6.8 Moderating Role of Blockchain

The use of technology has the ability to affect not just the success of businesses but also the performance of persons working in such businesses. The use of BC technology is now very necessary in order to lessen the risks associated with breaches of security and privacy, as well as a general lack of confidence in the online world (Joshi et al., 2022; Sciarelli et al., 2021). Previous research on the mediating function of BC between digital business strategy and innovation and financial success

came to the conclusion that such a role does exist for BC (Khalil et al., 2021). The implementation of enterprise risk management has less of an impact on the competitive advantage as a result of the use of information technology (Saeidi et al., 2019). The use of artificial intelligence (AI) and customer relationship management in India has favorably tempered the influence that digital transformation has had on the entrepreneurial process in small and medium businesses (SMEs) (Chatterjee et al., 2021). In the context of telecommunications firms, the use of QR technology has moderated the impact of innovative practices and environmentally responsible supply chain management (Indiani & Fahik, 2020). The use of BC is anticipated to alleviate concerns regarding trust, communication quality, security, and privacy in the process of this study project. When adopting the BC technology for security and convenience, business partners, stakeholders, consumers, and suppliers will have a tendency to regard telecommunication firms as being more secure, confidential, trustworthy, and having a high degree of communication quality. On the other hand, to the best of our knowledge, none of the earlier studies looked at how the use of BC may have a moderating role in the relationship. As a result, the following suggestions are made based on this study:

H_9: *BC moderates the effect of security on IoT adoption.*

H_{10}: *BC moderates the effect of privacy on IoT adoption.*

H_{11}: *BC moderates the effect of trust on IoT adoption.*

H_{12}: *BC moderates the effect of communication quality on IoT adoption.*

3. Research Methodology

This research is quantitative in nature, and it examines the predictors of using IoT by telecommunication companies in GCC. The unit of analysis in organizations. The population of this study includes all the telecommunication companies in GCC. These companies account for 138 companies (57 in United Arab Emirates (UAE)), 38 companies in Saudi Arabia, 8 in Kuwait, 12 in Qatar, 13 in Oman, and 8 in Bahrain). These companies are the population of this study. The research is interested in highly advanced technology such as BC and IoT. Thus, to select only respondents who have knowledge about the technology, the study is deploying purposive sampling. This sampling technique is preferable due to the need for certain information from the respondents. Thus, IT professionals working in telecommunication companies in GCC are selected as the target respondents (Sekaran & Bougie, 2019). Snowballing approach and network referral were deployed in this study to collect the data.

A questionnaire is used as the tool to gather the data. The questionnaire is based on previous research and was taken from it as well. The measurement of PEOU (consisting of three items) and PU (consisting of four items) was adopted from Gao and Bai (2014) and Karahoca et al. (2018), respectively. Additionally, security (consisting of three items) and privacy (consisting of four items) were adopted from Shin and Shin (2011) and Park and Kim (2014), respectively. Trust (consisting of four items) was adopted from Mashal and Shuhaiber (2019), and the adoption of IoT (consist of three items) was adopted from Davis et al. (1989); Venkatesh and Davis (2000), and Alotaibi (2014). In addition, the seven points that make up the competitive advantage were taken from Saeidi et al. (2019). In conclusion, the BC use was something that the researchers devised on their own, and it includes a total of 4 items. In addition, the quality of one's communication is something that one develops independently, and it consists of four components. The validity of the questionnaire was evaluated by a panel of three technology adoption specialists. In order to make the instrument more valid, the comments and suggestions that were given were taken into account and followed. Following that, a pilot study was carried out in order to determine the accuracy of the measurement. The reliability of the assessment was supported by the fact that every single Cronbach's Alpha (CA) score was more than 0.70.

For the field data collection, the questionnaire was made online and sent to respondents. A question was highlighted to ask about the knowledge of IoT and BC. Respondents with limited knowledge were asked to refrain from answering the questionnaire. Respondents were asked to forward the questionnaire to those who meet the inclusion criteria. The data collection took place in the first half of 2022. Follow-up procedures were implemented to increase the response rate. The total collected responses were 315 responses.

4. Findings

4.1 Data Examination

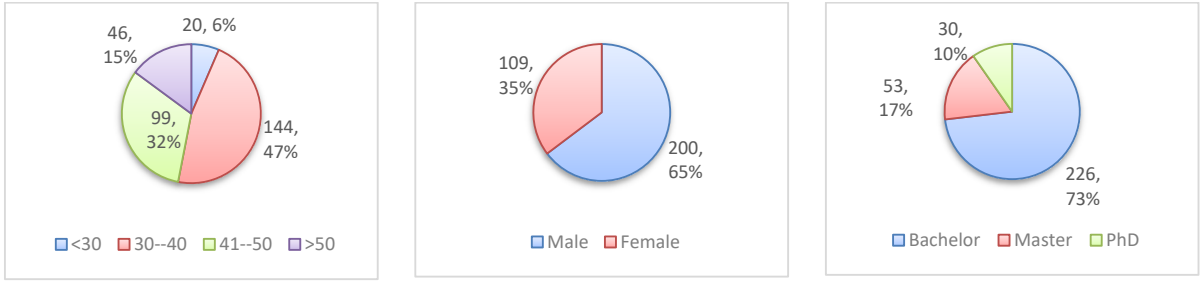
The data of this study was examined based on the suggestion of Hair et al. (2017) for missing values, normality, outliers, and multicollinearity. A total of 315 responses were collected. Two of the responses were empty and they were deleted. In addition, the data is free from missing values due to the use of the “required” function. Further, the outliers were examined and four responses were deleted. According to the information shown in Table 2, every value of skewness and kurtosis is lower than the absolute value (1). The variation inflation factor (VIF) is less than 5, and the tolerance is more than 0.20. According to Hair et al. (2017)' recommendations, this satisfies the assumptions of normality and multicollinearity (2017).

