The Usage of Internet of Things in Agriculture: The Role of Size and Perceived Value

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The application of internet of things (IoT) has reached all fields and industries with variation among countries. One of the industries that received less attention is the agriculture. This research intended to identify the factors that affect the intention to use IoT (IUIoT) among farmers in developing countries such as Iraq. Based on technology acceptance model (TAM) and theory of planned behavior (TPB), this study proposed that perceived usefulness (PU), perceived complexity (PC), subjective norms (SN), reliability (RE) and cost saving (CS) will affect the IUIoT. Perceived value (PV) is proposed as a mediator while land size is proposed as a moderator. The data of this study was collected from 223 farmers in Iraq using purposive sampling. The analysis of Smart PLS showed that the effect of PU, PC, RE, SN, and CS on IUIoT are significant. PV mediated fully the effect of PC and partially the effect of other variables on IUIoT. Land size did not moderate the effect of PV on IUIoT. Decision makers are recommended to ease the process of using the IoT and to enlighten farmers about the benefits of using the IoT.

Povzetek: Narejena je študija, kako internet vpliva na kmetijstvo v Iraku.

1 Introduction

The increase in the population has intensified the need for using technology to speed the process of production while maintaining the quality of supply. In agriculture industry, the use of Internet of things (IoT) is promising. IoT can help in monitoring the field and ensuring the accuracy in dealing with plants. IoT will have a major impact on agriculture. Drones for farm surveillance, drip irrigation, and more are being developed [1], [2]. IoT has been used in several sectors such as smart homes or educations [3], [4] medical usage [5], small and medium enterprises (SMEs) [6], [7] and higher education. The usage of IoT in agriculture sector is limited [8], [9].

Nevertheless, researchers recently showed interest in this field after the outbreak of COVID19 and the global instable supply of food [10]. Researchers are working to develop solutions and product that help in developing the agriculture using IoT-based application. One of the increasingly used application is the integration between machine learning [11] [12] and IoT based application to enable machine to machine decision making and enhance the monitoring of field in agriculture industries [13]–[15]. In addition, several applications were developed for the usage in agriculture, and these include the management systems, and the monitoring systems using IoT applications. In addition, the control systems, and unmanned machinery were developed for the usage in agriculture. Wi-Fi, LoRaWAN, mobile communication, ZigBee, and Bluetooth were all

employed in IoT-based agriculture, as were other wireless communication technologies often found in agriculture [16]. All these applications helps the industry of agriculture and breeding [17].

When it comes to the usage of IoT based on countries, there is a gap between developed and developing countries [18]. The usage of IoT and its application is dominated by the developed countries. In particular, studies of IoT agriculture has been conducted in developed and emerging economies [9] while the usage of these IoT application in developing countries such as Iraq is still in its infancy stage. Iraq is an oil producing country in which the agriculture is the second important sector after oil. Based on a report of the United Nations (UN) in 2021, approximately 22% (9.5 million ha) of Iraq is suitable for agriculture production. However, only 5 million ha are being used. Agriculture contributes by 5% to the gross domestic product (GDP) of Iraq and employs almost 20% of the workforce [19].

It is believed that by using the technology such as IoT, the productivity of the sector will increase. However, in Iraq, and everywhere else, the adoption rate of the IoT is still limited. IoT adoption rate decreased from 18% in 2018 to 8.2% in 2020 [20]. Researchers indicated that there are several theories that can predict the adoption of IoT. The most widely used one is the technology acceptance model (TAM) by [21] who referred to the importance of the ease of use (PEOU) as well as the usefulness (PU) of the technology. In addition, theories such as the theory of planned behaviour highlighted the role of subjective norms (SN) [22]. Both TAM and TPB allow users to add additional contextual variables. In this study, the perceived value (PV) of the IoT, cost saving, reliability of the services is critical for forming the decision to use the technology. Consequently, this research intended to identify the factors that affect the intention to use IoT (IUIoT) among farmers in Iraq. The study examines the mediating role of PV and the moderating role of land size among the variables. The next sections elaborate on the prior literature as well as the method along with the results, discussion of the findings, implication and conclusion.

2 Literature review

2.1 IoT in Agriculture

According to the UN Food and Agriculture Organization, by 2050, the world would need to increase the production of food by 70% and this is because the high increase in population, dwindling agricultural areas, and the depletion of scarce natural resources [23]. As a result of decreasing yields in various main crops and decreasing supplies of natural resources such as fresh water and arable land, the situation has become worse. Farmers are also concerned about a changing composition of the agricultural workforce. As a result, agricultural labor has decreased in the vast majority of nations [24]. In response to a shrinking agricultural workforce, farmers have begun implementing internet connection solutions into their daily operations in an effort to minimize the amount of human labor required.

By assuring excellent yields, profitability, and environmental preservation, IoT technologies aim to assist farmers narrow the supply-demand gap [25]. Precision agriculture uses IoT to enhance yields while lowering costs [26]. Agriculture's IoT includes specialized equipment, wireless connections, software, and IT services. More than 75 million IoT devices in agriculture are expected to be installed by 2020, with yearly adoption expanding at a rate of 20 percent [27]. As a result of this, it is predicted that the worldwide smart agriculture industry would quadruple in size by 2025 [28].

An IoT-enabled smart farming system helps to decrease waste, increase productivity in the fields and farm vehicles, and optimize the use of resources like water, energy, and fertilizer by analyzing data from sensors on the farm [29]–[31]. Smart farming solutions for IoT use sensors to keep tabs on the agricultural field (light, humidity, temperature, moisture in the soil, crop health, etc.) and automate watering [32]. Farmers can keep tabs on their fields from anywhere at any time. Additionally, they may choose between manual and automatic solutions for taking the appropriate steps depending on this information. As a result, farmers may use sensors to activate irrigation when soil moisture levels fall [33], [34].

