Adoption of internet of things (IoT) in the agriculture industry deploying the BRT framework

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Abstract

Purpose – The purpose of this paper is to investigate the adoption of Internet of Things (IoT) in the agriculture industry by the farmers' in India using the theoretical lens of the behavioral reasoning theory (BRT).

Design/methodology/approach – A survey on farmers was conducted to examine the adoption of IoT in agriculture industry (IoT-A) using BRT. The data analysis of the primary survey was done by applying the structural equation modelling (SEM) technique.

Findings – The 'reasons for' adoption of IoT-A were as follows: Relative advantage, social influence, perceived convenience, and perceived usefulness. The 'reasons against' adoption were as follows: Image barrier, technological anxiety, perceived price and perceived risk. The BRT theory provides the platform to discuss the psychological processing of acceptance of IoT in agriculture industry by the farmers.

Practical implications – This research has unique implications as it studies the rural consumers' behavior of innovation adoption namely IoT in agriculture. It provides the specific reasons 'for' and 'against' IoT adoption in agriculture, which will give directions to the marketers of IoT technology to develop suitable marketing strategies to improve the adoption in rural areas.

Originality/value – This research takes the first step in the direction toward deliberation of the adoption of IoT-A by farmers in an emerging Indian economy using the BRT theory, which discusses the 'reasons for' and 'reasons against' adoption in a proposed model.

Keywords IoT adoption, Agriculture, Farmers, PLS–SEM, Behavioral reasoning theory **Paper type** Research paper

Introduction

Technology has transformed every business and industrial sector in India and the agricultural industry is no exception. Internet of Things (IoT) technology has revolutionized the processes in every industry and it plays a key role in revamping agriculture industry (Muangprathub *et al.*, 2019). Ashton (2009), a pioneer in technology, coined the term IoT (Gubbi *et al.*, 2013). IoT is defined as- "An open and comprehensive network of intelligent objects that have the capacity to auto-organize, share information, data and resources, reacting and acting in case of situations and changes in the environment" (Madakam *et al.*, 2015: pp. 165). IoT technology is an Internet-based dynamic global architecture which is rapidly growing worldwide. IoT is based on the standard communication protocols. Hence, it has the capability of self-configuration with physical and virtual identities along with the integration within the information network (Sundmaeker *et al.*, 2010). With the rapid increase in the population of the world and constraints of resources, it has become necessary to improve crop production to feed the growing population. IoT is a technological innovation that is apt to address this growing concern. IoT-A is useful for the agriculture industry as it facilitates automation and monitoring from anywhere in the world by replacing humans.



Benchmarking: An International Journal © Emerald Publishing Limited 1463-5771 DOI 10.1108/BIJ-08-2019-0361

We would like to thank the respected Editor of the journal and Reviewers for guiding us at every step to improve the research manuscript.

IoT in agriculture industry in India

Received 5 August 2019 Revised 5 December 2019 4 January 2020 Accepted 7 January 2020 IoT-A is gaining popularity as it provides all-time information about health of crops and soil, crop storage conditions, energy consumption, animal behaviour, fertilizers, and machineries utilized (Ahmed *et al.*, 2018). The benefits of IoT-A can be listed in applications as follows: 1) Ear tags and collar units can provide the real-time description of herd location, animal behaviour, grazing time, walking time, water consumption time, and resting time (Lee and Choudhury, 2017). 2) IoT sensors arrayed in vehicles, in water, or on the ground provide the data of crop's health and soil moisture which can be accessed using mobile phones and tablets by farmers as it is stored wirelessly on cloud-based systems or servers (Lee and Choudhury, 2017). 3) Farmers who deal with crops can take smarter decisions regarding soil, crop maturity, air quality, and weather using the data received from IoT sensors (Guerra, 2017).

IoT technology-based applications such as- self-driving tractors, GPS field mapping, sensors in the farm equipment, IoT-based field-level weather forecast, machine optimization tools, and productivity measurement tools are helping for better crop production in the limited availability of arable land, water, and fuel (Jayashankar *et al.*, 2018; Ray, 2017; Talavera *et al.*, 2017). It is forecasted that the global IoT-A market will increase from 2018 to 2023 with a compounded annual growth rate of 14.5 percent and it will be USD 28.65 billion by 2023 (BIS Research, 2018). IoT-A is helpful to avoid losses and to increase productivity. It has also brought about a tremendous change in agriculture management (Kite-Powell, 2015). As per the UN Report (2017), by the year 2050, the world population is predicted to increase to 9.8 billion and feeding these many people are going to be a challenge. Hence, the agriculture industry must leverage IoT technology for farming to improve productivity (Ashford, 2015).

In India, about 58 percent of the population relies on agriculture for their livelihood. The gross value (GDP) added by agriculture industry and associated industries is USD 274.23 billion in 2018 (IBEF, 2018). World Bank predicts that by the year 2050, half the Indian population would be urbanized and the agriculture industry workforce will be reduced by 25.7 percent, which would require technology to enhance the farming process (ETMarkets, 2018). Technology and modern techniques of agriculture are catalysts for improving agriculture produce. IoT technology is helping the farmers to monitor the agriculture process to enhance productivity in the agriculture industry. In India, 40 startups are dealing with agricultural IoT (Chatterjee, 2018). The main challenges in India are the lack of awareness about IoT technology among the farmers and the lack of usage of a high level of technology-based machinery (Chatterjee, 2018).

IoT has helped services, logistics, and manufacturing sector to increase revenue and improve efficiency (Lee and Lee, 2015). There are studies conducted globally to comprehend the IoT adoption in the context of logistics industry (Hsu and Yeh, 2017), IT organization leaders (Kamin, 2017), smart home service (Kim *et al.*, 2017), IoT services (Lee and Shin, 2016), IoT-based smart devices in smart cities of India (Mital *et al.*, 2018), IoT for data-driven asset management (Brouse *et al.*, 2017), IoT in manufacturing (Mourtzis *et al.*, 2016), IoT-based innovation adoption by poor urban communities (Roy *et al.*, 2016); IoT adoption in Italian banks (Ammirato *et al.*, 2018), IoT-based elderly healthcare wearables (Sivathanu, 2018), healthcare technology products (Karahoca *et al.*, 2018), IoT adoption in agriculture industry, and agriculture supply chain in different countries (Jayashankar *et al.*, 2018; Lin *et al.*, 2016; Warren, 2004).