Table 2
Normality and Multicollinearity

Variables	N	Mean	Std. Deviation	Normality		Multicollinearity	
				Skewness	Kurtosis	Tolerance	VIF
Perceived Usefulness	309	3.24	.70	-.214	-.295	.633	1.580
Perceived Ease of Use	309	3.39	.71	-.251	-.382	.668	1.498
Security	309	3.31	.67	-.070	-.496	.630	1.588
Privacy	309	3.20	.69	-.370	-.527	.520	1.925
Communication Quality	309	3.18	.68	-.385	-.117	.612	1.635
Trust	309	3.36	.77	-.394	-.595	.705	1.418
BC Usage	309	3.34	.71	-.391	-.387	.812	1.232
Adoption of IoT	309	3.28	.57	-.648	-.186		
Competitive Advantage	309	3.29	.78	-.307	-.738	.582	1.718
				Std. error =0.139	Std. error =0.276		

4.2 Profile of the Respondents

Fig. 2 shows the background information of the respondents. More than 95% of the respondents are older than 30 years with males accounting for 64.7%. A total of 73.1% of the respondents are holders of bachelor's degrees while others have master's and Ph.D. degrees. The high education of the respondents is due to the use of purposive sampling where only those who meet the criteria were invited to participate in this study.



Age Gender Education

Fig. 2. Background of the Respondents

4.3 Smart PLS-Measurement Model

The measurement model (MM) can be assessed based on the suggestion of Hair et al. (2017) based on five criteria. Table 3 shows the results of evaluating the MM.

Table 3
Results of Assessing the Measurement Model

Variables	Item	Factor loading	CA	CR	AVE
Adoption of IoT	AIOT1	0.91	0.88	0.93	0.81
	AIOT2	0.89			
	AIOT3	0.89			
BC usage	BCU1	0.98	0.97	0.98	0.91
	BCU2	0.93			
	BCU3	0.92			
	BCU4	0.98			
Competitive advantage	CA1	0.88	0.92	0.94	0.76
	CA2	0.90			
	CA3	0.90			
	CA4	0.81			
	CA5	0.86			
Communication quality	CQ1	0.91	0.89	0.93	0.82
	CQ2	0.89			
	CQ3	0.91			
Perceived ease of use	PEOU1	0.92	0.89	0.93	0.82
	PEOU2	0.88			
	PEOU3	0.90			
Perceived usefulness	PU1	0.89	0.89	0.92	0.75
	PU2	0.86			
	PU3	0.85			
	PU4	0.87			
Privacy	PV1	0.72	0.78	0.87	0.70
	PV2	0.89			
	PV3	0.89			
Security	SE1	0.92	0.89	0.93	0.82
	SE2	0.89			
	SE3	0.91			
Trust	TRT1	0.91	0.87	0.92	0.79
	TRT2	0.88			
	TRT3	0.88			

These include factor loading (FL), reliabilities such as CA and Composite reliability (CR), and convergent as well as discriminant validity. The factor loading was examined, and it was found that items from communication quality (CQ4), items from privacy (PV4), and items from a competitive advantage (CA6, CA7) had low loading of less than 0.70. Therefore, these items were removed from the model. The CA and CR were above 0.70 indicating that the data has a high CA and CR. Further, the convergent validity is fulfilled because the average variance extracted (AVE) is larger than 0.50 indicating that at least 50% of the variance in the indicator (variable) can be explained by the items. This also confirms the validity of the newly developed measurement of BC and CQ. The discriminant validity is achieved because the root square of AVE is larger than the cross-loading of the indicators. In other words, the diagonal value underlined in Table 4 is greater than the row and column.