An important part of the smart farming method is data gathered by sensors and control systems as well as robots and autonomous vehicles along with automated hardware and variable rate technologies. Motion sensors and button cameras as well as wearable gadgets are also included [26], [27]. For a wide range of agricultural applications including crop health evaluation, irrigation management, crop monitoring, crop spraying, planting, and soil and field analysis ground- and air-based drones are being deployed [30], [31]. Geofencing for livestock and livestock tracking the location, well-being, and health of cattle may be tracked through wireless IoT apps. In addition to lowering labor expenses, this data aids in the prevention of disease transmission [32], [33].

An IoT-enabled smart greenhouse monitors and regulates the environment automatically, eliminating the need for human involvement. Artificial networks employ sensor data from the farm to anticipate the crop's production rate. A wide range of variables, such as soil type and moisture content, are included in this data set. Farmers may get precise soil data through a dashboard, or a mobile app developed specifically for their needs [29], [30], [33]. Therefore, IoT in agriculture is a promising field and it has implication for the food security of nations. However, few of the prior literature examine the determinant of adopting the IoT in agriculture and in particular in developing countries such as Iraq.

2.2 Theoretical framework of IoT adoption

IoT is a new technology that has developed largely during the last two decades that aims to enhance the quality of living for all individuals. The technology is based on the connectivity of everything to anything at any time and facilitate the interaction among devices [35]. IoT is new pattern in the wireless communication between machines and things [36]. TAM model is one of the theoretical adoption theories that is being used widely to explain the adoption of IoT. TAM proposed that ease of use or perceived complexity (PC) is critical for the adoption along with the perception of usefulness which is similar to other terms such as relative advantage and performance expectancy [37]. In agriculture context, [9] in the US examined the adoption of IoT using the TAM model. The findings showed that trust affects positively the PV and negatively the perceived risk. PV affected positively and perceived risk affected negatively the IoT adoption. Along with TAM, the TPB is also deployed by researchers. [38] used TPB to explain the adoption of smart device. SN was a critical factor for smart device usage. Additional contextual factors are related to the cost saving [7], reliability [39], and size [9]. In this paper, the TAM and TPB are deployed to explain the IUIoT by farmers.

2.3 Conceptual Framework and Hypotheses Development

The framework of this study is developed based on TAM and TPB. PU from TAM and PC which is similar to PEOU [37] are proposed to affect the IUIoT. SN from TPB is anticipated to have a positive impact on IUIoT. In addition, reliability and cost saving are predicted to have a significant effect on IUIoT. The PV is predicted to mediate the impact of PU, PC, SN, and reliability on IUIoT. Land size is placed in this research as a moderating variable between PV and IUIoT. Figure 1 shows the conceptual framework.

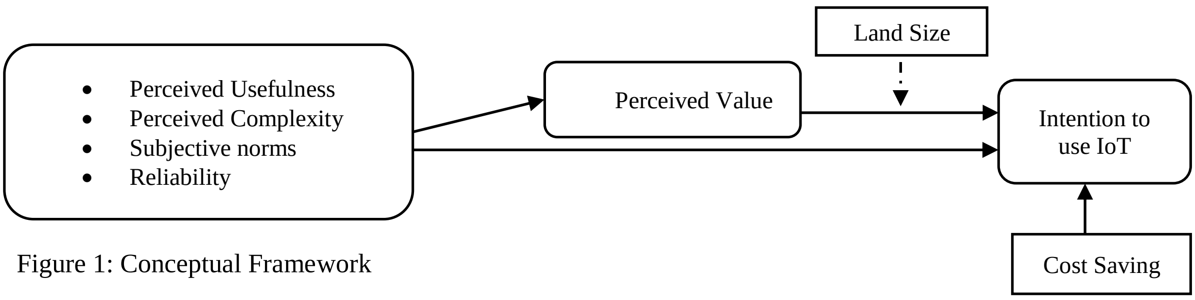

Figure 1: Conceptual Framework

2.3.1 PU and IUIoT

PU is one of the variables of TAM and it is considered as important predictor of the technology adoption. Several studies in the literature indicated that there is a positive link between PU and IUIoT. For instance, PU affected positively the IUIoT in smart home in China [40]. PU also affected the attitude toward using IoT in smart transport system [41], PV of IoT in Taiwan [42], behavioural IUIoT in Library [42]. In this study, farmers who perceived IoT to be useful will tend to use the IoT in agriculture. Accordingly, the following is proposed;

H1: PU impacts positively the IUIoT

2.3.2 PC and IUIoT

PC is used in diffusion of innovation theory (DOI) by [43]. It is similar to other terms such as effort expectancy, and PEOU [37]. PC is among the variables that impact the IoT usage in Malaysia [44]. It was also found to have a significant effect on resistance to use smart device in France [45]. In this study, farmers who perceive the IoT to be complex and difficult to be used, they will tend to not use the IoT. Thus, it is proposed that PC of IoT will positively impact the IUIoT.

H2: PC affects negatively the IUIoT.

2.3.3 SN and IUIoT

The subjective norm is one of the variables of TPB and it is about the influence that exert by others on an individual to use a technology such as IoT. SN was examined in the context of IoT. For example, [46] found that SN affected positively the IUIoT smart connected devices in New Zealand. Other terms that is similar to SN such as social influence [37] were found to have a significant positive effect on IUIoT smart home [47], intention to adopt IoT [48]. In this study, the effect of others who are using or intent to use the IoT will have a positive impact on the decision of farmers to use the IoT. Accordingly, this study proposed the following.

H3: SN impacts positively the IUIoT.

2.3.4 Reliability and IUIoT

The reliability of IoT is critical for using the technology. Few studies examine the effect of reliability of the IUIoT. Reliability of the IoT services affected the intention of consumers in Saudi Arabia [39]. Reliability also affected positively the IUIoT cloud among SMEs in India [7]. In this study, reliability of the IoT will have a positive impact on the IUIoT among farmers. In this study, the following is proposed:

H4: Reliability of IoT services affects positively the IUIoT.