IoT-A aids the farmers regarding soil checkup, weather forecasting, water system automation, and improvement of the quality of the crop (Verma and Usman, 2016). IoT-A is beneficial for the following a) Monitoring of quality of water and soil – selecting the right breed of plants as per the soil's quality, identifying the water-related diseases in ponds on time for applying pesticides and using fertilizers (Ojha *et al.*, 2015). b) Management of irrigation – optimum usage of farm material and water in agriculture (Gutierrez *et al.*, 2014) c) Monitoring of the farm – Monitoring of remote farm and farm machines through automation to avoid delay in agricultural activities and damage of farm (Lerdsuwan

and Phunchongham, 2017). d) Fertilizer usage control - balancing nutrition of soil and ensuring the quality and growth of the crop (Oiha et al., 2015). e) Cattle movement monitoring – monitoring movement of cattles in the farm to avoid damage in the farm (Baranwal et al., 2016). f) Pest management and disease control – effective utilization of pesticides and fertilizers for improving crop quality and yield (Cambra et al., 2014). Thus IoT technology is beneficial to the farmers (Channe et al., 2015). Surprisingly, meager academic research and scholarly work are available in the area of adoption of IoT-A sector in the Indian context. This shows that an imperative need exists to inspect the adoption of IoT for agriculture by farmers in India (Chatterjee, 2018; Khan and Ismail, 2018). There is no empirical study that discusses the behavioral intention to use IoT-A by Indian farmers. The existing studies of technology adoption by farmers and rural households have been addressing the adoption factors (Moya et al., 2016; Amin and Li, 2014; Beza, 2017; Nejadrezaej et al. 2018: Rezaej and Ghofranfarid. 2018: Kante et al. 2018: Zhou. 2017). However, there is a scarcity of research discussing the adoption factors and deterrent factors of new technologies such as IoT for the agriculture industry in a unison framework (Madakam et al., 2015; Elijah et al., 2018; Khanna and Kaur, 2019; Javashankar et al., 2018). This study fills this theoretical gap by exploring the factors 'for' and 'against' the IoT adoption in agriculture industry and forms the research question (RQ) to focus on the farmers' behavior toward IoT in agriculture.

RQ. What are the predictors of behavioral intention to use IoT in agriculture industry by Indian farmers?

This study has the objectives to propose a conceptual model, wherein the authors considered the BRT to study the adoption behaviour of IoT-A by the farmers and validate the proposed theoretical model.

The authors aim to describe the behavioural intention of the farmers by studying the 'reasons for' (RF) and 'reason against' (RA) adoption of IoT-A. The study also investigates the impact of control variables such as farm size and farmer's age on the farmer's adoption intention. This research considered the present studies of IoT (Zhao *et al.*, 2010; Elijah *et al.*, 2018; Jayashankar *et al.*, 2018) to address the RQ. The objective is to identify the behavioral intention to use IoT in agriculture industry by the Indian farmers.

For organizations that are into the development and marketing of new services and products, it is very crucial to investigate whether consumers will adopt the new innovations. Currently, organizations are majorly dependent on the consumer's attitude and perception about the products' characteristics to anticipate the adoption of innovation by consumers. Research in this area was primarily based on technology adoption model (TAM) (Davis, 1989), innovation diffusion theory (IDT) (Rogers, 1983), and theory of reasoned action (TRA) (Ajzen and Fishbein, 1973). However, the diffusion of innovation (DOI) research is broadly criticized for ignoring the factors of resistance of the consumers toward the innovation (Ram, 1987; Ram and Seth, 1989; Garcia et al., 2007). The rate of failure of new services and products was observed to be high. Hence, resistance-based research ideology claimed that instead of comprehending the reasons of adoption, managers and research scholars should pay more emphasis on the factors preventing consumers from innovation adoption (Antioco and Kleijnen, 2010). Our proposed theoretical model is grounded in the BRT literature (Westaby, 2005a, b; Gupta and Arora, 2017a; Sivathanu, 2018; Westaby et al., 2010) which is related to the Theory of Planned Behaviour (TPB) (Aizen and Driver, 1992). It elaborates through a detailed, thoughtful insight into individual behavior and decision-making that considers the particular contextual RF and RA adoption (Westaby, 2005a, b) in the context of IoT in agriculture. This research uniquely contributes to the literature of IoT adoption in agriculture. In the area of technology for agriculture, it is a crucial topic for researchers and practitioners who are eager to investigate the adoption of IoT for agriculture industry at the

farmers' level. This research also provides insights to the government, marketers, policymakers, and IoT experts to understand the farmer's behavioral intention toward IoT in agriculture.

This study is arranged with an additional section of the literature review, which discusses the extant literature and theories considered to develop the proposed theoretical model. The next part of the study includes development of hypotheses and research methodology. Another section of this study addresses the data analysis and results. The study ends with the discussion, implications (theoretical and managerial), the scope for further research, and limitations. The last section includes the conclusion of this study.

Literature review

IoT in agriculture (IoT-A)

IoT technology applications include ubiquitous computing and real-time processing, which have the capability to offer smarter services to the user. IoT is the vast network which connects the people, data, and applications using the Internet. It enables the interactive connectivity, digital management, and control of services (Chaudhary *et al.*, 2016). The fundamental network infrastructure of IoT can connect many smart objects through the Internet, starting from microsensors to heavy vehicles used for agriculture purpose. IoT can be used for farm monitoring, soil and water quality monitoring, intelligent greenhouses, scientific disease and pest monitoring, cattle movement monitoring controlled use of fertilizers, irrigation management, asset tracking, and remote control and diagnosis (Ahmed *et al.*, 2018). IoT-A is endowing farmers with automation technology and decision-making tools which seamlessly connect knowledge, service, and products for better quality along with productivity and profit in farming (Elijah *et al.*, 2018). There exist present studies explaining the applications of IoT-A (Elijah *et al.*, 2018; Patil and Kale, 2017; Ahmed *et al.*, 2018).

Theoretical background

IoT-A is an innovation in technology (Jayashankar *et al.*, 2018). Hence, different adoption models for technology are considered to study the adoption of IoT in various industrial sectors such as TAM, IDT, TRA, TPB, and the unified theory of acceptance and use of technology (UTAUT) (Venkatesh *et al.*, 2003).

The TAM, TRA, and TPB were used to study the adoption of IoT in India (Mital *et al.*, 2018). TAM model was considered to explore the adoption of IoT-based smart home services (Dong *et al.*, 2017; Kim *et al.*, 2017). Adoption of IoT in healthcare technology products was studied using the TAM and IDT model (Karahoca *et al.*, 2018). There are many studies carried out on the adoption of different technologies by the farmers and rural households using the various adoption models as presented in Table I.

Innovation resistance theory (IRT)

The innovation diffusion models and technology adoption models mainly discuss the adoption factors of technology, and not much importance is provided to the consumer's resistance toward the adoption of the innovation. The resistance factors of innovation technology are highlighted in some studies (Ram, 1987; Laukkanen *et al.*, 2007, 2009; Kleijnen *et al.*, 2009). IRT theory suggests the innovation resistance factors of the consumers (Ram, 1987). Resistance or barriers to change or innovation happens when an individual develops conflicts between tradition and innovation (Ram and Sheth, 1989). There are two perspectives to the barriers/resistance to innovation including functional and psychological (Ram and Sheth, 1989). The psychological barrier comprises traditional barrier, and value barrier.