Table 4
Discriminant Validity

	AIOT	BCU	CQ	CA	PEOU	PU	PV	SE	TRT
Adoption of IoT	**0.90**								
BC Usage	0.22	**0.95**							
Communication Quality	0.47	0.07	**0.90**						
Competitive Advantage	0.44	0.42	0.24	**0.87**					
Perceived Ease of Use	0.40	0.06	0.56	0.13	**0.90**				
Perceived Usefulness	0.49	0.03	0.55	0.20	0.56	**0.87**			
Privacy	0.56	-0.04	0.52	0.32	0.38	0.44	**0.84**		
Security	0.61	0.01	0.53	0.40	0.38	0.53	0.69	**0.91**	
Trust	0.41	0.12	0.28	0.23	0.23	0.28	0.28	0.38	**0.89**

4.4 Smart PLS Structural Model

In the structural model (SM) stage, Hair et al. (2017) suggested examining the explanatory power (R-square) which is supposed to be greater than 0.25 to be weak and greater than 0.50 to be medium, and greater than 0.75 to be strong. In addition, the predictive relevance (Q-square) should be greater than zero as well as the effect size (F-square) should be greater than 0.02 to be considered as weak, 0.15 to be considered medium and 0.35 to be considered strong. The path coefficient (B) represents the hypothesis and it is accepted if the p-value (P) is less than 0.05. Fig. 3 shows the SM of this study, and it includes the moderating role of BC.

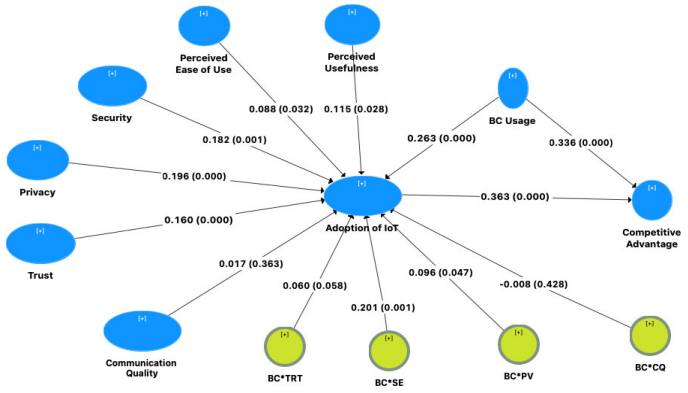


Fig. 2. Structural Model

Table 5
Results of Hypotheses Testing, R-square, Q-square, and F-square

Hypothesis	Path	B	Std.	T	P	R^2	Q^2	F^2	Remark
H1	SE → AIOT	0.182	0.059	3.091	0.001	0.585	0.459	0.03	Supported
H2	PV → AIOT	0.196	0.052	3.781	0.000			0.04	Supported
H3	TRT→ AIOT	0.160	0.040	4.055	0.000			0.05	Supported
H4	CQ → AIOT	0.017	0.048	0.350	0.363			0.00	Rejected
H5	PEOU → AIOT	0.088	0.043	2.52	0.032			0.02	Supported
H6	PU → AIOT	0.115	0.055	2.17	0.028			0.02	Supported
H7	AIOT → CA	0.363	0.066	5.528	0.000	0.300	0.219	0.18	Supported
H8	BCU→ CA	0.336	0.063	5.321	0.000			0.15	Supported
H9	BC×SE → AIOT	0.201	0.066	3.046	0.001			0.04	Supported
H10	BC×PV → AIOT	0.096	0.048	2.001	0.047			0.02	Supported
H11	BC×TRT → AIOT	0.060	0.038	1.572	0.058			0.01	Rejected
H12	BC×CQ → AIOT	-0.008	0.046	0.180	0.428			0.01	Rejected

In Table 5, it can be seen that the value of R^2 for the adoption of IoT is 0.585 and for the competitive advantage is 0.300 indicating that 58.5% of the adoption of IoT can be explained by the variables such as security, privacy, trust,

communication quality, PEOU, and PU while 30% of the competitive advantage can be explained by using the IoT and BC. Similarly, for Q^2, because the value is larger than zero (0), it may be concluded that the independent variable can accurately predict the dependent variable. For the effect size, all the effect sizes are accepted except for the path of CQ→AIOT, BC×TRT→AIOT, BC×CQ→AIOT.

4.5 Hypotheses Testing

As shown in Fig. 3 and presented in Table 6, the effect of security on AIOT is positive at B=0.182 and a p-value less than 0.05. Thus, H1 is supported. For H2 and H3, privacy and trust affected positively the AIOT leading to accepting H2 and H3. For H4, it is rejected because the p-value of the communication quality→AIOT is larger than 0.05. For H5 and H6, the effect of PEOU and PU on AIOT is confirmed to be significant at B=0.088 and B=0.115 respectively. This leads to accepting H5 and H6. The effect of AIOT and BC on the competitive advantage was confirmed to be positive and significant. Thus, H7 and H8 are supported. For the moderating effect, the product indicator approach was used to examine the moderators. In this approach, the indicators of the independent variable (IV) are multiplied by the indicator of the moderator (M) to create a new variable called M×IV. The moderating role of BC was confirmed only in the case of security and privacy while no support was found for the case of trust and communication quality. This leads to accepting H9 and H10 and rejecting H11 and H12 as shown in Table 5.