2.3.5 Cost saving and IUIoT

The cost saving is critical in all business and agriculture is no exception. The effective management of IoT using machine to machine communication which enables the machine learning will help in reducing the cost of agriculture [13], [49]. Cost saving was examined in limited number of studies. For instance, [7] among SMEs in India found that cost saving is one of the critical factors for adopting IoT cloud. [50] in Iraq found that cost in significant predictors of doctors' use of IoT. On the other hand, [51] found that perceived cost is insignificant factor for using IoT among Italian logistic companies. In this study, the cost saving and in particular in the context of developing countries such as Iraq is critical for farmers to have strong IUIoT. Thus, the following is proposed:

H5: Cost saving affects positively the intention to use IoT.

2.3.6 PV as a mediator

PV is a comparison between the paid value and the received value. In other term, farmer compared the value that they received with the value that they pay for having the services. [52] in US found that variables of TAM such as PU and PEOU affected the PV of IoT. [42] found that PU affected the PV which in turn affected the adoption of IoT. Few studies examined the mediating role of PV. For instance, [9] in US deployed PV as a mediator between trust and IUIoT in agriculture. The findings showed that PV mediated the effect of trust on IUIoT. In UK, PV mediated the effect of PU on IUIoT [53]. In this research, the PV is proposed as a mediating variable between PU, PC, SN, and reliability on IUIoT. Thus, the following is proposed.

H6: PV positively mediate the impact of PU on IUIoT.
H7: PV positively mediate the impact of PC on IUIoT.
H8: PV positively mediate the impact of SN on IUIoT.
H9: PV positively mediate the impact of on IUIoT.

2.3.7 Land Size as a Moderator

Land size is measured by the HA that each farmer owns. Most of studies on moderating role of size were conducted in corporate governance studies [54]. In technology adoption, few deployed this variable. For instance, firm size as a variable was deployed in the study of [9] in US in adopting IoT in agriculture and it was found that size is critical for the adoption. Firm size was found to affect the adoption of IoT in Italy [51]. Size moderated the effect of technology usage on technology effectiveness [55]. However, in the context of Iraq, the farmers are the owners of the land. Thus, farmers with large land size will benefit from the economic scale and tend to use the IoT and vice versa. In this study, land size is expected to moderate the effect of PV on IUIoT.

H10: land size moderates the effect of PV on IUIoT.

3 Research Methodology

In conducting a research, the researchers have to determine the population, sampling, and instrument of data collection [56]. A questionnaire is used to gather data for this quantitative research. This research focuses on farmers in Iraq. Purposive sampling is used since there is no database or association of Iraqi farmers. Farmers with a bachelor's degree are selected for this research. Accordingly, farmers with less than a high school education were not included. A questionnaire is used to gather the data. The factors were taken from a variety of sources that have researched the adoption of IoT and other technologies. The measurement of PU (5 items) and IUIoT (3 items) were adopted from [21], [57], measurement of PC (4 items) adopted from [43], measurement of reliability (4 items) was adopted from [7] and measurement of SN (5 items) was adopted from [22], measurement of PV was adopted from [58]. Experts in Arabic and English translated the measurement using back-to-back translation and independently validated the measurement. A pilot study was conducted on 30 farmers to assess the reliability and all the measurement were found reliable with Cronbach's Alpha (CA) greater than 0.70 as recommended by [59]. Data was collected using online questionnaire. A total of 238 questionnaires were collected. Seven were removed because they are empty making the valid responses accounts to 231. The data is analyzed using SPSS and Smart PLS.

4 Findings

This part of the research elaborates on the data examination, background of the participants, and analysis of measurement and structural model.

4.1 Data examination

A number of analyses, including missing values, outliers, normality, and multicollinearity, were scrutinized in the data set under consideration. The missing value analysis was conducted using frequency analysis. No missing value were found due to the use of "required function" in online questionnaire. However, eight answers were deleted due to outliers' existence. This makes the valid responses 223. The data is distributed normally because the curve shows a bell-shaped and the values of the skewness (SK) and kurtosis (KU) are less than one (1). There is no problem with multicollinearity since VIF (variation inflation factors) are less than 5 and tolerance is more than 0.20 as shown in Table 1.

Table 1: Data Examination

Variable	Response	Normality		Multicollinearity	
		SK	KU	Tolerance	VIF
PU	223	-.41	-.48	.35	1.89
PC	223	-.31	-.63	.43	1.73
SN	223	-.44	-.49	.51	1.32
Reliability	223	-.51	-.41	.49	1.15
Cost saving	223	-.63	-.43	.61	1.49
PV	223	-.39	-.48	.49	1.88
IUIoT	223	-.76	-.61		

4.2 Profile of Respondents

A total of 223 respondents have participated in this study. The respondents are majority males (92%) and this could be due to the fact that farming is a male dominant industry. The respondents are holders of bachelor degree (87%) and this could be also due to the purposive selection of educated farmers. the respondents are in the age group between 40-50 years (53%) with experience of using technology (61%) of more than five years. The land size for the majority (61%) ranged between 10-30 ha.

4.3 Measurement Model

The measurement model (MM) was evaluated based on the suggestions of [60]. Factor loading (FL) showed that some items have loading less than 0.70 and they were removed. This includes items from PU and SN. The reliabilities (CA and Composite reliability (CR)) are larger than the recommended value of 0.70. average variance extracted (AVE) is larger than 0.50. This leads to a conclusion that the convergent validity has been fulfilled in this research. In addition, the root square of AVE is greater than the cross loading supports the fulfilment of discriminant validity as shown in Table 2.

4.4 Structural Model

For evaluating the structural model (SM), [52] suggested to examine the values of R-square (greater than 0.25 is acceptable), Q-square (greater than zero is acceptable), F-square (greater than 0.02). In addition, the path coefficient should be tested. Figure 2 presents a graphical demonstration of the SM.