					Т.Т.
Authors	Technology context	IS adoption model and theory	Factors/Variables anal	yzed	agriculture industry in
(Kante <i>et al.</i> , 2019)	Information and communication technologies (ICT)-based farm input information	TAM, DOI, UTAUT, TRA, TPB	Compatability*, lower advantage*, simplicity information quality*, c (ICT)-based farm input	cost*, relative *, social influence, bbservability*, use of t information*	India
(Junior <i>et al.</i> , 2019)	ERP systems in the farm context	TOE, DOI, Inter- organizational relation (IOR)	Compatability*, ERP e advantage*, evaluation	environment*, relative 1*, competitive pressure*	
(Kante <i>et al.</i> , 2018)	(ICT)	TAM, TPB, TRA, TAM 2, UTAUT, SCT, IDT	Simplicity*, cost*, obse advantage*, informatic influence compatibility	ervability*, relative on quality*, social *	
(Nejadrezaei <i>et al.</i> , 2018)	Pressurized irrigation technology	UTAUT	Effort expectancy*, pe facilitating conditions*	rformance expectancy*,	
(Rezaei and Ghofranfarid, 2018)	Rural households' renewable energy	UTAUT, TAM, IDT	Social norms, awarenes perceived behavioral c	ss*, relative advantage*, ontrol*, moral norms*	
(Beza, 2017)	Mobile Short message service (SMS)	UTAUT	Effort expectancy*, tru expectancy*, social inf approach goals, facilita motivation price value	ust*, habit, performance luence, mastery tting conditions, Hedonic *	
(Zhou, 2017)	Solar water pump technology	TAM, UTAUT	Awareness*, perceived tolerance, attitude towa conditions* perceived	l usefulness*, cost ards usage*, facilitating ease of use*	
(Moya <i>et al</i> ., 2016)	Mobile-based communication	UTAUT	Social influence*, effor facilitating conditions*	t expectancy*, , affordability,	
(Amin and Li, 2014)	ICT-based microfinance platform	FTAM	Bangladesh Innovativeness, occupational relevance*, perceived ease of use*, perceived usefulness*, relative advantage, self- efficacy*, social influence	<i>China</i> Perceived ease of use, innovativeness*, perceived usefulness*, self-efficacy, occupational relevance*, social influence*, relative advantage*	
(Moghaddam and Khatoon- abadi, 2013)	New information and communication technology	TAM, TPB, TRA, TAM 2, UTAUT	The individual (user) cl (user's household) char innovation*, knowledg regarding the ICT*	haracteristics*, the social racteristics*, relating to re and skills of user	Table I. Summary: research on technology adoption by farmers and rural
Note: *Significa	int		_ 0		households

The study conducted in Europe to understand the barriers of technological innovations for smart-climate agriculture found that a farmer's belief and opinion are a barrier for adoption (Long *et al.*, 2016). The study discussing the IoT resistance/barriers with reference to smart services found that perceived complexity (usage barrier), perceived risk security and self-image incongruence (image barrier), perceived health risk (risk barrier), need for human interaction (traditional barrier) and inertia (individual barrier) affect the resistance to smart services (Mani and Chouk, 2018).

Behavioral reasoning theory (BRT)

The existing literature discusses the factors of adoption and barriers for technology by farmers and the adoption of IoT by different consumers. However, there is paucity of research addressing both these determinants in a single framework. As per the studies of social psychology, these determinants of barriers and factors for adoption may not be necessarily logically contradicting each other (Westaby et al., 2010). The relative influence of the determinants of resistance and adoption can be studied in a single model. BRT (Westaby, 2005a, b). BRT is an expansion of TPB (Ajzen and Driver, 1992). TPB discusses that intentions are connected to behavior and intentions are mainly influenced by the individual's perceived control, subjective norms, and attitude. TPB is extensively used in social science research (Greve, 2001). BRT discusses the reasoning of the behavior for individual decision-making and it consists of an individual's RF and RA toward the specific behavior which is context-specific (Westaby, 2005a). The decision-making theory (Pennington and Hastie, 1988a, b) and the BRT (Westaby, 2005a). are quite similar; however, BRT indicates the reasons with respect to context specificity which mention the linkages between people, behaviors, global motives, beliefs, and intentions (Westaby, 2005b). Reasons and beliefs differ theoretically. The definition of 'reason' is "specific subjective factors people use to explain their anticipated behavior and can be conceptualized as anticipated reasons, concurrent reasons and post-hoc reasons." Reasons are discussed in two perspectives in BRT wherein RF and RA behave in a particular manner (Westaby, 2005b). Both are distinctly different and are conceptually discussed as benefit/cost, facilitator/constraints and pros/cons to perform a specific behavior (Westaby, 2005a). Adoption of IoT-based wearables for healthcare was investigated using BRT. (Sivathanu, 2018) stated that RF includes convenience, compatibility, ubiquity, and relative advantage while RA includes usage barrier, risk barrier, and traditional barrier. The BRT model is shown in Figure 1.

BRT has been recently used to study the adoption of different innovations (Pillai and Sivathanu, 2018; Claudy and Peterson, 2014; Claudy *et al.*, 2015; Sun and Oh, 2012; Gupta and Arora, 2017a, b; Claudy *et al.*, 2013; Sivathanu, 2018; Karapanos *et al.*, 2017). Hence, in this study, the authors have chosen the BRT as it provides a better explanatory power to understand the RA and RF adoption of IoT in agriculture industry by the farmers in a single theoretical framework.

Theoretical basis of conceptual framework and development of hypotheses

BRT framework provides the adoption factors and impervious factors in a single model for an innovation technology. The BRT mainly explains the critical role of reasoning in the psychological process of behavior (Westaby, 2005a, b). As per the TRA model, Attitude (global construct) is observed as the antecedent of behavioral intention (H1). BRT provides a more robust understanding of the RF and RA adoption that affects attitude (H2a; H2b) and





Figure 1. Behavioral reasoning

theory (Westaby, 2005b) the behavioral intention (H3a; H3b). The individual's values (openness to change) are observed as underlying thoughts that affect his/her reasoning (H4a, H4b) and also influences the attitude (H5), BRT provides a detailed understanding of the RF and RA adoption of the innovation. BRT mentions that the adoption of innovation will be dependent on the context of decision, such as the type of innovation (Westaby, 2005a, b; p. 103). BRT provides the adoption reasons and resistance reasons in a single framework. Figure 2 shows the proposed model, and Table II provide the definition of constructs.

IoT in agriculture industry in India

Figure 2.

Attitude and adoption intentions

Attitude means – "a psychological tendency that is expressed by evaluating a particular entity (e.g.-innovation) with some degree of favour or disfavour" (Eagly and Chaiken, 1998: pp. 1). The research confirmed that attitude affects the behavior of an individual (Fishbein and Ajzen, 1975; Davis, 1989). The studies regarding various innovations found that attitude affects the intention of adoption of renewable energy by rural households in Iran (Rezaei and Ghofranfarid, 2018), new information technology adoption intention by Malaysian agricultural community (Wei et al., 2012), IoT-based wearables in elderly healthcare (Sivathanu, 2018), and innovation adoption (Claudy et al., 2015). IoT for agriculture industry is an innovation for farmers in India and hence, it is imperative to test the influence of the farmer's attitude toward IoT-A on behavioral intention thereby leading to this hypothesis.

H1. Farmer's attitude towards IoT-A will positively affect the adoption intention.