5. Dissuasion

This research was carried out to investigate the factors that are predictive of the IoT, as well as the moderating function that BC plays in the relationship between the two, and their combined influence on the competitive advantages held by telecommunications firms in the GCC. According to the results, the influences of trust, security, and privacy on AIOT have a beneficial and noticeable impact on the technology. This suggests that security, privacy, and trust are essential components for the adoption of IoT by telecommunication firms, and it is necessary to concentrate on these factors in order to convince enterprises to engage in IoT. These findings are consistent with the findings of previous research, which point to the significance of trust, privacy, and security in relationships (Garry & Harwood, 2019; Ireda et al., 2019; Sepasgozar et al., 2018; Shaikh et al., 2019). The results showed that communication quality is not a significant predictor of IoT adoption. This might be explained due to the notion that telecommunication companies have not yet digitalized communication with customers, suppliers, and business partners and this might affect the goodness of the communication and lead to an insignificant effect on IoT adoption. The findings also showed that PEOU and PU which are the main predictors of TAM are critical for the adoption of IoT by telecommunication companies in GCC. The perceived benefits and the degree of easiness in using the technology is critical for encouraging decision-makers to use the technology. Accordingly, the increase in the level of PU and PEOU will lead to an increase in the adoption of IoT. These findings agree with prior literature such as Singh and Msibi (2021), Alanazi and Soh (2019), and Wang et al. (2018) who found that PU and PEOU are important predictors of the adoption of IoT. These findings are also in line with the proposition of the TAM model regarding the variables of PEOU and PU. Using IoT and BC were proven to have substantial implications on competitive advantage. In the future, businesses that adopt BC and IoT early will have a distinct edge over their rivals. In keeping with the RBV, which predicted that businesses would gain an edge via efficient use of their resources, we see that advantage materialize (Barney, 1991). This is consistent with the literature's observation that increasing one's reliance on technological means (such as BC use and digitization) improves supply chain efficiency and organizational creativity (Khalil et al., 2021; Rane et al., 2020).

In terms of the moderating role of BC usage, it was found significant in the case of privacy and security. This could be due to the fact that BC has the ability to secure transactions and make them more confident. Accordingly, by using the BC, telecommunication companies can create a more secure and confidential environment. However, the result also showed that BC usage did not moderate the effect of trust and communication quality on IoT adoption. A possible explanation is that trust in the service providers who are yet limited has not matured yet and there is a need for more effort to establish a trusting environment.

6. Implication

This research adds to the existing body of knowledge by analyzing the factors that influence the success of technology implementation in commercial enterprises like telecommunications providers. The research determined what drives these businesses to use IoT solutions. As a result, the research has aided the spread of Internet of Things technologies in the setting of underdeveloped nations, particularly in the realm of communications. This research added to the existing body of knowledge by additionally investigating the moderating effect of BC use. There has been no research on BC consumption that we are aware of, at least not in the context of the GCC or developing nations. In addition, the research made a contribution to the literature by investigating the competitive edge achieved via the integration of IoT and BC.. By doing so, the study combined the theories of technology adoption such as TAM and SET with the strategic management theory such as RBV. This combination explained a significant variation in the adoption of IoT and the competitive advantage of telecommunication companies in GCC.

Based on the findings of this study, security, privacy, and trust as well as the PU and PEOU are critical for the adoption of IoT. Therefore, service providers of IoT to telecommunication companies are advised to enhance security, privacy, and trust. This can be done by using the BC technology which can mitigate the risk of using the IoT. Service providers are also advised to enhance their trust in telecommunication companies so that the adoption of IoT can be enhanced. Managers and top management at telecommunication companies should be aware that the usage of IoT and BC technology has become necessary for achieving a competitive advantage. The payment system and the business process can be largely enhanced by using these technologies. Using sensors for monitoring business operations can have a large contribution to cost reduction. In addition, payments that are secured by using BC can encourage customers to deploy the payment channel of telecommunication companies for making shopping and paying.

7. Conclusion

This study was conducted to identify the predictors of IoT adoption and the moderating role of BC usage. The findings of this study were derived from analyzing the hypotheses using Smart PLS. The findings showed that security, privacy, and trust are critical predictors of the adoption of IoT. In addition, the findings also supported the hypotheses of PU and PEOU and their impact on the adoption of IoT. BC and the adoption of IoT were found to have a major contribution to the competitive advantage of telecommunication companies in GCC. BC usage moderated positively the effect of security and privacy on the adoption of IoT indicating that the increase in the level of using BC will lead to more secure and confidential transactions by telecommunication companies in GCC. The study has some limitations that are worth mentioning. The study was conducted in GCC thus, the study is limited to these countries. The study also deployed purposive sampling to select only those who are aware of the technologies. Further, the study is limited to telecommunication companies. As a way forward, this study suggests that the adoption of IoT and the usage of BC should be examined in future studies. BC is still relatively a new technology and more research in the context of developing countries can enrich the literature regarding the usage of this technology. Future studies are recommended to focus on the usage of this technology in a specific industry such as the banking industry in a single country. Further research is required to use random sampling to enhance the generalizability of the findings. Future research is also recommended to include more variables such as the IT knowledge of the managers and the cost of acquiring the technology. Combining theories is the norm of the literature and future studies are recommended to combine other theories to enhance the explanatory power of the adoption of IoT and the usage of BC.