4.5. Hypotheses Testing

The hypotheses were tested using the SM of Smart PLS. H1 proposed a direct effect between PU and IUIoT. Table 3 shows confirmed the hypothesis is significant (B=0.10, P<0.05). H1 is supported. The effect of PC on IU is positive. Thus, H2 is supported. For H3, the effect of SN on IUIoT is positive at B=0.12 and P-value less than 0.05. The fourth hypothesis proposed a direct link between reliability and IUIoT. H4 is accepted since the p-value is less than 0.05. for H5, the cost saving affected positively the IUIoT. Thus, H5 is supported.

Table 2: Result of the Measurement Model

	CA	CR	AVE	PC	CS	IUIoT	PU	PV	RE	SN
PC	0.92	0.94	0.80	0.90						
CS	0.91	0.94	0.74	0.28	0.86					
IUIoT	0.93	0.95	0.79	0.45	0.46	0.89				
PU	0.94	0.95	0.84	0.62	0.34	0.46	0.92			
PV	0.92	0.94	0.80	0.26	0.40	0.43	0.35	0.89		
RE	0.90	0.93	0.78	0.35	0.46	0.44	0.38	0.35	0.88	
SN	0.88	0.92	0.74	0.58	0.44	0.47	0.60	0.35	0.38	0.86

Note: PC: Perceived complexity, CS: cost saving, IUIoT: Intention to use IoT, PU: Perceived usefulness, PV: Perceived value, RE: Reliability, SN: Subjective norms.

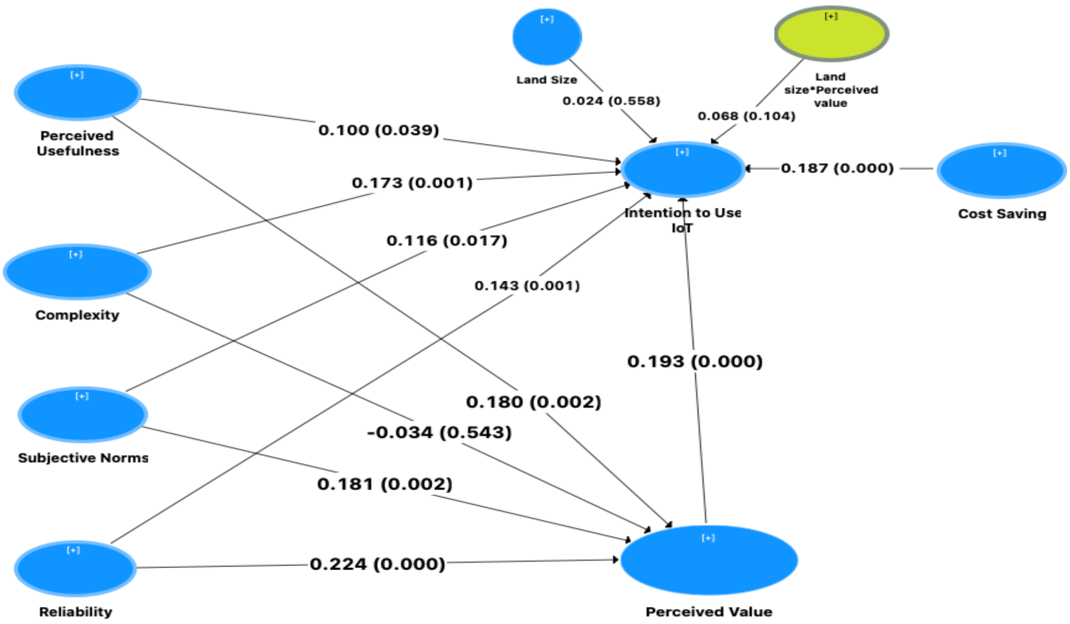

Figure 2: Structural Model

The direct and indirect effect were compared to test the mediation role of PV. The PV as shown in Table 3 has a partial mediation role between the variables (PU, SN, and reliability) and full mediation role between PC and IUIoT. Therefore, H6, H7, H8, and H9 are supported. For the moderating effect of land size, the moderating is tested using product indicator approach. The findings as shown in Table 3 indicated that land size did not moderate the effect of PV on IUIoT. Thus, H10 is rejected.

Table 3 shows the results of assessing the SM. Value of R-square is 0.41 indicating that 41% of the variation in the IUIoT can be explained by the variables. The Q-square as shown in Table 3 is larger than zero indicating that the independent variable can predict the dependent variable. The F-square is larger than 0.02 for all paths except for the moderator and the effect of PC on PV. Moreover, Table 3 shows the hypotheses (H), path, path coefficient (B), standard deviation (Std.), T-value (T), P-value (P), f-square (f^2), Q-square (Q^2), and R-square (R^2).

Table 3: Result of Structural Model

H	Path	B	Std.	T	P	f^2	Q^2	R^2
H1	PU -> IUIoT	0.10	0.05	1.97	0.05	0.03	0.32	0.41
H2	PC -> IUIoT	0.17	0.05	3.39	0.00	0.03		
H3	SN -> IUIoT	0.12	0.05	2.49	0.01	0.04		
H4	Reliability -> IUIoT	0.14	0.04	3.22	0.00	0.04		
H5	Cost Saving -> IUIoT	0.19	0.05	3.83	0.00	0.05		
Mediator								
	PV -> IUIoT	0.19	0.04	4.58	0.00	0.03	0.35	0.43
H6	PU -> PV -> IUIoT	0.03	0.01	2.48	0.01	0.03		
H7	PC -> PV -> IUIoT	-0.01	0.01	0.56	0.58	0.01		
H8	SN -> PV -> IUIoT	0.03	0.01	2.53	0.01	0.04		
H9	Reliability -> PV -> IUIoT	0.04	0.01	3.20	0.00	0.04		
Moderator								
	Land Size -> IUIoT	0.02	0.04	0.62	0.54	0.00	0.39	0.44
H10	Land size*PV -> IUIoT	0.07	0.04	1.66	0.10	0.01		