Reasons and attitude

Context-specific reasons predict the attitude toward particular intentions and behaviors because they help individuals defend and justify their activities, which protect and support



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BIJ	Constructs	Definition
	RF (Reason for)	
	Relative advantage	"The degree to which an innovation is perceived as being better than the idea it supersedes." (Percent 102): p. 212)
	Social influence	"Social influence is the extent to which consumers perceive that their peers (e.g., family and friends) believe that they should use a particular table n_{1}^{2} (n_{2}^{2}) n_{1}^{2} (n_{2}^{2}) n_{2}^{2} (n_{2}^{2}) n_{2}^{2} (n_{2}^{2}) n_{2}^{2}) n_{2}^{2}) n_{2}^{2} (n_{2}^{2}) n_{2}^{2}) n_{2}^{2}) n_{2}^{2}) n_{2}^{2} (n_{2}^{2})
	 Perceived convenience 	"The extent to which one can control an IoT system at anytime and from anywhere through wireless of mobile phone or personal computer."
	Perceived usefulness	"The extent to which using an IoT system is perceived as being easy to use." (Dong <i>et al.</i> , 2017: p. 121)
	RA (Reason against)	
	Image barrier	"Image barrier is a percpetual problem that arises due to sterotyped thinking and makes life difficult for an innovation." (Ram and Sheth, 1989; p. 9)
	Technological anxiety	"An individual's apprehension, or even fear, when she/he is faced with the possibility of using computers." (Venkatesh 2000 p. 349)
	Perceived price	"Price is what is given up or sacrificed to obtain a product." (Zeithaml, 1988; p. 10)
	Perceived risk	"A physical risk that refers to the concern that the innovation might be harmful, unhealthy of cause injury". (Mani and Chouk, 2018: p. 59)
Table II.	Value of openness to change	"Values are critical motivators of behaviors and attitudes." (Schwartz, 2012; p. 17)
factor (construct) presented in the framework	Attitude toward adoption of IoT for agriculture	"A psychological tendency that is expressed by evaluating a particular entity (e.g., innovation) with some degree of favour or disfavour." (Eagly and Chaiken, 1998: p. 1)

their self-worth (Westaby, 2005a, b: p. 98). The reasons are defined as "the subjective probability that a specific factor is part of the person's behavioral explanation set" (Westaby, 2005a, b: p. 100). Reasons differ from beliefs as an individual can carry belief regarding the outcome of the adoption of innovation, however, it is not necessary that it would affect the final adoption decision (Claudy et al., 2015). BRT discusses the two perspectives to reasons including RF and RA. It is argued that individuals may have a positive belief toward the adoption of innovation. However, still they might not adopt because of RA the particular behavior (Claudy et al., 2015). Individuals might have RF/RA the adoption of innovation, which will also have a positive/negative attitude toward innovation (Claudy et al., 2015). The innovation adoption studies using BRT provide the empirical evidence that RF and RA form the attitude toward innovation (Pillai and Sivathanu, 2018; Sun and Oh, 2012; Gupta and Arora, 2017b; Siyathanu, 2018; Karapanos et al., 2017). To explain the farmer's RF and RA adoption and their influence on attitude with respect to IoT-A, the hypotheses are posited as follows:

- H2a. Farmer's 'reason for' adoption of IoT-A influences the attitude toward IoT-A adoption.
- H2b. Farmer's 'reason against' IoT-A adoption influences the attitude toward IoT-A adoption.

Reasons and intentions

Individuals are more at ease when they have adequate reasons to justify or preserve their anticipated behaviors (Westaby, 2005a, b). BRT discusses the influence of reasons on the individual's behavioral intention (Westaby, 2005a, b) and explains the context-specific adoption factors influencing the adoption of inventions. The innovation adoption studies confirmed that RF positively influences and RA negatively influences the behavioral intention (Claudy *et al.*, 2015; Sivathanu, 2018; Gupta and Arora, 2017a; Karapanos *et al.*, 2017). IoT is a new technology in agriculture industry for farmers, and there may be many RF and RA that influence the behavioral intentions which need to be tested. Hence, below hypotheses are formed.

- H3a. Farmer's 'reason for' IoT-A adoption influences the adoption intention of IoT-A.
- H3b. Farmer's 'reason against' IoT-A adoption influences the adoption intention of IoT-A.

Values and reasons

The reasoning for behavior does not happen in isolation, and it is possible that reasoning is predisposed by an individual's deep-rooted values (Westaby, 2005a, b, p. 102). Values are considered as motivation constructs that help an individual to strive for and attain the desired goals (Schwartz, 2006). So, values provide direction to the individual to examine and select the alternative behavior. Values refer to the openness to change, which stimulates individuals to drive their own intellectual or emotional interests toward unknown directions (Schwartz, 1992). "Values are one important, an especially central component of our self and personality, distinct from attitudes, beliefs, norms, and traits" (Schwartz, 2012: p. 17). It is discussed in BRT (Westaby, 2005a, b) and the theory of explained behavior (Pennington and Hastie, 1988a, b) that values influence the reasoning of adoption. As per (Claudy et al., 2013), individuals would adopt innovations when they are sure that innovation is suited for personal values. The existing studies confirm the influence of values (openness to change) on reasoning (Gupta and Arora, 2017a; Siyathanu, 2018). IoT for agriculture industry is an innovation for farmers and farmer's values-openness to change will affect the reasoning of adoption of IoT in agriculture. So, the following hypotheses are developed. "Openness to change" value construct is considered from existing studies (Sivathanu, 2018; Claudy et al., 2015)

- *H4a.* The value of farmer will (positively/negatively) affect the 'reason for' IoT-A adoption.
- *H4b.* The value of farmer will (positively/negatively) affect the 'reason against' IoT-A adoption.

Values and attitudes

"Values are critical motivators of behaviors and attitudes" (Schwartz, 2012: p.17). Sometimes reasons for adoption are not fully activated; hence, individuals may rely on heuristics motives (Kahneman *et al.*, 1982). Values influence the attitude of individuals regarding the adoption of innovation (Westaby, 2005a, b; Schwartz, 2012). The extant literature confirms the influence of values on attitude toward adoption of innovation (Claudy *et al.*, 2015) and IoT-based health care wearables (Sivathanu, 2018). IoT-A is an innovation, and farmers might have openness to change that will affect the attitude toward IoT-A adoption. Hence, a hypothesis is postulated as follows:

H5. Farmers' values will (positively/negatively) affect their attitude toward IoT-A adoption.

Overall, behavioral reasoning theory provides an interesting model to examine the adoption of IoT-A by farmers. This conceptual model facilitates the research by verifying attitude, values, and reasons in one model.

Reasons extraction and measures

Farmers are in the initial stage of using basic information and communications technology (ICT) for farming (Singla, 2018); however, IoT-A is a new technology for Indian farmers. It will be insightful to explore the reasons for the adoption of IoT in agriculture. For this reason, farmers were surveyed in Maharashtra state in India.

Reason extraction

This part of the research mainly aims to explore the reasons of the adoption of IoT-A. Qualitative research was performed to extract the RF and RA adoption, which are particular to the context of IoT-A. The existing studies of BRT were considered to use this method of reason elicitation (Westaby, 2005a, b; Sivathanu, 2018; Westaby *et al.*, 2010; Pillai and Sivathanu, 2018; Gupta and Arora, 2017b). The discussion regarding the list of reasons was done with the subject matter experts– top authorities from the Indian agricultural sector including Department of Agricultural Research and Education (DARE), Indian Council of Agricultural Research (ICAR), technology providers of IoT-A, and professors from agriculture institutes such as College of Agriculture, Pune before finalization.