References

Al-Hashimy, H. N. H., Hamoud, A. K., & Fatima Alaa Hussain. (2019). The Effect of Not Using Internet of Things in Critical Life Situations in The Health Field and The Effect on Iraqi Profitability: Empirical Study in Basra. *Journal of Southwest Jiaotong University*, *54*(4), 1–13.

Alazie Dagnaw, G., & Ebabye Tsige, S. (2019). Impact of Internet of Thing in Developing Country: Systematic Review. *Internet of Things and Cloud Computing*, *7*(3), 65. https://doi.org/10.11648/j.iotcc.20190703.12

Ali Syed, T., Alzahrani, A., Jan, S., Siddiqui, M. S., Nadeem, A., & Alghamdi, T. (2019). A Comparative Analysis of Blockchain Architecture and its Applications: Problems and Recommendations. *IEEE Access*, *7*, 176838–176869. https://doi.org/10.1109/ACCESS.2019.2957660

Alkhateeb, A., Catal, C., Kar, G., & Mishra, A. (2022). Hybrid Blockchain Platforms for the Internet of Things (IoT): A Systematic Literature Review. *Sensors*, *22*(4). https://doi.org/10.3390/s22041304

Almetere, E. S., Kelana, B. W. Y., & Mansor, N. N. A. (2020). Using UTAUT Model to Determine Factors Affecting Internet of Things Acceptance in Public Universities. *International Journal of Academic Research in Business and Social Sciences*, *10*(2). https://doi.org/10.6007/ijarbss/v10-i2/6915

Barney, J. (1991). Special Theory Forum The Resource-Based Model of the Firm: Origins, Implications, and Prospects. In *Journal of Management* (Vol. 17, Issue 1, pp. 97–98). https://doi.org/10.1177/014920639101700107

Blanter, A., & Holman, M. (2014). *Silicon Valley Thought Leaders Series. Internet of Things 2020: A Glimpse into the Future.*

Bobko, P., Barelka, A. J., & Hirshfield, L. M. (2014). The construct of state-level suspicion: A model and research agenda for automated and information technology (IT) contexts. *Human Factors*, *56*(3), 489–508.

Chatterjee, S., Chaudhuri, R., Vrontis, D., & Basile, G. (2021). Digital transformation and entrepreneurship process in SMEs of India: a moderating role of adoption of AI-CRM capability and strategic planning. *Journal of Strategy and Management*.

Choi, D., Chung, C. Y., Seyha, T., & Young, J. (2020). Factors affecting organizations' resistance to the adoption of blockchain technology in supply networks. *Sustainability*, *12*(21), 8882.

Clohessy, T., & Acton, T. (2019). Business Transformation through Blockchain. *Business Transformation through Blockchain*, *July*. https://doi.org/10.1007/978-3-319-98911-2

Cranmer, E. E., Papalexi, M., tom Dieck, M. C., & Bamford, D. (2022). Internet of Things: Aspiration, implementation and contribution. *Journal of Business Research*, *139*(September), 69–80. https://doi.org/10.1016/j.jbusres.2021.09.025

Das, S. (2019). The Early Bird Catches the Worm - First Mover Advantage through IoT Adoption for Indian Public Sector Retail Oil Outlets. *Journal of Global Information Technology Management*, *22*(4), 280–308. https://doi.org/10.1080/1097198X.2019.1679588

Dataprot. (2022). Internet of Things statistics for 2022 - Taking Things Apart. In *DataPort*. https://dataprot.net/statistics/iot-

statistics/

Davis, F. D. (1989). Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology. *Source: MIS Quarterly*, *13*(3), 319–340.

Dedeoglu, V., Jurdak, R., Dorri, A., Lunardi, R. C., Michelin, R. A., Zorzo, A. F., & Kanhere, S. S. (2020). *Blockchain Technologies for IoT* (Issue September). Springer Singapore. https://doi.org/10.1007/978-981-13-8775-3_3

Dhagarra, D., Goswami, M., & Kumar, G. (2020). Impact of Trust and Privacy Concerns on Technology Acceptance in Healthcare: An Indian Perspective. *International Journal of Medical Informatics*, *141*(February), 104164. https://doi.org/10.1016/j.ijmedinf.2020.104164

Dong, X., Chang, Y., Wang, Y., & Yan, J. (2017). Understanding usage of Internet of Things (IOT) systems in China: Cognitive experience and affect experience as moderator. *Information Technology & People*, *30*(1), 117–138. https://doi.org/http://dx.doi.org/10.1207/S15327825MCS0301_03

Florea, A. I., Anghel, I., & Cioara, T. (2022). A Review of Blockchain Technology Applications in Ambient Assisted Living. *Future Internet*, *14*(5). https://doi.org/10.3390/fi14050150

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

Garaus, M., & Treiblmaier, H. (2021). The influence of blockchain-based food traceability on retailer choice: The mediating role of trust. *Food Control*, *129*, 108082.