5 Discussion and Implications

This study was conducted to understand the factors that lead to the IUIoT. The study contributed to the literature by examining the factor that led to the IUIoT in agriculture industry in developing countries. The study also contributed to the literature by examining the moderating role of land size and the mediating role of PV. The findings showed that the PU, PC, SN, and reliability as well as the cost saving are critical for the IUIoT among farmers in Iraq. These findings indicate that decision makers can capitalize on the usefulness of IoT as well as its reliability and ease of use to enhance the usage of this technology in the agriculture industry. The reliability of the services that are provided by the IoT and the ability of reducing the cost of agriculture are encouraging factors for farmers to deploy the technology. These findings are in line with the findings of prior literature such as [40] [41] [42] [42]. The mediating role of PV was confirmed among the variables and the IUIoT.

The findings indicate that PV mediated fully the effect of PC with IUIoT. PU mediated partial the effect of other variables such as PU, reliability, and SN on IUIoT. This indicates that high PV might lead farmers to deploy the technology despite the notion that it might be complex. In addition, PV can explain part of the relationship between PU, reliability and SN with IUIoT. The moderating role of land size was not confirmed in this study. Large land size or small is not a matter for the IUIoT by farmer. More benefits and ease to use as well as reliable and the cost-effective services are the reason for the adoption rather than the land size. In other words, farmers with small or large land size might have the same IUIoT.

As shown by prior literature, the importance of using IoT in agriculture is increasing and it is considered critical for nations to achieve the food security [27] [28] [32] [33], [34]. Based on these findings, decision makers are recommended to create a positive reputation about the usage of IoT among farmers. the benefits of the IoT should be highlighted. Ministry of agriculture can hold workshops and courses to increase the awareness of IoT and its implications for farming and agriculture. Field experiment about the usage of IoT can be administrated to farmers to increase their IUIoT.
Having knowledge about the cost saving and the reliability of IoT will enhance the IUIoT among farmers.

6 Conclusion

This study was conducted in Iraq. The findings showed that PU, PC, SN, cost saving, and reliability are critical factors for the IUIoT. In addition, PV mediated full the effect of PC and partially the effect of PU, SN, and reliability on IUIoT. Land size did not moderate the effect of PV on IUIoT. The study deployed a purposive sampling technique which might reduce the generalization of the findings. The study was conducted on farmers in Iraq. As a way forward, future studies are recommended to deploy a random sampling technique and to examine the factors that lead to the usage of IoT in other countries. The future work is suggested to include other variables that can explain the IUIoT such as the internet speed and the local coverage of the internet. Additional variables can be the availability of the services. Decision makers are recommended to ease the process of IoT for farmers and to increase the awareness about the benefits of using the IoT so that the farmers can deploy this technology to increase the productivity of land and the contribution of this sector to the economy and the employment.

References

[1] M. K. Kagita, M. Kaosar, and N. Thilakarathne, "Survey on AI-based IoT and drone-equipped smart agriculture," *Artif. Intell. Things Smart Environ. Appl. Transp. Logist.*, p. 101, 2022. https://www.degruyter.com/document/doi/10.1515/9783110760477-007/html

[2] F. A. Almalki, B. O. Soufiene, S. H. Alsamhi, and H. Sakli, "A low-cost platform for environmental smart farming monitoring system based on IoT and UAVs," *Sustainability*, vol. 13, no. 11, p. 5908, 2021. https://www.mdpi.com/2071-1050/13/11/5908.

[3] A. Hong, C. Nam, and S. Kim, "What will be the possible barriers to consumers' adoption of smart home services?," *Telecomm. Policy*, vol. 44, no. 2, p. 101867, 2020. https://www.sciencedirect.com/science/article/abs/pii/S0308596119301983?via%3Dihub

[4] Malallah FL, Saied MG, Alasaady MT, Shareef BT. Internet of things: Web-based questionnaire for university evaluation. The Scientific Journal of Cihan University–Slemani PP. 2019;26:44. https://sj.sulicihan.edu.krd/internet-of-things-web-based-questionnaire-for-university-evaluation/

[5] D. Dhagarra, M. Goswami, and G. Kumar, "Impact of Trust and Privacy Concerns on Technology Acceptance in Healthcare: An Indian Perspective," *Int. J. Med. Inform.*, vol. 141, no. February, p. 104164, 2020. https://www.sciencedirect.com/science/article/pii/S1386505620302276?via%3Dihub

[6] J. Lorente-Martínez, J. Navío-Marco, and B. Rodrigo-Moya, "Analysis of the adoption of customer facing InStore technologies in retail SMEs," *J. Retail. Consum. Serv.*, vol. 57, no. June, p. 102225, 2020.

https://www.sciencedirect.com/science/article/abs/pii/S0969698920300643?via%3Dihub

[7] V. S. Narwane, R. D. Raut, B. B. Gardas, M. S. Kavre, and B. E. Narkhede, "Factors affecting the adoption of cloud of things: The case study of Indian small and medium enterprises," *J. Syst. Inf. Technol.*, vol. 21, no. 4, pp. 397–418, 2019. https://www.emerald.com/insight/content/doi/10.1108/JSIT-10-2018-0137/full/html

[8] C. Yoon, D. Lim, and C. Park, "Factors affecting adoption of smart farms: The case of Korea," *Comput. Human Behav.*, vol. 108, no. May 2019, p. 106309, 2020. https://www.sciencedirect.com/science/article/abs/pii/S0747563220300637?via%3Dihub