Then, semi-structured interviews were done face-to-face with 50 farmers who were using any type of technology for agriculture and currently not using IoT for agriculture. They were chosen conveniently, including both male and female farmers. These interviews were conducted in the local, regional language near the Gram Panchayat and rural market place. These farmers were shown videos explaining IoT-A and its advantages in the regional language before the survey. These RF adoption factors finalized after literature review and semi-structured interviews include the following: Relative advantage (Kante et al., 2018; Claudy et al., 2015), social influence (Moya et al., 2016), perceived convenience (Dong et al., 2017; Gupta and Arora, 2017a), and perceived usefulness (Zhou, 2017; Moya et al., 2016). While conducting the semi-structured interviews, a list of statements regarding reasons for which the farmers will adopt IoT-A was provided. The statements with RF include the following: a) Relative Advantage: IoT-A provides better results than conventional farming techniques. b) Social Influence: Farmers in the community and society members who influence me feel that I should use IoT in agriculture industry c) Perceived convenience: IoT-A technology is convenient as it can be used anywhere and anytime. d) Perceived usefulness: IoT-A helps me take quick decisions about my farm and farming techniques. Participants were requested to rate the RF on a five-point (strongly agree-5 to strongly disagree-1) Likert scale. The scale was calibrated considering the present studies (Oh and Teo, 2010; Richins and Dawson, 1992; Westaby, 2005a, b). Based on the top four reasons that emerged, the RF IoT-A adoption were finalized as relative advantage (mean = 4.38, SD = 0.88), social influence (mean = 4.23, SD = 0.84), perceived convenience (mean = 4.12, SD = 0.81). perceived usefulness (mean = 3.98, SD = 0.79).

The same process was used to examine the RA adoption of IoT-A. The participants were given the list regarding RA why they will not adopt IoT-A. Using extensive literature, the semi-structured interviews were done with the farmer respondents and the RA finalized were image barrier (Ram and Sheth, 1989), technological anxiety (Mani and Chouk, 2018), perceived price (Mani and Chouk, 2018), and perceived risk (Jayashankar *et al.*, 2018; Mani and Chouk, 2018). While conducting the semi-structured interviews, respondents were given a list of statements regarding RA IoT-A adoption. The statement with RA was as follows: *Image Barrier*: I do not think positive of the IoT-A technology; *Technological Anxiety*: I am apprehensive of using IoT-A technology; *Perceived Price*: The price of IoT-A technology is very high; *Perceived Risk*: You feel it is a risk as the IoT-A provider companies will share the data of your farm with other farmers without your consent. Participants were requested to rate the RA on a five-point Likert scale. These reasons were confirmed finally based on the top four RA IoT-A adoption and those were as follows: Perceived price (mean = 4.12, SD = 0.89),

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technological anxiety (mean = 4.08, SD = 0.87), perceived risk (mean = 4.05, SD = 0.84), image barrier (mean = 4.02, SD = 0.82).

Measures

The measurement of the scales was used from the present research of BRT (Westaby, 2005a, b; Westaby *et al.*, 2010), and Table I illustrates the other research on adoption considered. These latent variables were measured with a five-point (1 = "strongly disagree" and 5 = "strongly agree") Likert scale.

Research methodology

Design of research instrument

The research instrument was taken from the BRT (Westaby, 2005a, b) literature to investigate the adoption of IoT-A. The scales used to measure the latent variables are mentioned in Table III. The scales used for RF and RA were as per extant literature and reason elicitation. The validity and reliability of the latent variables are verified.

Sampling

To ensure face validity, the scope and objectives of this research were discussed with identified subject matter experts. The suggestion of subject matter experts was incorporated in the questionnaire administered in the local dialect, and then a pilot survey (N = 220) was conducted to evaluate the reliability and validity of the constructs. The villages surveyed for the pilot study were 10 digital villages in the Maharashtra state of India selected from the list by Ministry of Electronics and information technology (MEITY), Government of India. The constructs' operationalization was measured using a five-point Likert scale. The survey was conducted among the farmer respondents in Gram panchayat, rural hospitals, rural markets, and visiting rural households by administering questionnaires in the local, regional language for ease of farmers' understanding. The target farmer respondents chosen for the survey were the farmers who were using any type of technology for the farming purpose and not the IoT technology in agriculture. These farmers were shown videos of IoT-A and demonstration of

Demographic	Characteristics	Frequency	Percentage
Age (in years)	Below 25	506	32
	25-50	727	46
	Above 50	347	22
Gender	Male	1090	69
	Female	490	31
Farm size	Below 5 acres	364	23
	5–10 acres	616	39
	10 acres and above	600	38
Crop yield	Sugar cane	237	15
	Jawar	363	23
	Rice	221	14
	Cotton	190	12
	Pulses	269	17
	Fruits (Banana/Mango/Gauva/	300	19
	Grapes)		
Using any type of technology (Not IoT for	Less than six months	664	42
agriculture)	6–12 Months	490	31
	More than a year	426	27

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> Table III. Profile of respondents (N = 1.580)

IoT-A technology-based devices in the local dialect before filling the questionnaire. The data of the pilot survey were analyzed with partial least squares structural equation modeling (PLS–SEM) and subsequently the final result was executed after getting suitable pilot study results. Cronbach alpha was utilized to investigate the data reliability and internal consistency. Table III illustrates the operationalization of the latent variables of this research.

Primary data collection

Sufficient sample size was ensured considering the thumb rule (Gefen, 2000). The maximum number of items is in the latent variable which comprises RF with 14 items; hence, sample size must be 10 times of it, namely, 140 is the expected minimum sample size. The collected data were executed with a structured questionnaire administered in the local dialect to the respondents. The same respondent selection method was used as mentioned in the pilot study, and it was ensured that farmers using any type of technology for agriculture industry and who do not use IoT-A were surveyed. The purposive convenience sampling method was used for this research in the 45 digital villages in the Maharashtra state of India selected from MEITY list, wherein some type of farming technologies was used by the farmers. The survey was conducted among the farmer respondents in Gram panchayat, rural hospitals, rural markets, and visiting rural households. These farmers were shown videos about the IoT in agriculture industry in the regional language and demonstration of IoT-A technology-based devices. The chosen target respondents were suitable as these farmers were aware of some type of technology for farming and had sizable income and land. The total farmer respondents surveyed were 2.885 out of which 1.580 were found fit for analysis with a survey response rate of 54.76%. Table III provides a demographic profile of the farmers.

It is necessary to mention that the questionnaires were translated in the local language Marathi for reason elicitation, pilot survey, and final data collection. This method is based on the back translation method (Brislin, 1970, 1976).

Nonresponse bias

The *t*-test was done to analyze the difference in the response between the early wave (890) and late wave (690) groups (Armstrong and Overton, 1977; Tsou and Hsu, 2015). The result (p = 0.46) proved that there is no issue of nonresponse bias in this study. Finally, the total responses found to be fit in all respects were 1,580.