Garry, T., & Harwood, T. (2019). Trust and its predictors within a cyber-physical system context. *Journal of Services Marketing*, *33*(4), 407–428. https://doi.org/10.1108/JSM-01-2018-0007

Ge, M., Syed, N. F., Fu, X., Baig, Z., & Robles-Kelly, A. (2021). Towards a deep learning-driven intrusion detection approach for Internet of Things. *Computer Networks*, *186*. https://doi.org/10.1016/j.comnet.2020.107784

Hasan, A. S. M. T., Sabah, S., Haque, R. U., Daria, A., Rasool, A., & Jiang, Q. (2022). Towards Convergence of IoT and Blockchain for Secure Supply Chain Transaction. *Symmetry*, *14*(1), 1–19. https://doi.org/10.3390/sym14010064

Indiani, N. L. P., & Fahik, G. A. (2020). Conversion of online purchase intention into actual purchase: the moderating role of transaction security and convenience. *Verslas: Teorija Ir Praktika/Business: Theory and Practice*, *21*(1), 18–29.

Ireda, A. M. A., Ben-Mubarak, M. A., & Buhari, A. (2019). *Factors That Influence An Academic Institution's Intention To Accept CloudIOT: A Proposed Framework*. *2*(IcoIESE 2018), 140–143. https://doi.org/10.2991/icoiese-18.2019.25

Johnson, V. L., Woolridge, R. W., Wang, W., & Bell, J. R. (2020). The impact of perceived privacy, accuracy and security on the adoption of mobile self-checkout systems. *Journal of Innovation Economics Management*, *1*, 221–247.

Joshi, S., Pise, A. A., Shrivastava, M., Revathy, C., Kumar, H., Alsetoohy, O., & Akwafo, R. (2022). Adoption of Blockchain Technology for Privacy and Security in the Context of Industry 4.0. *Wireless Communications and Mobile Computing*, *2022*.

Kamble, S. S., Gunasekaran, A., Parekh, H., & Joshi, S. (2019). Modeling the internet of things adoption barriers in food retail supply chains. *Journal of Retailing and Consumer Services*, *48*, 154–168.

Karahoca, A., Karahoca, D., & Aksöz, M. (2018). Examining intention to adopt to internet of things in healthcare technology products. *Kybernetes*, *47*(4), 742–770. https://doi.org/10.1108/K-02-2017-0045

Karamchandani, A., Srivastava, S. K., Kumar, S., & Srivastava, A. (2021). Analysing perceived role of blockchain technology in SCM context for the manufacturing industry. *International Journal of Production Research*, *59*(11), 3398–3429.

Khalil, M., Khawaja, K. F., & Sarfraz, M. (2021). The adoption of blockchain technology in the financial sector during the era of fourth industrial revolution: a moderated mediated model. *Quality & Quantity*, 1–18.

Khan, A. U., Zhang, Z., Chohan, S. R., & Rafique, W. (2021). Factors fostering the success of IoT services in academic libraries: a study built to enhance the library performance. *Library Hi Tech*, *2025*. https://doi.org/10.1108/LHT-06-2021-0179

Kim, J., Kim, M., & Lee, J. (2021). Securing Fresh Data in Wireless Monitoring Networks: Age-of-Information Sensitive Coverage Perspective. *ArXiv Preprint ArXiv:2103.07149*.

Kumar, N. M., & Mallick, P. K. (2018). The Internet of Things: Insights into the building blocks, component interactions, and architecture layers. *Procedia Computer Science*, *132*, 109–117. https://doi.org/10.1016/j.procs.2018.05.170

Lustenberger, M., Malešević, S., & Spychiger, F. (2021). Ecosystem readiness: Blockchain adoption is driven externally. *Frontiers in Blockchain*, *4*(720454).

Mahadeo, J. D. (2009). Towards an Understanding of the Factors Influencing the Acceptance and Diffusion of e-Government Services. *Electronic Journal of E-Government*, *7*(4), pp381-392.

Mahlous, A. R., & Ara, A. (2020). The Adoption of Blockchain Technology in IoT: An Insight View. *Proceedings - 2020 6th Conference on Data Science and Machine Learning Applications, CDMA 2020*, *June*, 100–105. https://doi.org/10.1109/CDMA47397.2020.00023

Maley, J. F., & Moeller, M. (2014). Global performance management systems: The role of trust as perceived by country managers. *Journal of Business Research*, *67*(1), 2803–2810. https://doi.org/10.1016/j.jbusres.2012.08.003

Market Data Forecast. (2021). *49 Stunning Internet of Things Statistics 2021 [The Rise Of IoT]*. Market Data Forecast. https://techjury.net/blog/internet-of-things-statistics/#gref

Mashal, I., & Shuhaiber, A. (2019). What makes Jordanian residents buy smart home devices?: A factorial investigation using PLS-SEM. *Kybernetes*, *48*(8), 1681–1698. https://doi.org/10.1108/K-01-2018-0008

Mircea, M., Stoica, M., & Ghilic-Micu, B. (2021). Investigating the Impact of the Internet of Things in Higher Education Environment. *IEEE Access*, *9*, 33396–33409. https://doi.org/10.1109/ACCESS.2021.3060964