[9] P. Jayashankar, S. Nilakanta, W. J. Johnston, P. Gill, and R. Burres, "IoT adoption in agriculture: the role of trust, perceived value and risk," *J. Bus. Ind. Mark.*, vol. 33, no. 6, pp. 804–821, 2018. https://www.emerald.com/insight/content/doi/10.1108/JBIM-01-2018-0023/full/html

[10] P. K. Dutta and S. Mitra, "Application of agricultural drones and IoT to understand food supply chain during post COVID-19," *Agric. Informatics Autom. Using IoT Mach. Learn.*, pp. 67–87, 2021. https://onlinelibrary.wiley.com/doi/10.1002/9781119769231.ch4

[11] Malallah F, Al-Jubouri A, Sabaawi A. Smiling and non-smiling emotion recognition based on lower-half face using deep-learning as convolutional neural network. InProceedings of the 1st International Multi-Disciplinary Conference Theme: Sustainable Development and Smart Planning, IMDC-SDSP 2020, Cyperspace, 28-30 June 2020. https://eudl.eu/doi/10.4108/eai.28-6-2020.2298175

[12] Omran T, Sharef BT, Hadjar K, Subramanian S. Machine Learning for Improving Teaching Methods Through Sentiment Analysis. Appl. Math. 2020;14(2):309-17. https://www.naturalspublishing.com/files/published/154cu611k7w9vw.pdf

[13] R. Akhter and S. A. Sofi, "Precision agriculture using IoT data analytics and machine learning," *J. King Saud Univ. Inf. Sci.*, 2021. https://www.sciencedirect.com/science/article/pii/S1319157821001282?via%3Dihub

[14] AlRubaiei M, sh Jassim H, Sharef BT, Safdar S, Sharef ZT, Malallah FL. Current vulnerabilities, challenges, and attacks on routing protocols for mobile ad hoc network: a review. Swarm Intelligence for Resource Management in Internet of Things. 2020 Jan 1:109-29. *Conference for Emerging Technology (INCET)*, 2020, pp. 1–5. https://www.sciencedirect.com/science/article/pii/B9780128182871000127?via%3Dihub

[15] A. Sharma, A. Jain, P. Gupta, and V. Chowdary, "Machine learning applications for precision agriculture: A comprehensive review," *IEEE Access*, vol. 9, pp. 4843–4873, 2020. https://ieeexplore.ieee.org/document/9311735

[16] W.-S. Kim, W.-S. Lee, and Y.-J. Kim, "A review of the applications of the internet of things (IoT) for agricultural automation," *J. Biosyst. Eng.*, vol. 45, no. 4, pp. 385–400, 2020. https://link.springer.com/article/10.1007/s42853-020-00078-3

[17] A. Khanna and S. Kaur, "Evolution of Internet of Things (IoT) and its significant impact in the field of Precision Agriculture," *Comput. Electron. Agric.*, vol. 157, pp. 218–231, 2019. https://www.sciencedirect.com/science/article/abs/pii/S0168169918316417?via%3Dihub

[18] Alrubaiei MH, Al-Saadi MH, Shaker H, Sharef B, Khan S. Internet of Things in Cyber Security Scope. InBlockchain Technology and Computational Excellence for Society 5.0 2022 (pp. 146-187). IGI Global. https://www.igi-global.com/chapter/internet-of-things-in-cyber-security-scope/295169

[19] United Nations, "Agriculture value chain study in Iraq: Dates, grapes, tomatoes and wheat," 2021. https://www.wfp.org/publications/agricultural-value-chain-study-iraq-dates-grapes-tomatoes-and-wheat-2021

[20] Dataprot, "Internet of Things statistics for 2022 - Taking Things Apart," 2022. https://dataprot.net/statistics/iot-statistics/#:~:text=The%20global%20IoT%20healthcare%20market,worth%20%24158.1%20billion%20in%202022.&text=According%20to%20the%20most%20recent,industry%20was%20worth%20%2414.28%20billion.

[21] F. D. Davis, "Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology," *Source MIS Q.*, vol. 13, no. 3, pp. 319–340, 1989. https://www.jstor.org/stable/249008?origin=crossref

[22] I. Ajzen, "The theory of planned behavior," *Organ. Behav. Hum. Decis. Process.*, 1991. https://www.sciencedirect.com/science/article/abs/pii/074959789190020T

[23] Yahya N. Agricultural 4.0: Its implementation toward future sustainability. InGreen Urea 2018 (pp. 125-145). Springer, Singapore. https://link.springer.com/chapter/10.1007/978-981-10-7578-0_5

[24] X. Chen, C. Shuai, Y. Zhang, and Y. Wu, "Decomposition of energy consumption and its decoupling with economic growth in the global agricultural industry," *Environ. Impact Assess. Rev.*, vol. 81, p. 106364, 2020. https://www.sciencedirect.com/science/article/abs/pii/S0195925519304019?via%3Dihub

[25] A. Z. Abideen, V. P. K. Sundram, J. Pyeman, A. K. Othman, and S. Sorooshian, "Food Supply Chain

Transformation through Technology and Future Research Directions—A Systematic Review," *Logistics*, vol. 5, no. 4, p. 83, 2021. https://www.mdpi.com/2305-6290/5/4/83

[26] A. D. Boursianis *et al.*, "Internet of things (IoT) and agricultural unmanned aerial vehicles (UAVs) in smart farming: A comprehensive review," *Internet of Things*, vol. 18, p. 100187, 2022. https://www.sciencedirect.com/science/article/abs/pii/S2542660520300238?via%3Dihub

[27] N. N. Misra, Y. Dixit, A. Al-Mallahi, M. S. Bhullar, R. Upadhyay, and A. Martynenko, "IoT, big data and artificial intelligence in agriculture and food industry," *IEEE Internet Things J.*, 2020. https://ieeexplore.ieee.org/document/9103523