Table III displays the respondents' demographic profile including the following: Agewise–46 percent of the farmers are in between 25 and 50 age group. In the farm size, only 23 percent have below 5 acres land, 39 percent have between 5–10 acres, and 38 percent have 10 acres and above. The crop yields are as follows: Sugarcane 15 percent, Jawar 23 percent, rice 14 percent, cotton 12 percent, pulses 17 percent, and fruits (banana/mango/guava/grapes) 19 percent. The farmers surveyed were using some type of technology (not IoT for agriculture): 42 percent are using for less than 6 months, 31 percent are using from 6 to 12 months, and 27 percent are using for more than a year.

Data analysis and results

Common method bias

The single factor Harman test (Wang *et al.*, 2018; Podsakoff *et al.*, 2003) was performed to inspect the common method bias. Common method bias is not present as the variance of 34 percent was explained by a single factor which is less than 50 percent. Hence, the validity and reliability of the measures were verified. In addition, recursiveness in the structural model may cause endogeneity (Lai *et al.*, 2018; Dubey *et al.*, 2018). The variance in an exogenous variable may be endogenous to the model (Guide and Ketokivi, 2015) as the cross-sectional

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data may result in a misspecified model. Hence, a Ramsey regression equation error test was applied (Lai *et al.*, 2018) and it was ascertained that the endogeneity was not an issue in the proposed model. Hence, the validity and reliability of the measures were proved.

Measurement model

PLS–SEM was used for the analysis of the conceptual model. PLS–SEM is popularly used in social science studies as it is suitable for nonnormal data and supports small and large sample sizes (Hair *et al.*, 2014, 2017). The SmartPLS 2.0 software (Ringle *et al.*, 2005) was applied for primary data analysis. The measurement properties in the final model were calculated for the latent constructs that are reflective in nature and have multiple indicators

High internal consistency of all the constructs was confirmed as Cronbach alpha was more than 0.7 (Nunnally, 1978). As per Table IV, CR values confirm the high level of reliability and internal consistency of all the constructs as the outer loading for all the items were greater than 0.6. The AVE values are greater than 0.5, so the convergent validity for all the constructs is proved (Hair *et al.*, 2017; Guadagnoli and Velicer, 1988).

The Heterotrait–Monotrait ratio (HTMT) criterion as shown in Table V was used to examine the discriminant validity of the constructs as it is a better measure than the widely used Fornell–Larcker Criteria (Neneh, 2019; Henseler *et al.*, 2015). Following the conservative criteria of HTMT value of 0.85, it is observed that the highest HTMT value found in Table V was 0.604, which is well below the threshold value of 0.85, confirming the discriminant validity (Verkijika and De Wet, 2018; Henseler *et al.*, 2015).

Structural model

The reliability and validity of the measurement model were confirmed, and then the path analysis was done to examine the relationship between the latent variables using the structural model. The calculations of the path coefficients and its significance level are mentioned in Table VI, and the assessment of the level of R^2 values and predictive relevance Q^2 is dispayed in Table VII. The model fit index calculated for the estimated model using the SmartPLS software, namely standardized root mean square residual (SRMR) value is 0.054 which is lower than 0.06 indicating an acceptable fit (Hu and Bentler, 1999), and normed fit index (NFI) value for the estimated model is 0.908 which is considered acceptable as it is above 0.9 (Byrne, 2008).

The results in Figure 3 reveal that reasons are particular to the context and antecedents of adoption of IoT-A. The findings indicate that the attitude (H1: $\beta = 0.546$, p < 0.01) is a predictor of adoption intention of IoT-A. It is also found that RF (H2a: $\beta = 0.504$, p < 0.01) and RA (H2b: $\beta = -0.320$, p < 0.01) are antecedents of the attitude of farmers. The RF (H3a: $\beta = 0.295$, p < 0.01) and RA (H3b: $\beta = -0.246$, p < 0.01) influence the adoption intention of farmers. It is found that value (openness to change) does not influence the RF (H4a: $\beta = 0.331$ ns) and RA (H4b: $\beta = -0.233$ ns). It is also found that value is not a predictor of farmers' attitude (H5: $\beta = 0.308$ ns).

The second order path coefficients of reasoning are significant. The RF adoption are relative advantage ($\beta = 0.765$, p < 0.01), social influence ($\beta = 0.717$, p < 0.01), perceived convenience ($\beta = 0.750$, p < 0.01), and perceived usefulness ($\beta = 0.773$, p < 0.01). The farmers feel that IoT-A will be more beneficial than conventional methods of farming. Farmers also feel that social interaction with other farmers regarding IoT-A influence them to adopt IoT technology in agriculture industry. Farmers feel that IoT-A will be convenient for cattle movement tracking, usage of fertilizer, and control of agricultural activities (Ahmed *et al.*, 2018). Famers also mention that perceived usefulness is a RF the IoT-A adoption as it helps in increasing the productivity of their farm and in avoiding losses (Kite-Powell, 2015).

RA are image barrier ($\beta = 0.504$, p < 0.01), technological anxiety ($\beta = 0.563$, p < 0.01), perceived price ($\beta = 0.537$, p < 0.01) and perceived risk ($\beta = 0.558$, p < 0.01). Farmers do not

BIJ	Latent variables	Type	Factor loading	Item	Adapted from			
	Reasons for (RF) Relative advantage (RL) AVE = 0.709	Reflective	0.812	IoT in agriculture provides better results than conventional farming	(Claudy <i>et al.</i> , 2015; Gupta and Arora, 2017a) Adapted			
	$CR = 0.903$ $\alpha = 0.878$		0.874	techniques. I feel use of IoT in agriculture takes less time and efforts for farming than conventional				
			IoT in agriculture offers more value than conventional farming.					
	Social influence (SF) AVE = 0.736	Reflective	0.885	Farmers and society members who influence me feel that I should use IoT in agriculture.	(Venkatesh <i>et al.</i> , 2012)			
	CR = 0.899 $\alpha = 0.813$		0.861	Farmers and individuals who are important to me feel that I should consider the usage of IoT in agriculture.				
			0.879	The individuals who are very close to me will support me to use IoT in agriculture				
			0.847	Generally, people who are very close to me suggest me to use IoT in agriculture				
	Perceived convenience (PC) AVE = 0.766	Reflective	0.808	IoT in agriculture technology is convenient as it can be used any time.	(Dong <i>et al.</i> , 2017)			
	CR = 874 $\alpha = 0.799$	I feel that I can use IoT in agriculture technology from any place, so it seems to be						
						0.869	IoT in agriculture is not complicated, so it is very convenient to use.	
	Perceived usefulness (PF) AVE = 0.705	Reflective	0.853	IoT in agriculture would help me to take quick decisions about my farm and farming tophnique	(Davis, 1989; Karahoca <i>et al.</i> , 2018)			
	$\alpha = 0.802$			0.854	IoT in agriculture would enable me to decide the yield of my farm and improve the			
			0.842	performance of my farm. IoT in agriculture will enhance the effectiveness of my forming				
Table IV.			0.824	Usage of IoT in agriculture will help make it easier to take decisions regarding my farm				
construct validity and construct measurements				and farming techniques.	(continued)			