Muzammal, S. M., & Murugesan, R. K. (2018). A Study on Leveraging Blockchain Technology for IoT Security Enhancement. *Proceedings - 2018 4th International Conference on Advances in Computing, Communication and Automation, ICACCA 2018*, *August 2019*. https://doi.org/10.1109/ICACCAF.2018.8776806

Narwane, V. S., Raut, R. D., Gardas, B. B., Kavre, M. S., & Narkhede, B. E. (2019). Factors affecting the adoption of cloud of things: The case study of Indian small and medium enterprises. *Journal of Systems and Information Technology*, *21*(4), 397–418. https://doi.org/10.1108/JSIT-10-2018-0137

Nascimento, D. A. do, Neto, A. R., Filho, E. G. C., Neto, J. A. C., Araújo, A. K. R., Gonçalves, K. L. F., & Leite, F. de A. (2019). A Bibliometric Study about Internet of Things. *International Journal of Advanced Engineering Research and Science*, *6*(4), 213–220. https://doi.org/10.22161/ijaers.6.4.24

Osmonbekov, T., & Johnston, W. J. (2018). Adoption of the Internet of Things technologies in business procurement: impact on organizational buying behavior. *Journal of Business & Industrial Marketing*.

Pennino, D., Pizzonia, M., Vitaletti, A., & Zecchini, M. (2022). Blockchain as IoT Economy Enabler: A Review of Architectural Aspects. *Journal of Sensor and Actuator Networks*, *11*(2). https://doi.org/10.3390/jsan11020020

Post, R., Smit, K., & Zoet, M. (2018). Identifying Factors Affecting Blockchain Technology Diffusion. *Twenty-Fourth Americas Conference on Information Systems*, 1–10. https://aisel.aisnet.org/cgi/viewcontent.cgi?article=1152&context=amcis2018%0Ahttps://aisel.aisnet.org/amcis2018/AdoptionDiff/Presentations/19

Raj, A., & Shetty, S. D. (2021). IoT eco-system, layered architectures, security and advancing technologies: A comprehensive survey. *Wireless Personal Communications*, 1–37.

Rane, S. B., Thakker, S. V., & Kant, R. (2020). Stakeholders' involvement in green supply chain: a perspective of blockchain IoT-integrated architecture. *Management of Environmental Quality: An International Journal*.

Rastogi, R., & Garg, P. (2021). Investigation of air quality prediction and analysis amidst pandemic challenges with Indian sciences of Agnihotra: ML-based study for Healthcare 4.0. *Interdisciplinary Environmental Review*, *21*(1), 66–85.

Rastogi, R., Saxena, M., Sagar, S., Tandon, N., Rajeshwari, T., & Singh, B. (2021). Effects of herbal woods in homa therapy on air quality: experiments amidst unlocking the society in pandemic challenges. *International Journal of Environmental Engineering*.

Romero-Rodríguez, J. M., Alonso-García, S., Marín-Marín, J. A., & Gómez-García, G. (2020). Considerations on the implications of the internet of things in spanish universities: The usefulness perceived by professors. *Future Internet*, *12*(8), 1–13. https://doi.org/10.3390/FI12080123

Saeidi, P., Saeidi, S. P., Sofian, S., Saeidi, S. P., Nilashi, M., & Mardani, A. (2019). The impact of enterprise risk management on competitive advantage by moderating role of information technology. *Computer Standards & Interfaces*, *63*, 67–82.

Sciarelli, M., Prisco, A., Gheith, M. H., & Muto, V. (2021). Factors affecting the adoption of blockchain technology in innovative Italian companies: an extended TAM approach. *Journal of Strategy and Management*, *15*(3), 495–507. https://doi.org/10.1108/JSMA-02-2021-0054

Sekaran, U., & Bougie, R. (2019). *Research methods for business: A skill building approach*. john wiley & sons.

Sepasgozar, S. M. E., Sargolzaei, S., Sepasgozar, S. M. E., Kamardeen, I., & Sargolzaei, S. (2018). A model for increasing the security of internet of things in smart transportation systems. *ISARC 2018 - 35th International Symposium on Automation and Robotics in Construction and International AEC/FM Hackathon: The Future of Building Things*, *Isarc*. https://doi.org/10.22260/isarc2018/0087

Shachak, A., Kuziemsky, C., & Petersen, C. (2019). Beyond TAM and UTAUT: Future directions for HIT implementation research. *Journal of Biomedical Informatics*, *100*, 103315.

Shaikh, H., Khan, M. S., Mahar, Z. A., Anwar, M., Raza, A., & Shah, A. (2019). A conceptual framework for determining acceptance of internet of things (IoT) in higher education institutions of Pakistan. *2019 International Conference on Information Science and Communication Technology, ICISCT 2019*, 1–5. https://doi.org/10.1109/CISCT.2019.8777431

Shaikh, H., Maher, Z. A., Raza, A., Koondhar, M. Y., Hussain, S., & Shah, A. (2021). Acceptance of IoT Learning Among University Students at Pakistan. *International Journal of Advanced Trends in Computer Science and Engineering*, *10*(3), 2267–2271. https://doi.org/10.30534/ijatcse/2021/1101032021

Singh, R., & Singh, P. K. (2021). Integrating blockchain technology with iot. *CEUR Workshop Proceedings*, *2786*(1), 81–82.