[28] E. Gomes, A. Banos, P. Abrantes, J. Rocha, S. B. P. Kristensen, and A. Busck, "Agricultural land fragmentation analysis in a peri-urban context: From the past into the future," *Ecol. Indic.*, vol. 97, pp. 380–388, 2019. https://www.sciencedirect.com/science/article/abs/pii/S1470160X1830791X?via%3Dihub

[29] B. B. Sinha and R. Dhanalakshmi, "Recent advancements and challenges of Internet of Things in smart agriculture: A survey," *Futur. Gener. Comput. Syst.*, vol. 126, pp. 169–184, 2022. https://www.sciencedirect.com/science/article/abs/pii/S0167739X21003113?via%3Dihub

[30] V. K. Quy *et al.*, "IoT-Enabled Smart Agriculture: Architecture, Applications, and Challenges," *Appl. Sci.*, vol. 12, no. 7, p. 3396, 2022. https://www.mdpi.com/2076-3417/12/7/3396

[31] A. A. R. Madushanki, M. N. Halgamuge, W. A. H. S. Wirasagoda, and S. Ali, "Adoption of the Internet of Things (IoT) in agriculture and smart farming towards urban greening: A review," *Int. J. Adv. Comput. Sci. Appl.*, vol. 10, no. 4, 2019. https://thesai.org/Publications/ViewPaper?Volume=10&Issue=4&Code=IJACSA&SerialNo=2

[32] P. Chanak and I. Banerjee, "Internet-of-Things-enabled smartvillages: An overview," *IEEE Consum. Electron. Mag.*, vol. 10, no. 3, pp. 12–18, 2020. https://thesai.org/Publications/ViewPaper?Volume=10&Issue=4&Code=IJACSA&SerialNo=2

[33] M. A. Haque, S. Haque, D. Sonal, K. Kumar, and E. Shakeb, "Security enhancement for IoT enabled agriculture," *Mater. Today Proc.*, 2021. https://www.sciencedirect.com/science/article/pii/S2214785320401695?via%3Dihub

[34] R. Maheswari, H. Azath, P. Sharmila, and S. S. R. Gnanamalar, "Smart village: Solar based smart agriculture with IoT enabled for climatic change and fertilization of soil," in *2019 IEEE 5th International Conference on Mechatronics System and Robots (ICMSR)*, 2019, pp. 102–105. https://ieeexplore.ieee.org/document/8835454

[35] G. Alazie Dagnaw and S. Ebabye Tsige, "Impact of Internet of Thing in Developing Country: Systematic Review," *Internet Things Cloud Comput.*, vol. 7, no. 3, p. 65, 2019. https://www.sciencepublishinggroup.com/journal/paperinfo?journalid=238&doi=10.11648/j.iotcc.20190703.12

[36] H. Hamidi, "An approach to develop the smart health using Internet of Things and authentication based on biometric technology," *Futur. Gener. Comput. Syst.*, vol. 91, pp. 434–449, 2019. https://www.sciencedirect.com/science/article/abs/pii/S0167739X18313517?via%3Dihub

[37] V. Venkatesh, M. Morris, G. Davis, and F. Davis, "User Acceptance of Information Technology: Toward a Unified View," *MIS Q.*, vol. 27, no. 3, pp. 425–478, 2003. https://www.jstor.org/stable/30036540

[38] M. Mital, V. Chang, P. Choudhary, A. Papa, and A. K. Pani, "Adoption of Internet of Things in India: A test of competing models using a structured equation modeling approach," *Technol. Forecast. Soc. Change*, vol. 136, pp. 339–346, 2018. https://www.sciencedirect.com/science/article/abs/pii/S0040162517302949?via%3Dihub

[39] A. AlHogail, "Improving IoT Technology Adoption through Improving Consumer Trust," *Technologies*, vol. 6, no. 3, p. 64, 2018. https://www.mdpi.com/2227-7080/6/3/64

[40] X. Dong, Y. Chang, Y. Wang, and J. Yan, "Understanding usage of Internet of Things (IOT) systems in China: Cognitive experience and affect experience as moderator," *Inf. Technol. People*, vol. 30, no. 1, pp. 117–138, 2017. https://www.emerald.com/insight/content/doi/10.1108/ITP-11-2015-0272/full/html

[41] S. M. E. Sepasgozar, S. Sargolzaei, S. M. E. Sepasgozar, I. Kamardeen, and S. Sargolzaei, "A model for increasing the security of internet of things in smart transportation systems," *ISARC 2018 - 35th Int. Symp. Autom. Robot. Constr. Int. AEC/FM Hackathon Futur. Build. Things*, no. Isarc, 2018. http://www.iaarc.org/publications/2018_proceedings_of_the_35th_isarc/a_model_for_increasing_the_security_of_internet_of_things_in_smart_transportation_systems.html

[42] Hsu CL, Lin JC. Exploring factors affecting the adoption of internet of things services. Journal of Computer information systems. 2018 Jan 2;58(1):49-57. https://www.tandfonline.com/doi/abs/10.1080/08874417.2016.1186524

[43] Rogers EM, Singhal A, Quinlan MM. Diffusion of innovations. InAn integrated approach to communication theory and research 2014 Apr 8 (pp. 432-448). Routledge. https://www.taylorfrancis.com/chapters/edit/10.4324/9780203887011-36/diffusion-innovations-everett-rogers-arvind-singhal-margaret-quinlan

[44] Salleha SM, Daudb NM. Probing the influence of Internet of Things (IOT) usage on the grassroots

innovators' sustainability: A Malaysian perspective. International Journal of Innovation, Creativity and Change. 2019;7(4):181-95. https://www.researchgate.net/profile/Mohd-Norzaidi/publication/337884778_Probing_the_Influence_of_Internet_of_Things_IOT_Usage_on_the_Grassroots_Innovators'_Sustainability_A_Malaysian_Perspective/links/5e8abfe1a6fdcca789f7e77c/Probing-the-Influence-of-Internet-of-Things-IOT-Usage-on-the-Grassroots-Innovators-Sustainability-A-Malaysian-Perspective.pdf