Latent variables	Type	Factor loading	Item	Adapted from	lo I in
Reasons against (R Image barrier (IB)	A) Reflective	0.874	I do not think positive of the	(Ram and Sheth, 1989;	industry in
AVE = 0.774 CR = 0.892		0.867	IoT in agriculture technology. Using IoT for agriculture	Pillai and Sivathanu, 2018; Laukkanen <i>et al.</i> ,	mua
$\alpha = 0.812$		0.831	would be generally difficult. Image of IoT for agriculture in my mind is that IoT in	2007)	
Technological anxiety (TX)	Reflective	0.801	agriculture is complex. I would avoid using IoT in agriculture as I am not	(Mani and Chouk, 2018)	
AVE = 0.756 CR = 0.886 $\alpha = 0.801$		0.842	familiar with it. I feel hesitant to use most of IoT in agriculture technology as I have a fear of making mistakes and feel that I		
		0.851	I am apprehensive of using		
Perceived price (PP)	Reflective	0.863	I feel that the price of IoT in agriculture technology is very	(Mani and Chouk, 2018)	
AVE = 0.748 CR = 0.904		0.870	I think IoT in agriculture will		
$\alpha = 0.779$		0.863	The expenses will be high for		
Perceived risk (PR) AVE = 0.793 CR = 0.869	Reflective	0.872	You feel a risk as the IoT for agriculture provider companies will share the data of your farm with other	(Jayashankar <i>et al.</i> , 2018; Mani and Chouk, 2018)	
$\alpha = 0.801$		0.812	farmers without your consent. IoT for agriculture provider companies will share the raw data of your farm to real estate speculators without		
		0.865	informing you which you feel is very risky. There is a high risk that IoT for agriculture provider companies will share data of your form with commodify		
		0.821	trading without your consent. There is a high risk that data from your farm will allow agriculture technology providers to make decisions		
Value of	Reflective	0.867	about your farm. I always look for new	(Claudy et al., 2015)	
openness to change (VC) AVE = 0.714		0.855	methods to do farming. I am open to experimenting with new things and methods	modified by author	
$CR = 0.857$ $\alpha = 0.817$		0.866	of farming. I am ready for new experiences in farming methods.		
				(continued)	Table IV.

BIJ	Latent variables	Туре	Factor loading	Item	Adapted from
	Attitude (AT) AVF = 0.729	Reflective	0.892	IoT for agriculture is a good	(Claudy <i>et al.</i> , 2015; Gupta and Arora
	CR = 0.861 $\alpha = 0.805$		0.876	IoT for agriculture has many benefits.	2017a) modified by author
			0.872	IoT in agriculture will add a lot of value in the near future.	
	 Adoption intention (AN) 	Reflective	0.881	I will use IoT for agriculture purposes.	(Gupta and Arora, 2017a; Fishbein and
	AVE = 0.733 CR = 0.859		0.891	I can foresee that I will use IoT for agriculture.	Ajzen, 1975)
	$\alpha = 0.779$		0.877	I feel that I will use IoT technology for agriculture	
Table IV.				purpose.	

have a positive image of IoT-A as they feel that IoT-A will be difficult and complicated to operate. The farmers are hesitant and apprehensive to adopt IoT-A as they are not much familiar with the new technology that creates technological anxiety. Farmers in India are already loaded with loans (Pandey *et al.*, 2019) and they think that IoT-A will be costly for them. Also, farmers feel that adoption of IoT-A is risky as their farm data will be shared with others without their consent.

Control variables

Farm size was considered as a control variable in the study to check if different farm sizes had an effect in explaining the adoption intention of farmers in IoT-A. Farmers' age was also added as a control variable to the model to verify if different ages of the farmers had an effect to explain their intention to adopt IoT-A. The results reveal that the control variables including farmers' age ($\beta = -0.005$ ns) and farm size ($\beta = 0.019$ ns) do not significantly influence the behavioral intention to adopt IoT-A. Hence, the results of the study show that for small-, medium- or large-sized farms and young, middle-aged or older farmers, there are no significant results for the adoption intention of IoT-A. This reveals that neither farmers' age nor farm size is a driver for adoption intention of IoT-A.

Discussion and implications

It is found that the context-specific RF IoT-A adoption are as follows: Relative advantage, social influence, perceived convenience and perceived usefulness. IoT technology is perceived relatively advantageous by the farmers as it yields better results and takes less time for farming activities than conventional farming methods. As per the second order path coefficients values, perceived usefulness ($\beta = 0.773$) is the crucial RF the adoption intention of IoT-A, which supports the existing studies (Amin and Li, 2014; Dong *et al.*, 2017; Zhou, 2017). The IoT technology for agriculture is useful for predicting natural calamities, monitoring crops, understanding the requirement of fertilizers, and carrying out lot of decision-making related to farming. In total, IoT is useful for multiple farming functions to improve the productivity of the farm (Verma and Usman, 2016). Farmers mainly look for the usefulness of the technology before adoption. Social influence is also a key predictor for adoption (Moya *et al.*, 2016) as farmers interact with other villagers before taking up the adoption of IoT-A. The farmers in India have many community-wide discussions at the Panchayat forum, where various farming and personal issues are discussed. Hence, social influence matters while adopting a new technology. Farmers have to take strenuous efforts to conduct farming

					Я	Ĺ			Я	A		
Constructs		AN	At	RL	SF	PC	PF	B	ΤX	ΡP	RR	VC
AN		0.604	I	I	I	I	I	I	I	I	I	I
AT		0.362	0.542	I	I	I	I	I	I	I	I	I
RF	RL	0.232	0.288	0.486	I	I	I	I	I	I	I	I
	SF	0.258	0.248	0.266	0.446	I	I	I	I	I	I	I
	PC	0.246	0.238	0.248	0.479	0.482	I	I	I	I	I	I
	ΡF	0.240	0.228	0.286	0.326	0.342	0.468	I	I	I	I	I
RA	B	0.282	0.230	0.242	0.214	0.269	0.261	0.406	I	I	I	I
	ΤX	0.268	0.242	0.204	0.108	0.214	0.224	0.244	0.424	I	I	I
	ЪЪ	0.234	0.264	0.236	0.242	0.238	0.224	0.228	0.266	0.408	I	I
	RR	0.206	0.182	0.180	0.176	0.184	0.194	0.124	0.148	0.186	0.442	I
VC		0.218	0.242	0.144	0.138	0.128	0.246	0.236	0.164	0.184	0.168	0.508

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Table V.Discriminant validity
(using HTMT)

BIJ	Hypothesis	Path	β	t-Statistics	Supported
		First order			
	H1	$AT \rightarrow AN$	0.546	3.076***	Yes
	H2a	$RF \rightarrow AT$	0.504	8.773***	Yes
	H2b	$RA \rightarrow AT$	-0.320	7.864***	Yes
	H3a	$RF \rightarrow AN$	0.295	3.712***	Yes
	H3b	$RA \rightarrow AN$	-0.246	2.985***	Yes
	• H4a	$VC \rightarrow RF$	0.331	1.867	No
	H4b	$VC \rightarrow RA$	-0.233	1.821	No
	H5	$VC \rightarrow AT$	0.308	1.225	No
		Second order			
		$RF \rightarrow RL$	0.765	8.304***	Yes
		$RF \rightarrow SF$	0.717	5.987***	Yes
		$RF \rightarrow PC$	0.750	8.048***	Yes
		$RF \rightarrow PF$	0.773	7.539***	Yes
		$RA \rightarrow IB$	0.504	3.628***	Yes
		$RA \rightarrow TX$	0.563	3.614***	Yes
Table VI. Path coefficients and summary of hypothesis testing		$RA \rightarrow PP$	0.537	3.249***	Yes
		$RA \rightarrow PR$	0.558	4.280***	Yes
	Notes: <i>t</i> -values for (sig. level = 10%),	two-tailed test: ***t-value (Hair <i>et al.</i> , 2011)	e 2.58 (sig. level = 1%)), **1.96 (sig. level = 5%)) and *t-value 1.65
	Endogenous latent	constructs		R^2	