Singh, U. G., & Msibi, A. (2021). Students' perceptions towards IoTs adoption: A case study. *Journal of Physics: Conference Series*, *1714*(1). https://doi.org/10.1088/1742-6596/1714/1/012044

Sujata, S., & Shalini, C. (2021). Exploring Factors Influencing Adoption of Blockchain in Accounting Applications using Technology – Organization – Environment Framework Exploring Factors Influencing Adoption of Blockchain in Accounting Applications using Technology – Organization – Envir. *Journal of International Technology and Information Management*, *30*(1), 30–68.

Sun, Y., Fan, L., & Hong, X. (2018). Technology development and application of blockchain: Current status and challenges. *Strategic Study of Chinese Academy of Engineering*, *20*(2), 27–32.

Taufiq, R., Meyliana, Hidayanto, A. N., & Prabowo, H. (2018). The Affecting Factors of Blockchain Technology Adoption of Payments Systems in Indonesia Banking Industry. *Proceedings of 2018 International Conference on Information*

Management and Technology, ICIMTech 2018, *September*, 506–510. https://doi.org/10.1109/ICIMTech.2018.8528104
Teisserenc, B., & Sepasgozar, S. (2021). Adoption of blockchain technology through digital twins in the construction industry 4.0: A PESTELS approach. *Buildings*, *11*(12). https://doi.org/10.3390/buildings11120670
Tsourela, M., & Nerantzaki, D. M. (2020). An internet of things (Iot) acceptance model. assessing consumer's behavior toward iot products and applications. *Future Internet*, *12*(11), 1–23. https://doi.org/10.3390/fi12110191
Venkatesh, Morris, Davis, & Davis. (2003). User Acceptance of Information Technology: Toward a Unified View. *MIS Quarterly*. https://doi.org/10.2307/30036540
Wang, Xiwei, Li, J., Yang, M., Chen, Y., & Xu, X. (2018). An empirical study on the factors influencing mobile library usage in IoT era. *Library Hi Tech*, *36*(4), 605–621. https://doi.org/10.1108/LHT-01-2018-0008
Wang, Xu, Zha, X., Ni, W., Liu, R. P., Guo, Y. J., Niu, X., & Zheng, K. (2019). Survey on blockchain for Internet of Things. *Computer Communications*, *136*, 10–29. https://doi.org/10.1016/j.comcom.2019.01.006

Appendix

Communication Quality	Source
Having IoT will enhance communication with customers	Self-developed
Having IoT will increase communication quality with business partners.	
Having IoT will improve our communication quality with suppliers.	
Having IoT will improve the overall internal business process.	
Security	
The security of the Internet of Things is an important issue for our company	Shin and Shin (2011); Park and Kim (2014)
We are confident that the private information in Internet of Things services is secure.	
The security of data backups is a determinant of using Internet of Things services.	
Privacy	
The Privacy of the Internet of Things is important issue for our company	Shin and Shin (2011); Park and Kim (2014)
We believe nobody can view information or data stored in the Internet of Things services without our agreement.	
Service stability is a determinant of using Internet of Things services.	
We believe that certain technical procedures exist to protect personal information.	
Trust	
The service provider of the Internet of Things is trustworthy	(Mashal & Shuhaiber, 2019)
Service provider of Internet of Things reliable	
The service provider of the Internet of Things is controllable	
The service provider of the Internet of Things is competent	
Perceived usefulness	
Using the Internet of Things (IoT) will enable us to accomplish more duties.	(Gao & Bai, 2014; Karahoca et al., 2018)
Using the Internet of Things will make it easier for us to control our operations.	
Using the Internet of Things will significantly increase the quality of our business	
The Internet of Things is advantageous.	
Perceived ease of use	
Internet of Things is easy	(Gao & Bai, 2014; Karahoca et al., 2018)
Interaction with Internet of Things devices is clear and understandable.	
Learning to use Internet of Things is easy for our employees.	
BC usage	Self-developed
We are using blockchain to secure our payment	
We are using blockchain to satisfy our security needs	
We are using blockchain to enhance the confidentiality in our transactions.	
We are using the blockchain to increase the trust with stakeholders.	
Adoption of IoT	
We rely on Internet of Things services to do tasks.	Davis et al. (1989); Venkatesh and Davis (2000) Alotaibi (2014)
We have subscribed to Internet of Things services	
We are regularly using Internet of Things services	
Competitive advantage	

The superior quality of our company's goods and services surpasses that of our competition. Our firm is more competent than the competitors in R&D and innovation. Our firm has superior management capabilities compared to its rivals. Our firm is more profitable than the rivals. Our corporate reputation is superior than that of our rivals. Our firm is far more adaptable than the rivals. Our future growth is superior to that of the rivals.	(Saeidi et al., 2019).