[45] I. Chouk and Z. Mani, "Factors for and against resistance to smart services: role of consumer lifestyle and ecosystem related variables," *J. Serv. Mark.*, vol. 33, no. 4, pp. 449–462, 2019. https://www.emerald.com/insight/content/doi/10.1108/JSM-01-2018-0046/full/html

[46] E. D. T. Jaspers and E. Pearson, "Consumers' acceptance of domestic Internet-of-Things: The role of trust and privacy concerns," *J. Bus. Res.*, vol. 142, no. January, pp. 255–265, 2022. https://www.sciencedirect.com/science/article/abs/pii/S0148296321009589?via%3Dihub

[47] I. Mashal and A. Shuhaiber, "What makes Jordanian residents buy smart home devices?: A factorial investigation using PLS-SEM," *Kybernetes*, vol. 48, no. 8, pp. 1681–1698, 2019. https://www.emerald.com/insight/content/doi/10.1108/K-01-2018-0008/full/html

[48] Van Thuy N. The adoption of the internet of things in Vietnam. International Journal of Innovation, Creativity and Change. 2020;12(4):22-35. https://ijicc.net/images/vol12/iss4/12403_Thuy_2020_E_R1.pdf

[49] R. Sharma, S. S. Kamble, A. Gunasekaran, V. Kumar, and A. Kumar, "A systematic literature review on machine learning applications for sustainable agriculture supply chain performance," *Comput. Oper. Res.*, vol. 119, p. 104926, 2020. https://www.sciencedirect.com/science/article/abs/pii/S0305054820300435?via%3Dihub

[50] A. Alhasan, L. Audah, I. Ibrahim, A. Al-Sharaa, A. S. Al-Ogaili, and J. M. Mohammed, "A case-study to examine doctors' intentions to use IoT healthcare devices in Iraq during COVID-19 pandemic," *Int. J. Pervasive Comput. Commun.*, 2020. https://www.emerald.com/insight/content/doi/10.1108/IJPCC-10-2020-0175/full/html

[51] A. Rey, E. Panetti, R. Maglio, and M. Ferretti, "Determinants in adopting the Internet of Things in the transport and logistics industry," *J. Bus. Res.*, vol. 131, no. December 2020, pp. 584–590, 2021. https://www.sciencedirect.com/science/article/abs/pii/S014829632030878X?via%3Dihub

[52] Meiryani M, Cornelia C, Kikkawa SD, Ulinnuha H, Lidiyawati L. Examining User Acceptance and Adoption of the Internet of Things in Indonesia. InProceedings of the 6th International Conference on Information System and Data Mining 2022 May 27 (pp. 126-130). https://dl.acm.org/doi/abs/10.1145/3546157.3546176

[53] R. El-Haddadeh, V. Weerakkody, M. Osmani, D. Thakker, and K. K. Kapoor, "Examining citizens' perceived value of internet of things technologies in facilitating public sector services engagement," *Gov. Inf. Q.*, vol. 36, no. 2, pp. 310–320, 2019. https://www.sciencedirect.com/science/article/abs/pii/S0740624X1730446X?via%3Dihub

[54] S. A. Shatnawi, A. Marei, M. M. Hanefah, M. Eldaia, and S. Alaaraj, "Audit Committee and Financial Performance in Jordan: The Moderating Effect of Ownership Concentration," *Montenegrin J. Econ.*, vol. 17, no. 4, pp. 45–53, 2021. http://mnje.com/sites/mnje.com/files/045-053_-_shatnawi_et_al._-_pay_pal_-__nik_-_rrr.pdf

[55] A. Lutfi, M. Al-Okaily, A. Alsyouf, A. Alsaad, and A. Taamneh, "The impact of AIS usage on AIS effectiveness among Jordanian SMEs: A multi-group analysis of the role of firm size," *Glob. Bus. Rev.*, p. 0972150920965079, 2020. https://journals.sagepub.com/doi/10.1177/0972150920965079

[56] S. Alaaraj, Z. A. Mohamed, and U. S. A. Bustamam, "External growth strategies and organizational performance in emerging markets: The mediating role of inter-organizational trust," *Rev. Int. Bus. Strateg.*, 2018. https://www.emerald.com/insight/content/doi/10.1108/RIBS-09-2017-0079/full/html

[57] L. Gao and X. Bai, "A unified perspective on the factors influencing consumer acceptance of internet of things technology," *Asia Pacific J. Mark. Logist.*, vol. 26, no. 2, pp. 211–231, 2014. https://www.emerald.com/insight/content/doi/10.1108/APJML-06-2013-0061/full/html

[58] F. Calza, M. Pagliuca, M. Risitano, and A. Sorrentino, "Testing moderating effects on the relationships among on-board cruise environment, satisfaction, perceived value and behavioral intentions," *Int. J. Contemp. Hosp. Manag.*, vol. 32, no. 2, pp. 934–952, 2020. https://www.emerald.com/insight/content/doi/10.1108/IJCHM-09-2019-0773/full/html

[59] Hair Jr JF, Sarstedt M, Ringle CM, Gudergan SP. Advanced issues in partial least squares structural equation modeling. saGe publications; 2017 Apr 5. https://books.google.com.bh/books?hl=en&lr=&id=-f1rDgAAQBAJ&oi=fnd&pg=PP1&dq=Advanced+issues+in+partial+least+squares+structural+equation+modeling&ots=vY11hpJVbV&sig=a9_-LMdxZ2HUc4I3XYfTycNIDTU&redir_esc=y#v=onepage&q=Advanced%20issues%20in%20partial%20least%20squares%20structural%20equation%20modeling&f=false

[60] Leguina A. A primer on partial least squares structural equation modeling (PLS-SEM). https://www.tandfonline.com/doi/abs/10.1080/1743727X.2015.1005806?journalCode=cwse20