	-			
	Attitude Adoptio	e toward adoption of IoT-A on intention toward IoT-A	0.663 0.690	0.318 0.332
	Reasons for adoption of IoT-A		0.753	0.458
	Reasons	s against adoption of IoT-A	0.614	0.284
	Note: A Value	Assessment of predictive relevance (Q^2) Effect size		
Table VII.	0.02	Small		
Results of R ² and	0.15	Medium		
predictive relevance Q^2	0.35	Large		

activities. IoT helps in the field monitoring functions such as the functioning of water supply pumps and soil moisture checks using mobile devices, which is very convenient for the farmers while farming.

The RA the adoption of IoTA are image barrier, technological anxiety, perceived price, and perceived risk. The most influential RA the adoption of IoT-A is technological anxiety as farmers are not well versed in using IoT-A technology (Kumar and Kansara, 2018), which is one of the barriers for adoption of IoT (Mani and Chouk, 2018). The image of IoT in agriculture industry is perceived by farmers as complex and difficult. They don't perceive it very positively; hence, image barrier is a deterrent for adoption. Perceived price is another important RA as farmers perceive that it will be costly to use IoT-A for farming. Farmers in India do not have a large amount of disposable income to invest in new technology. Moreover, farmers feel risky to use IoT-A because they think that their farm data and crop yield data will be shared with other farmers or real estate speculators without their consent. Additionally, farmers perceive a risk that IoT provider companies will start driving their farming activities; hence, they consider IoT in agriculture as risky.



Theoretical implications

This research supports the present BRT literature and found that (openness to change) value does not influence the attitude (Claudy *et al.*, 2015; Sivathanu, 2018) and RA (Gupta and Arora, 2017a, b; Claudy *et al.*, 2015) adoption of IoT-A. The results contradict the existing studies as value (openness to change) does not influence the RF adoption (Claudy *et al.*, 2015; Pillai and Sivathanu, 2018; Sivathanu, 2018; Gupta and Arora, 2017a). This clearly shows that farmers are not open to new changes or adoption of IoT-A.

The research offers a contribution to the adoption of innovation and IoT-A adoption literature by using the BRT theory to inspect the influence of reasons on consumers' thinking process toward the decision of innovation adoption rather than just discussing beliefs of adoption. The reasons may vary depending on the type of technology and the innovation adoption context (Claudy *et al.*, 2015). BRT provides a feasible option to the frequently used DoI research which permits more psychological paths in consumer adoption decisions.

The research explains the IoT-A adoption behavior of farmers in a developing country such as India. It provides focus on RF and RA the adoption of IoT in agriculture industry.

60 percent of the mobile subscription market in India is rural and by 2020, it is predicted that the market will grow by 1.2 billion mobile subscribers (Sharma, 2017). Though mobile phones are used so extensively, still technological anxiety is one of the RA adoption by farmers. Dearth of research exists regarding the adoption of IoT-A where factors for adoption (Jayashankar *et al.*, 2018) and barriers of adoption are in a single framework. This research takes the first step to deliberate the adoption of IoT-A using BRT mentioning both, RF and RA which makes a unique theoretical contribution. This study also adds new RA adoption in the BRT framework– Perceived price(Mani and Chouk, 2018) and Technological anxiety (Mani and Chouk, 2018). This study also considered the control variables- farmers age and farm size in the theoretical model and found that they are not significant in the adoption of IoT-A.

Practical implications

This research has strong implications for marketers as it discusses the RF and RA adoption for deriving the marketing strategy. The RF adoption such as social influence can be leveraged by conducting mass social awareness campaigns and informative sessions to demonstrate the usefulness of IoT to top rural authorities such as village head (Sarpanch), village school principals, teachers, and doctors who generally influence the rural population in India. Marketers can even provide case studies and use cases to the farmers which discuss the relative advantages and benefits of IoT in agriculture industry from nearby villages thereby conveying the usefulness of the new IoT technology in agriculture industry.

The RA such as perceived risk, technological anxiety, and image barrier can be reduced for the farmer by conducting awareness and training sessions about the usage of IoT-A, which should be provided on a continuous basis. IoT-A companies can have a center for information and training at Taluka areas initially so that IoT can be extensively used by farmers, which will help Indian farmers to improve the crop yield and assist their livelihood.

This research offers key implications for the policymakers and government as they can formulate policies to improve the adoption of IoT-A considering the RF and RA the adoption of IoT-A. As technological anxiety and image barrier are important hurdles for farmers, the government can also take key responsibility in providing education to the farmers along with nongovernmental organizations (NGOs) operating in the rural areas. Farmers perceive that price of IoT-A is high; so the government can come up with schemes to provide subsidies to IoT-A companies thereby reducing prices that are affordable to the farmers.

Developers and designers of IoT can provide simple IoT solutions for agriculture industry which can easily reduce the technological anxiety and image barriers of the farmers. Marketers should also ensure continuous assistance and training to the farmers to reduce these barriers. The marketers also need to convince the farmers regarding the security of their farm data so that they do not perceive a risk to use IoT in agriculture industry. The government, NGOs, and IoT provider companies can tie up to provide cost-effective IoT technology solutions for agriculture industry to reduce the price burden on the farmers, which would motivate them to adopt IoT for agriculture industry. Developers and designers can also ensure the usage of local language on IoT devices for agriculture, which would facilitate an easy understanding of the functioning of the IoT technology by the farmers.

Limitations and future research scope

This research explains the adoption of IoT-A by discussing the RF and RA in a single BRT framework. This is distinctive research to understand the adoption of IoT-A in India. This work has limitations as it is a cross-sectional study, and caution needs to be taken before generalizing the outcome of this research. Furthermore, the moderating role of experience in

technology infrastructure, availability of technology, personal innovations, and risk-taking ability can be tested. The RF and RA of adoption of IoT-A may vary with cultures of different developing countries, which can be studied further. This study discusses the IoT adoption by farmers in the agriculture industry. Further studies can be made for IoT adoption in various service sectors. Though this study has limitations, it provides very interesting insights to marketers of IoT-A and research scholars in this area.

Conclusion

The research highlights the context-specific RF and RA the adoption of IoT-A in an emerging economy such as India. The RF the adoption of IoT-A are relative advantage, social influence, perceived convenience, and perceived usefulness. The RA are image Barrier, technological anxiety, perceived price, and perceived risk. This study contributes insights to the adoption of IoT-A and farmers' behavior toward IoT in agriculture industry. The research has provided directions to marketers to develop marketing strategies for IoT-A considering the reasons of adoption. This study has theoretical contributions to IoT-A literature and practical implications for IoT-A marketers, policymakers, and the government.

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